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THE PRIMARY INDICATORS METHOD—A PRACTICAL APPROACH TO WETLAND RECOGNITION AND DELINEATION IN THE UNITED STATES

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Abstract: Over the past 30 years, various methods have been developed to identify and delineate wetlands for regulatory purposes in the United States. This paper discusses major limitations of existing methods and offers an alternative method called the "primary indicators method." This new method is based on using features (national and regional plant and soil characteristics) unique to wetlands for identifying wetlands and their boundaries. These primary indicators permit accurate wetland determinations and delineations in the absence of significant hydrologic modification because these features only develop in wetlands. Wetlands subject to significant drainage require an assessment of the current hydrology.

Key Words: wetland delineation, wetlands, U.S. wetlands, hydrophytic vegetation, hydric soils, wetland hydrology, disturbed wetlands, wetland boundary.

INTRODUCTION

The promulgation of wetland laws and regulations since the 1960s created the need to accurately define the limits of wetlands throughout the United States. State wetland protection laws passed in the 1960s and 1970s contained lists of plant species that characterized or exemplified wetlands. Consequently, wetland delineation in these states (e.g., Massachusetts, Rhode Island, Connecticut, New Jersey, and New York) has focused on using plant species as wetland indicators. Since the 1980s, Federal wetland regulatory agencies have used a three-parameter method for wetland identification and delineation, which involves finding "positive indicators" of hydrophytic vegetation, hydric soils, and wetland hydrology. The purpose of this paper is to briefly discuss the limitations of existing wetland delineation methods and describe an alternative—the "primary indicators method."

THE NEED FOR WETLAND DELINEATION STANDARDS

Wetland delineation is a relatively new area of interest and developed in response to efforts to protect wetlands and their functions through Federal and state laws. Since the early 1960s, these laws have had an increasing impact on significant areas of private property as well as on public lands. Landowners, developers, and public land managers need to know where wetlands are located in order to delimit the extent of government jurisdiction under these new laws.

Standardized methods are needed to ensure accurate identification of wetlands and their boundaries. Such methods should be (1) technically sound by making use of current scientific knowledge to accurately identify wetlands, as well as being legally defensible (rather than being arbitrary and capricious), (2) precise, i.e., produce repeatable results so that different investigators would identify essentially the same boundary for a given wetland regardless of the time of year of field inspection, (3) practical and easy to use, emphasizing relatively easily observed features that can be recognized by generalists in major biological and physical sciences, (4) efficient, e.g., requiring only minimal effort to identify the wetter wetlands and increased effort for more difficult-to-identify wetlands, (5) capable of producing most determinations in a single site inspection, (6) able to permit wetland identification throughout the year (except perhaps when the soil is frozen and the area is snow-covered), (7) sufficient in scope to encompass regional variation in wetlands throughout the United States, and (8) flexible enough to allow for limited use of professional judgment in difficult or confounding situations. Without standard methods and well-trained personnel to employ them, wetland identification and delineation would be extremely varied among individuals engaged in such tasks. This would pose a consistency problem for regulators and the regulated community alike. Moreover, it would further jeopardize our remaining wetland resources by failing to accurately locate them for subsequent evaluation of proposed impacts from various construction activities.

LIMITATIONS OF EXISTING WETLAND DELINEATION METHODS

There is longstanding recognition among the scientific community that certain plant communities represent wetlands (Table 1). Consequently, vegetation characteristics have been widely used to identify and delineate wetlands (Stewart and Kantrud 1971, Lefor and Tiner 1972, 1974, Golet and Larson 1974, DiPinto and McCollum 1988, Tiner 1989a). Vegetation largely remains the principal determinator of wetlands in states with the first wetland protection laws, including Massachusetts, Rhode Island, New York, Connecticut, New Jersey, Maryland, and Virginia. The first three states use vegetation for identifying both tidal and nontidal wetlands, while the latter four states use it for tidal wetlands only. A predominance of "wetland plants" determines both the presence of wetlands and their limits (e.g., wetlands exist where more than 50% of the plants are wetland species). Recent studies of wetlands and their boundaries, including wetland mapping, have found that (1) this type of simple vegetation assessment does not identify all areas with significant wetness, (2) the species level of plant classification has its limitations for identifying hydrophytic vegetation, since many plant species characteristic of wetlands have broad ecological amplitudes and wetland ecotypes of species that are more common on uplands exist, and (3) certain soil properties could be used to identify wetlands and to more accurately define wetland boundaries (Cowardin *et al.* 1979, Sipple 1985, 1988, Environmental Laboratory 1987, Tiner and Veneman 1987, Tiner 1988, 1991a). It is interesting to note that despite a reliance on plants for wetland delineations, no state has developed a comprehensive list of "wetland plants" for use in identifying state-regulated wetlands. This, among other things, makes it virtually impossible to achieve consistent and reproducible results.

In the 1980s, the Corps of Engineers (CE) and Environmental Protection Agency (EPA) developed approaches that used "positive indicators" of three parameters—hydrophytic vegetation, hydric soils, and wetland hydrology—to identify and delineate wetlands subject to federal regulation under the Clean Water Act (Environmental Laboratory 1987, Sipple 1988). Since the EPA method is no longer being used, only the 1987 CE method will be discussed. The apparent rationale for the CE's three-parameter approach is that wetlands exist only where "positive indicators" of all three parameters were found. The absence of positive indicators of any of the three parameters is sufficient to make a nonwetland determination, regardless of the strength of the other two; this is the basic rule of this method. Although it may be acceptable for regulatory purposes, this approach is technically flawed, since all vegetated wetlands are not included. The first two parameters are typically dependent on and the product of the third, so wetland hydrology is apparently the only independent variable. Yet, even the hydrology of a wetland may, in certain cases, be dependent on one of the others. For example, an important wetland-forming process called "paludification" in humid boreal and subarctic regions depends not only on an excess of water, but also on the ability of peat mosses (*Sphagnum* spp.) to wick up the water and continually advance up hill as a mat, leading to "swamping" or "bogging" of adjacent uplands while forming blanket or slope bogs (Skoropanov 1961, Crum 1988). The existence of these bogs depends on peat mosses as much as on an excess of water.

Perhaps the most serious shortcoming of the CE method is the emphasis that positive indicators of wetland hydrology be present at the time of observation, unless specific hydrologic data are available. This method may, therefore, be an extremely conservative and cautious approach to wetland delineation depending on how strictly the parameters are applied and the indicators used to verify them. Most vegetated wetlands have vegetation and soils present throughout the year, but it is well-known that the presence of water in most wetlands typically varies spatially and temporally over the year (Metzler and Tiner 1992, Mitsch and Gosselink 1986, Tiner 1988, among others). If hydrology must be verified, then indirect indicators are needed. The CE manual's list of wetland hydrology indicators emphasizes either direct observations of water (on the surface or within the majority of the root zone) or indirect indicators of surface water (e.g., silt marks, debris lines, water marks, scoured areas, and wetland drainage patterns), so indirect indicators of soil saturation are absent from the list. Although the list is presented as examples (see paragraph 49 p. 36), areas lacking these positive indicators of wetland hydrology are typically not considered wetland. This strict application of the three-parameter method leads to misclassifying seasonally waterlogged wetlands and the drier portions of wetlands as nonwetlands. Given the inherent weakness of the list of hydrology indicators, it is virtually impossible to identify hydrologic evidence of periodically saturated wetlands, such as certain pine flatwoods and wet meadows, during the dry portion of the growing season without considering properties in the soil, unless one uses professional judgment. Overall, the CE manual's lack of specificity regarding application of indicators for wetland hydrology and hydrophytic vegetation seriously impairs its ability to produce precise, accurate, and repeatable wetland delineations.

The shortcomings of the 1987 CE manual, in part, supported the need to develop an interagency manual, since some states chose the EPA manual for use in state regulatory programs and no state adopted the CE manual. In 1989, four Federal agencies (CE, EPA, Fish and Wildlife Service, and Soil Conservation Service) combined existing methodologies in developing a technical manual to identify vegetated wetlands in the U.S. entitled "Federal Manual for Identifying and Delineating Jurisdictional Wetlands" (Federal Interagency Committee for Wetland Delineation 1989). To identify "vegetated" wetlands *potentially* subject to some form of Federal regulation or policy ("jurisdiction"), the agencies maintained the general concept of the three-parameter approach and specifically defined three technical criteria—hydrophytic vegetation, hydric soils, and wetland hydrology—that would be used to identify wetlands. This approach required verification of all three criteria but attempted to resolve the difficulty of verifying the hydrology criterion in the dry season. Besides expanding the list of hydrology indicators to include oxidized rhizospheres and water-stained leaves, the 1989 manual allowed certain soil properties and various vegetation characteristics (e.g., buttressed stems, pneumatophores, and hypertrophied lenticels) to satisfy the wetland hydrology criterion in areas with no sign of significant hydrologic modification. Areas dominated by OBL, FACW, and/or FAC species[1] *and* having hydric soils (field-verified by their soil morphology) were considered to be wetlands, unless their hydrology was visibly modified or otherwise significantly drained. This approach recognized the interdependence of hydrophytic vegetation, hydric soils, and wetland hydrology and that certain vegetation and soils are valid indicators of wetland hydrology in many circumstances. This protocol was criticized by three-parameter fundamentalists who felt that there was a lack of sufficient hydrologic evidence to make a wetland determination. They viewed this method as a two-parameter approach, despite the fact that wetland hydrology was considered and presumed to be met given the nature of the vegetation and soils *and* the apparent lack of hydrologic alteration.

A major weakness of the 1989 interagency manual that created considerable confusion and misapplication relates to the hydric soil criterion. While this criterion developed by the National Technical Committee for Hydric Soils (NTCHS) was the best available at the time, its inclusion of drainage classes made it somewhat difficult to consistently apply in the field. The NTCHS technical criteria for hydric soils were originally developed to produce a national list of hydric soils from an existing soils database, and the inclusion of drainage classes facilitated this compilation. It did not, however, easily translate to field indicators. Drainage classes were established for agricultural applications and the soil properties used to identify specific drainage classes (e.g., somewhat poorly drained versus poorly drained) varied among states and even within a state (Peter Veneman, pers. comm.). Without, at least, regional standards for soil properties reflecting hydric conditions, field recognition of hydric soils and delineation of their limits would be extremely varied among soil scientists and non-soil scientists alike. The New England CE District recognized this problem, consulted with the region's soil scientists, and developed regional standards for the drainage classes for applying the 1989 manual.

The three-criteria and three-parameter approaches will always be subject to criticism due to the nature of wetlands, the interdependence between vegetation, soils, and hydrology, and the spatial and temporal variation in site wetness. Tiner (1991c) and Sipple (1992) readily acknowledge limitations of these approaches and the need to move forward with alternative approaches.

THE IMPRACTICALITY OF USING HYDROLOGY FOR WETLAND IDENTIFICATION

Hydrology is widely acknowledged as the driving force creating and maintaining wetlands (Mitsch and Gosselink 1986, Federal Interagency Committee for Wetland Delineation 1989, among others). Yet, due to its dynamic nature varying daily, seasonally, and annually, and the lack of long-term data for most wetland types, hydrology (especially the actual presence of water) is the least useful parameter for wetland identification (Environmental Laboratory 1987, Federal Interagency Committee for Wetland Delineation 1989) and "generally impracticable for delineating wetland boundaries" (p. 16, Sipple 1988). The proposed 1991 revisions to the Federal interagency manual attempted to use specific hydrology requirements to establish the limits of wetlands and, in effect, omitted about 50 percent (50 million ac; 20 million ha) of the Nation's wetlands (Environmental Defense Fund and World Wildlife Fund 1992). Tiner (1991b) discusses the futility of attempting to use hydrology to verify wetlands.

The presence of water in wetlands varies greatly between wetland types, among similar types, and even within an individual wetland. Daily, seasonal, and an-

[1] OBL = Obligate Hydrophytes (frequency of occurrence in wetlands >99% of the time); FACW = Facultative Wetland Species (frequency of occurrence in wetlands ranges between 67–99% of the time); FAC = Facultative Species (frequency of occurrence in wetlands ranges between 34–66%) (Reed 1988).

nual variations in hydrology are the rule and not the exception for wetlands. In arid and semiarid regions, annual variations are particularly pronounced, making terms like "mean rainfall year" or "normal rainfall year" virtually irrelevant. As a result of this dynamic hydrology and differences among the variety of wetland types, it is virtually impossible to define with any certainty the minimum wetness (frequency and duration) that creates a wetland (Tiner 1991b). Prolonged anaerobic conditions accompanying excessive wetness are largely responsible for the formation of plant communities and hydric soil properties associated with wetlands (Cowardin *et al.* 1979, Mitsch and Gosselink 1986). Anaerobic conditions can develop in soils within a day or two of flooding (Evans and Scott 1955, Turner and Patrick 1968, Ponnamperuma 1972, Gambrell and Patrick 1978). Repeated inundation or soil saturation for a couple of days during biologically active periods (i.e., when the upper part of the soil is not frozen) should be sufficient to create anaerobic conditions that favor the establishment of wetland plants, since such conditions in the majority of the root zone dictate whether a given plant will survive and grow, wither and die, or fail to germinate (Tiner 1991b). The long-term hydrology is also responsible for the development of certain soil properties. Hydric soil properties (e.g., gleying and organic accumulations) probably require a much longer duration of flooding or soil saturation to form than to produce a hydrophytic plant community, especially in floodplain environments. Regardless, both hydric soils and hydrophytic vegetation are the observable responses of wetland hydrology and should be the most useful indicators of wetland in areas not significantly drained. Recent U.S. Fish and Wildlife Service studies have further confirmed traditional scientific opinion and observations that there is an excellent correlation between "hydrophytic vegetation" and "hydric soils" for determining the presence of wetlands (Dick-Peddie *et al.* 1987, Erickson and Leslie 1987, 1989, Baad 1988, Christensen *et al.* 1988, Eicher 1988, Hubbard *et al.* 1988, Nachlinger 1988, Allen *et al.* 1989, Scott *et al.* 1989, Best *et al.* 1990, Segelquist *et al.* 1990, Veneman and Tiner 1990). Requiring that unaltered areas having such vegetation and soils must be demonstrably wet for a specific time period makes wetland identification unnecessarily burdensome and puts too much emphasis on a condition that is not documented in the scientific literature (Tiner 1991b). Existing Federal and state wetland definitions reflect this realization and typically do not mention specific time periods for inundation or soil saturation, but instead simply state that the area must be saturated or flooded long enough to support or be capable of supporting plants adapted to saturated soils.

At the present time, emphasis in wetland recognition should be placed on vegetation and soils that typically reflect an area's wetness. Specific hydrologic conditions should only be considered when an area has been significantly drained or similarly hydrologically modified. Altered hydrology usually negates the interpretive value of vegetation and soil properties. This makes it necessary to define hydrologic conditions that can be measured or to establish other means to evaluate whether the area is effectively drained or not. Regionally based wetland type-specific hydrology requirements could be established to determine whether such areas are still wetland or not.

Since soil and vegetation of wetlands are the direct result or manifestation of wetland hydrology, certain distinctive soil or vegetation characteristics should provide ample evidence to document the occurrence of wetland *in the absence of significant hydrologic modification* (drainage). Simply stated, hydrophytes and hydric soil properties are reliable indicators of wetland or wetland hydrology. The following method emphasizing these characteristics is offered as an alternative to the three-parameter method.

THE PRIMARY INDICATORS METHOD (PRIMET)

Wetlands are highly varied and complex habitats subject to different hydrologic regimes, climatic conditions, soil formation processes, and geomorphologic settings across the country. Within similar geographic areas, wetlands have developed characteristics different than adjacent uplands (nonwetlands) due to the presence of water in or on top of the soil for prolonged periods during the year. The visible expression of this wetness may be evident in the plant community and/or in the underlying soil properties. Consequently, every wetland in its natural undrained condition should possess at least one distinctive feature that distinguishes it from the adjacent upland. The "primary indicators method" (PRIMET) is founded on this premise. This approach is not really new but is an outgrowth of traditional methods used to recognize wetlands (Tiner 1988, 1989a), including the Fish and Wildlife Service's wetland classification system (Cowardin *et al.* 1979), which is widely recognized as the national standard for wetland classification (Mader 1991).

Most wetlands can be recognized by a single feature, such as a plant community dominated by OBL species (e.g., cattail marsh, buttonbush swamp, leatherleaf bog, or bald cypress swamp; Table 1) and the presence of organic soils (peats and mucks) or gleyed mineral soils. As long as there is *no evidence of significant drainage or similar hydrologic change*, any area possessing one of these or other distinctive features should be a wet-

Table 1. Examples of U.S. wetland types with diagnostic hydrophytic plant species listed. These species are not always the dominant species of the plant community, but represent those species restricted to wetlands and that may serve as highly reliable indicators of wetlands. The listed species occur only in wetlands, except for those marked by an asterisk (*) which are also highly specific to wetlands. (Sources: Stewart and Kantrud 1971, Sroka 1975, Herdendorf et al. 1981, Freehling 1982, Nelson et al. 1983, Duever et al. 1984, Tiner 1985a, 1985b, 1987, 1988, 1989b, 1993, Damman and French 1987, Glaser 1987, Laderman 1987, Wharton et al. 1987, Omhart et al. 1988, Christensen et al. 1989, Faber et al. 1989, Kantrud et al. 1989, Minshall et al. 1989).

Wetland Type (Region)	Major Species Restricted to Wetlands
Salt marsh (Northeast)	*Spartina alterniflora, S. patens**, *Distichlis spicata**, *Iva frutescens**, *Potentilla anserina, Triglochin maritimum, Salicornia europaea, Juncus gerardii**
Salt marsh (Southeast)	*Spartina alterniflora, Juncus roemerianus, Borrichia frutescens*
Brackish coastal marsh (Northeast)	*Scirpus americanus* (=*olneyii*), *S. robustus, Spartina cynosuroides, Hibiscus moscheutos, Typha angustifolia*
Tidal fresh marsh (Northeast)	*Zizania aquatica, Nuphar luteum, Peltandra virginica, Scirpus validus, S. fluviatilis, Acorus calamus, Bidens laevis*
Red maple swamp (Northeast)	*Symplocarpus foetidus, Carex stricta*
Cypress-gum swamp (Southeast)	*Taxodium distichum, Nyssa aquatica, N. sylvatica* var. *biflora, N. ogeche, Fraxinus caroliniana, Cephalanthus occidentalis, Salix caroliniana, Acer rubrum* ssp. *drummondii*
Mangrove swamp (Southeast)	*Avicennia germinans, Rhizophora mangle*
Tidal salt barren (Southeast)	*Batis maritima, Salicornia europaea, S. bigelovii, Monanthochloe littoralis*
Cypress Dome (Florida)	*Taxodium distichum, Saururus cernuus, Pontederia cordata, Rhynchospora glomerata, Woodwardia virginica, Nyssa sylvatica* var. *biflora*
Atlantic white cedar swamp (Northeast and Southeast)	*Chamaecyparis thyoides*
Shrub pocosin (coastal North Carolina)	*Zenobia pulverulenta, Chamaedaphne calyculata, Chamaecyparis thyoides, Sphagnum* spp.*
Inland wet meadow (Northeast and Midwest)	*Carex stricta, Juncus effusus**, *Acorus calamus, Calamagrostis canadensis**, *Scirpus cyperinus**
Inland marsh (Northeast and Midwest)	*Decodon verticillatus, Sagittaria* spp., *Pontederia cordata, Typha* spp., *Sparganium* spp., *Scirpus acutus, S. validus, S. pungens, Leersia oryzoides*
Semipermanently flooded prairie pothole marsh (Midwest)	*Scirpus validus, S. fluviatilis, S. acutus, S. heterochaetus, S. maritimus, Typha* spp., *Potamogeton* spp., *Lemna* spp., *Chara* spp., *Zannichellia palustris, Eleocharis acicularis, Senecio congestus**, *Rumex maritimus**
Seasonally flooded prairie pothole marsh (Midwest)	*Glyceria maxima* (=*grandis*), *Beckmannia syzigachne, Sparganium eurycarpum, Sium suave, Carex atherodes, Polygonum amphibium* (=*coccineum*), *Scolochloa festucacea, Scirpus pungens* (=*americanus*), *Puccinellia nuttalliana, Eleocharis palustris, E. acicularis, Salicornia rubra, Alopecurus aequalis, Alisma plantago-aquatica* (=*triviale*), *Rumex maritimus**, *Senecio congestus**, *Gratiola neglecta*
Temporarily flooded prairie pothole marsh (Midwest)	*Juncus balticus, Potentilla anserina, Carex lanuginosa, C. vulpinoidea, C. laeviconia, Triglochin maritimum, Calamagrostis canadensis**, *Ranunculus macounii, Rumex occidentalis, Rorippa palustris, Lysimachia hybrida, Stachys palustris, Polygonum lapathifolium*
Northern fen (Northeast)	*Scirpus cespitosus, Carex lasiocarpa, Calamagrostis canadensis**, *Carex utriculata* (=*rostrata*), *Carex exilis*
Rich fen (Upper Midwest)	*Carex lasiocarpa, C. livida, C. limosa, Menyanthes trifoliata, Rhynchospora alba, Triglochin maritimum, Utricularia intermedia, Drosera intermedia, Betula pumila, Andromeda glaucophylla, Vaccinium oxycoccus, Chamaedaphne calyculata, Carex echinata* (=*cephalantha*)
Larch-black spruce forested fen (Upper Midwest)	*Carex pseudocyperus, Rubus pubescens**, *Sphagnum* spp.*
Northern shrub bog (Northeast and Upper Midwest)	*Chamaedaphne calyculata, Kalmia polifolia, Ledum groenlandicum, Rhynchospora alba, Utricularia cornuta, Andromeda glaucophyllum, Eriophorum angustifolium, E. spissum, E. virginicum, Sphagnum* spp.*, *Vaccinium macrocarpon*
Black spruce bog (Northeast and Upper Midwest)	*Carex trisperma, Nemopanthus mucronatus, Kalmia polifolia, Ledum groenlandicum, Andromeda glaucophylla, Smilacina trifolia*
Playa marsh (Southwest)	*Sagittaria longiloba, Typha domingensis, Eleocharis* spp., *Potamogeton* spp.

Table 1. Continued.

Wetland Type (Region)	Major Species Restricted to Wetlands
Riparian wet shrub thicket (Southwest including S. Calif.)	*Salix goodingii, S. exigua, S. lasiandra*
Inland marsh (Southwest)	*Scirpus californicus, S. pungens, Typha* spp.
Riparian wetland (Utah)	*Salix wolfii, S. planifolia, Eleocharis pauciflora, Carex* spp.*
Western bottomland hardwood forest (Texas)	*Quercus lyrata, Carya aquatica*
Riparian forested wetland (New Mexico)	*Salix goodingii, S. exigua*

land. Significantly drained wetlands require assessment of the current hydrology.

A "primary indicator" is a single vegetation characteristic or soil property that can be reliably used to indicate the presence of wetland. It is a feature unique to wetlands. Since each primary indicator is decision-oriented, it does not have to be used in combination with other indicators. A potential list of primary wetland indicators for the U.S. is presented in Table 2. The list includes both vegetation and soil indicators that can be used to verify the presence of wetland in the absence of significant signs of drainage or similar hydrologic change. It may be expanded to include regional indicators that may serve to identify certain regional wetland types that may not possess any of the suggested indicators in a particular region; recommended additions should be sent to the author with supportive documentation. Steps for using PRIMET are outlined in Table 3. A sample field form is presented as Appendix 1. Examples of major U.S. wetlands with their primary indicators are given in Table 4.

Vegetation Indicators of Wetlands

Obligate wetland (OBL) species and facultative wetland (FACW) species are the most reliable vegetation indicators of wetland, and many wetlands are characterized by these species (Tiner 1988, 1991a). Since OBL species almost always occur in wetlands, their presence in an area typically signifies the presence of wetland. FACW species are less reliable indicators, although they occur more often in wetlands than in nonwetlands. A plant community dominated by OBL or OBL *and* FACW species should always be a wetland, provided the area's hydrology has not been significantly diminished by human impact or other forces. Many wetlands are dominated by FAC species and fewer by facultative upland (FACU) species.[2] In some of these communities, OBL species are present in lesser, but still significant numbers (i.e., 10 percent or more areal cover) to indicate wetland (Table 1). Facultative-type species may possess certain morphological characteristics that developed in response to wetland hydrology, which can be used to identify hydrophytic individuals (Tiner 1991a). The vegetation indicators presented in Table 2 represent diagnostic wetland plant communities and/or wetland plants with exceptional morphological expressions of wetland hydrology.

Soil Indicators of Wetland

Where primary vegetation indicators of wetlands are lacking, soil indicators must be relied upon to separate wetland from nonwetland. Organic soils (excluding Folists) designate wetlands, provided the area is not effectively drained. Many, if not most, organic soils support wetland plant communities with at least some OBL species present. Hydric mineral soils, however, support more varied communities, many of which do not have any OBL species present. Certain taxonomic groupings of mineral soils reflect hydric soils. The 1991 list of U.S. hydric soils includes soils in many subgroups (e.g., Cumulic, Fluvaquentic, Histic, Humic, Mollic, Pachic, Typic, Umbric, and Vertic) of Aquic suborders (U.S.D.A. Soil Conservation Service 1991). These soils when classified in the field according to "Soil Taxonomy" (Soil Survey Staff 1975, 1990) should indicate wetlands in their undrained condition since most are poorly and very poorly drained mineral soils. More importantly, however, near-surface properties of these soils that reflect a seasonal high water table at a given site may be used to identify many wetlands and delin-

[2] FACU species have a frequency of occurrence in wetlands between 1–33% of the time (Reed 1988).

Table 2. Recommended list of primary indicators of wetlands. The presence of any of these characteristics in an area that has not been significantly drained typically indicates wetland. The upper limit of wetland is determined by the point at which none of these indicators are observed. (*Note:* Exceptions may occur as they do with any method and will be specified in the future as detected. Primary indicators for hydric prairie soils are based on field-tested recommendations by Dr. Jim L. Richardson, North Dakota State University.)

Vegetation Indicators of Wetland

V1. OBL species comprise more than 50 percent of the abundant species of the plant community. (*An abundant species is a plant species with 20 percent or more areal cover in the plant community.*)
V2. OBL *and* FACW species comprise more than 50 percent of the abundant species of the plant community.
V3. OBL perennial species collectively represent at least 10 percent areal cover in the plant community and are evenly distributed throughout the community and not restricted to depressional microsites.
V4. One abundant plant species in the community has one or more of the following morphological adaptations: pneumatophores (knees), prop roots, hypertrophied lenticels, buttressed stems or trunks, and floating leaves. (*Note:* Some of these features may be of limited value in tropical U.S., e.g., Hawaii.)
V5. Surface encrustations of algae, usually blue-green algae, are materially present. (*Note:* This is a particularly useful indicator of drier wetlands in arid and semiarid regions.)
V6. The presence of significant patches of peat mosses (*Sphagnum* spp.) along the Gulf and Atlantic Coastal Plain. (*Note:* This may be useful elsewhere in the temperate zone.)
V7. The presence of a dominant groundcover of peat mosses (*Sphagnum* spp.) in boreal and subarctic regions.

Soil Indicators of Wetland

S1. Organic soils (except Folists) present.
S2. Histic epipedon (e.g., organic surface layer 8–16 inches thick) present.
S3. Sulfidic material (H_2S, odor of "rotten eggs") present within 12 inches of the soil surface.
S4. Gleyed* (low chroma) horizon or dominant ped faces (chroma 2 or less with mottles *or* chroma 1 or less with or without mottles) present immediately (within 1 inch) below the surface layer (A- or E-horizon) *and* within 18 inches of the soil surface.
S5. Nonsandy soils with a low chroma matrix (chroma of 2 or less) within 18 inches of the soil surface *and* one of the following present within 12 inches of the surface:
  a. iron and manganese concretions or nodules; or
  b. distinct or prominent oxidized rhizospheres along several living roots; or
  c. low chroma mottles.
S6. Sandy soils with one of the following present:
  a. thin surface layer (1 inch or greater) of peat or muck where a leaf litter surface mat is present; or
  b. surface layer of peat or muck of any thickness where a leaf litter surface mat is absent; or
  c. a surface layer (A-horizon) having a low chroma matrix (chroma 1 or less and value of 3 or less) greater than 4 inches thick; or
  d. vertical organic streaking or blotchiness within 12 inches of the surface; or
  e. easily recognized (distinct or prominent) high chroma mottles occupy at least 2 percent of the low chroma subsoil matrix within 12 inches of the surface; or
  f. organic concretions within 12 inches of the surface; or
  g. easily recognized (distinct or prominent) oxidized rhizospheres along living roots within 12 inches of the surface; or
  h. a cemented layer (orstein) within 18 inches of the soil surface.
S7. Native prairie soils with a low chroma matrix (chroma of 2 or less) within 18 inches of the soil surface *and* one of the following present:
  a. thin surface layer (at least ¼ inch thick) of peat or muck; or
  b. accumulation of iron (high chroma mottles, especially oxidized rhizospheres) within 12 inches of the surface; or
  c. iron and manganese concretions within the surface layer (A-horizon, mollic epipedon); or
  d. low chroma (gray-colored) matrix or mottles present immediately below the surface layer (A-horizon, mollic epipedon) and the crushed color is chroma 2 or less.

  Note: The native prairie region extends northward from Texas to the Dakotas and adjacent Canada.
S8. Remains of aquatic invertebrates are present within 12 inches of the soil surface in nontidal pothole-like depressions.
S9. Other regionally applicable, field-verifiable soil properties associated with prolonged seasonal high water tables.

* Gleyed colors are low chroma colors (chroma of 2 or less in aggregated soils and chroma 1 or less in soils not aggregated; plus hues bluer than 10Y) formed by excessive soil wetness; other non-gleyed low chroma soils may occur due to (1) dark-colored materials (e.g., granite and phyllites), (2) human introduction of organic materials (e.g., manure) to improve soil fertility, (3) podzolization (natural soil leaching process in acid woodlands where a light-colored, often grayish, E-horizon or eluvial-horizon develops below the A-horizon; these uniform light gray colors are not due to wetness).

Table 3. Steps for using the Primary Indicators Method.

Step 1.	Walk project site and identify different plant communities that are not significantly drained for evaluation (*—see footnote for significantly drained sites). When identifying a plant community, consider both overstory and understory species and landscape position. Go to Step 2.
Step 2.	In each homogeneous plant community, determine visually whether any primary vegetation indicators of wetland are present. If necessary, representative sampling plots may be established. The following plot sizes are recommended: 30-foot radius circular plot for woody plants, and 5-foot radius circular plot for herbaceous plants. Expand plot size appropriately in high diversity communities. If any primary vegetation indicator is present, the area is wetland, then go to Step 4. If no such indicators are present, go to Step 3.
Step 3.	Examine soil properties by digging a 1-foot diameter hole up to 2-feet deep, as necessary, and look for primary soil indicators of wetland. If any are present, the area is wetland. If soil indicators are not present, then the area is not a wetland. Go to Step 4.
Step 4.	Repeat Steps 2 and 3 for each remaining plant community. When all communities have been identified as wetland or nonwetland, go to Step 5.
Step 5.	Delineate boundaries between wetland and nonwetland plant communities. The limits of wetland are established by the point where primary indicators are lacking. By identifying several points between these plant communities, a relationship will be established that correlates the wetland boundary with a specific elevation or contour. Use these points to identify a contour that delimits the wetland boundary, follow that contour between the two plant communities, and check periodically to ensure that relationship is still holding true.

* Significantly drained sites should be evaluated based on criteria established by the appropriate regulatory authority. The criteria may require installing and monitoring groundwater observation wells over a multi-year period and comparing with a hydrology standard for that particular wetland type in a specific region of the country. Alternatively, drainage models may be developed for specific wetland types in certain soils to determine whether the apparent drainage is sufficient to effectively eliminate wetland functions of concern to the regulatory agency.

eate their upper boundaries. The more wide-ranging soil indicators are listed in Table 2; other regional indicators will undoubtedly emerge from application of this method.

The actual series name of a soil is not really important for field delineation of wetlands, since many series listed in "Hydric Soils of the United States" (U.S.D.A. Soil Conservation Service 1991) are only hydric in certain landscape positions (usually depressional areas, toes of slopes, or low slopes). Many, but not all, of these series are marked by a footnote on this list. Based on observations in the Northeast, any series on the list classified as an Aeric subgroup should be footnoted (Tiner and Veneman 1987), but they have not been so noted, presumably because "dry phases" have not been officially designated for these series.

The actual (field-verified) soil properties that result from a prolonged seasonal high water table should be useful in establishing the presence of wetland. These properties, which include a gleyed matrix[3] or redoximorphic low chroma mottles (ped faces) immediately below the A-horizon (surface layer) in combination with a gleyed matrix within 18 inches of the soil surface, are features that reflect long-term wetness (Table 2).

[3] Gleyed soils typically have, immediately below the A-horizon (surface layer), a dominant low chroma matrix of chroma 2 or less in aggregated soils or chroma 1 or less in soils that are not aggregated; these colors are due to excessive wetness and accompanying reducing conditions; hues bluer than 10Y also indicate gleyed conditions in some soils (U.S.D.A. Soil Conservation Service 1962).

Wetland Boundary Delineation

Following PRIMET, the boundary of a designated wetland will be located at the point at which none of the primary indicators of wetland are found (see Steps in Table 3). In gently sloping areas, soil indicators will typically be the determining factor because the plant community is usually transitional (mix of FACW, FAC, and FACU species) and, therefore, inconclusive in defining the wetland-nonwetland boundary. This will lead to a wetland boundary consistent with one following the 1989 Federal interagency manual, since hydric soil properties were used to verify the wetland hydrology criterion and to delineate the upper limit of wetland in areas not subject to significant hydrologic modification (Federal Interagency Committee for Wetland Delineation 1989). Differences between wetland boundaries established by PRIMET versus the 1987 CE manual cannot be meaningfully assessed due to the varied interpretations possible with the latter manual. The vegetation indicators are usually best used for identifying the majority of wetlands in the country and not for delineating their upper boundaries, with some exceptions. In areas of abrupt topographic change (e.g., distinct depressions), vegetation indicators may be the feature used to establish the wetland boundary. The boundary of paludified bogs in boreal and subarctic regions may be determined by the limits of the groundcover of certain peat mosses (*Sphagnum* spp.). Also, the upper limits of salt marshes on sandy soils may be represented by the limits of halophytic OBL species. The difficult wetland delineations, e.g., the edges of

Table 4. Examples of primary indicators that will typically be used to identify various wetland types in the United States. Where both vegetation and soil indicators are listed, the former will probably be the one used to identify the wetland. Soil indicators will be most useful for more difficult-to-identify wetlands and for boundary determinations in wetlands along low topographic gradients. In this table, vegetation indicators are preceded by the letter "V", while "S" designates soil indicators; refer to Table 2 for definitions of indicators.

Wetland Type	Most Likely Primary Indicator(s) to be Used
Tidal salt marsh	V1, V2, S1, S3
Tidal salt barren (irregularly flooded)	V3, V5
Mangrove swamp	V1, V2, V4, S1, S3
Inland shallow and deep marshes	V1, S1, S2, S3
Wet meadow (lower zone)	V1, V2, V3, S4
Wet meadow (upper zone)	S4, S7, S9
Northern fen	V1, V2, S1, S2, S3, S7
Alkaline flat (sparsely vegetated)	V6, S9
Prairie pothole (during average rainfall year)	V1, V2, S1, S2, S3, S4, S5, S7, S8, S9
Prairie pothole (after extended drought)	S7, S8, S9
Florida Everglades	V1, V2, V6
Red maple swamp (seasonally flooded)	V1, V2, V3, S1, S2, S4
Red maple swamp (temporarily flooded)	S4, S5
Seasonally flooded forested wetland (including bottomland hardwood swamp)	V1, V2, V3, V4, S4, S9
Temporarily flooded forested wetland	V5, V6, S4, S5, S6, S9
Ericaceous shrub bog	V1, V2, S1, S2
Paludified bog	V1, V2, V7, S1, S2
Pocosin	V1, V2, S1, S2, S4
Pitch pine lowland	V3, V6, S6, S9
Pine flatwoods	V6, S4, S6, S9
Atlantic white cedar swamp	V1, V2, S1, S2
Hemlock swamp	V6, S1, S2, S6, S9
Black spruce bog	V2, V3, V6, S1, S2
Larch swamp	V2, V3, V6, S1, S2, S4
Buttonbush swamp	V1
Cottonwood-willow sandbar thicket	V2, V3
Cypress swamp	V1, V2, V4
Cottonwood riparian forest	V3, S9

drier wetlands, however, will undoubtedly require the use of soil indicators, since they provide evidence of seasonally saturated conditions and better reflect the long-term hydrology of a site than vegetation.

When making wetland determinations in arid and semiarid regions during droughts, soil properties are often the key to accurate wetland identification and delineation. Since the vegetation responds more quickly to short-term changes in hydrology, the existing plant community may not adequately express site wetness based on the long-term hydrology. Consequently, PRIMET greatly simplifies the wetland delineation process as compared to the three-criteria approach by emphasizing only features that are highly reliable indicators of wetland in their own right. Since it can be used during droughts as well as wet years and is based on characteristics of wetland types that vary regionally, PRIMET has universal application across the U.S. and does not need a lengthy list of exceptions.

A wetland determination made by PRIMET intentionally does not require observations of water or indirect evidence of water-carried debris, water-stained leaves, or other similar signs of hydrology. These signs, although worth noting, indicate that an event is happening or has happened, but most reveal little about the duration and frequency of the event—which are vital to separating wetlands from nonwetlands in a strictly hydrologic sense. These signs may at times be observed in nonwetlands. For example, the 100-year floodplain includes areas that are flooded for short periods, on average, once in 100 years—clearly nonwetland areas.

After the limits of wetlands are identified based on technical considerations, decision-makers can formulate and implement policies to regulate or protect wetlands to varying degrees in accordance with wetland values and legal mandates. This is where wetland functions play a decisive role in determining the appropriate administrative response to proposed alterations.

Disturbed Areas

The only widespread disturbance that must be considered to make a wetland determination is drainage or similar hydrologic alteration that makes an area drier. If vegetation has been removed (e.g., by harvest, grazing, or fire) and the hydrology of an area has not been diminished, the soil indicators remain valid wetland indicators. If both vegetation and soils are removed, the area's hydrology should be considered significantly altered and should warrant further assessment. Areas of extensive ditching and tile drainage should be similarly treated.

In the context of existing regulatory programs, significantly drained sites, such as farmland or certain managed forests, or other areas where river flows are controlled, may need to be evaluated to determine whether the area is still wet enough to function as wetland. Hydrology and functions generally vary for each wetland type, so the requirements for assessing hydrology in disturbed sites should vary with the type of wetland affected. For example, hydrologically altered tidal wetlands may be assessed by considering whether the area is still periodically flooded by the tides in most years. For a hydrologically altered floodplain wetland in the eastern U.S., the hydrology requirement may be flooding for three days to one week during the year in most years (i.e., more than 50 years out of 100 years). For a similar wetland in the arid or semiarid regions of the U.S., flooding for three days to one week during the wet phase of the natural hydrologic cycle or in typical wet years may be sufficient to still consider the area as wetland. In disturbed wetlands dependent on ground-water conditions (e.g., wet meadows, wetlands in interstream divides, wet tundra, and many depressional wetlands), saturation near the surface (within the majority of the root zone, usually within 12 inches [30 cm] of the surface) for one to two months or more during the year (when the upper part of the soil is not frozen) in most years, may be a useful measure. Procedures for assessing current wetlands and making wetland determinations for hydrologically altered wetlands must be based on current knowledge of wetland types in each region. More scientific study must be given to this topic. In the meantime, regulatory agencies should establish workable standards for determining when a "wetland" has been effectively drained. Such standards should reflect differences among wetland types and account for variations in soil types and regional climates.

SUMMARY

PRIMET is a practical alternative to existing methods for delineating U.S. wetlands. It is based on the premise that every wetland in its natural undrained condition possesses at least one unique and distinctive feature that distinguishes it from the adjacent upland. PRIMET relies on the use of unique vegetation and soil characteristics for wetland identification and delineation. The method is efficient in that it does not require detailed descriptions of plant community composition or taxonomic classification of the soil. PRIMET is not intended to diminish the need for phytosociological studies of wetlands or detailed descriptions of hydric soils, but simply seeks to produce accurate, consistent, and reproducible wetland delineations with minimal effort. Although designed for use in the U.S., it should also be applicable elsewhere in North America, and the concept should be adaptable worldwide.

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Appendix 1. Field form for PRIMET.

PRIMARY INDICATORS METHOD—FIELD DATA FORM

Investigator: ______________________ (Name) ______________________ (Affiliation) Date: ______________________

Project: ______________________ Location: ______________________ (City/Town) ______________________ (County) ______________________ (State)

Plant Community Type: ______________________ Wetland Type: ______________________ (according to FWS Classification System)

PRIMARY INDICATOR OBSERVED (Circle and describe below):

Vegetative Indicators of Wetland

V1. OBL species comprise more than 50 percent of the abundant species of the plant community. **(An abundant species is a plant species with 20 percent or more areal cover in the plant community.)**
List OBL species: ______________________

V2. OBL *and* FACW species comprise more than 50 percent of the abundant species of the plant community.
List OBL and FACW species: ______________________

V3. OBL perennial species collectively represent at least 10 percent areal cover in the plant community and are evenly distributed throughout the community and not restricted to depressional microsites.
List OBL species and indicate estimated cover: ______________________

V4. One of the abundant plant species in the community has one or more of the following morphological adaptations: pneumatophores (knees), prop roots, hypertrophied lenticels, buttressed stems or trunks, and floating leaves. (*Note*: Some of these features may be of limited value in tropical U.S., e.g., Hawaii.) Specify: ______________________

V5. Surface encrustations of algae, usually blue-green algae, are materially present. (*Note*: This is a particularly useful indicator of drier wetlands in arid and semiarid regions.)

V6. The presence of significant patches of peat mosses (*Sphagnum* spp.) along the Gulf and Atlantic Coastal Plain. (*Note*: This may be useful elsewhere in the temperate zone.)

V7. The presence of a dominant groundcover of peat mosses (*Sphagnum* spp.) in boreal and subarctic regions.

List abundant plants (specify estimated areal cover and indicator status of each in parentheses): ______________________
____
____
____

Other comments of vegetation indicators: ______________________
____
____
____

Soil Indicators of Wetland

S1. Organic soils (except Folists) present. Type of Organic: ______________________ Thickness: ______________________

S2. Histic epipedon (e.g., organic surface layer 8 to 16 inches thick) present. Type of Organic: ______________________
Thickness: ____________

S3. Sulfidic material (odor of "rotten eggs") present within 12 inches of the soil surface.

S4. Gleyed* horizon or dominant low chroma ped faces (chroma 2 or less with mottles or chroma 1 or less with or without mottles) present immediately (within 1 inch) below the surface layer (A- or E-horizon) *and* within 18 inches of the surface.
(matrix color: ____________ thickness of horizon: ____________ mottle color: ____________)

S5. Nonsandy soils with a low chroma matrix (chroma of 2 or less) within 18 inches of the soil surface *and* one of the following present within 12 inches of the surface:
a. iron and manganese concretions or nodules;
b. easily recognized (distinct or prominent) oxidized rhizospheres along several living roots;
c. low chroma mottles.
(matrix color: ____________ depth to low chroma matrix: ____________ mottle color: ____________)

S6. Sandy soils with one of the following present:
a. thin surface layer (1 inch or greater) of peat or muck where a leaf litter surface mat is present (thickness:____________);
b. surface layer of peat or muck of any thickness where a leaf litter surface mat is absent (thickness: ____________)
c. surface layer (A-horizon) having a matrix chroma of 1 or less and value of 3 or less, and greater than 4 inches thick (matrix color: ____________ mottle color: ____________);
d. vertical organic streaking or blotchiness within 12 inches of the surface;
e. easily recognized (distinct or prominent) high chroma mottles occupy at least 2 percent of the low chroma subsoil matrix within 12 inches of the surface (matrix color: ____________ mottle color: ____________);
f. organic concretions within 12 inches of the surface;
g. easily recognized (distinct or prominent) oxidized rhizoshperes along several living roots within 12 inches of the surface;
h. cemented layer within 18 inches of the soil surface.

S7. Native prairie soils with a low chroma matrix (chroma of 2 or less) within 18 inches of the soil surface *and* one of the following present:
a. thin layer (at least 1/4 inch thick) of peat or muck;
b. accumulation of iron (high chroma mottles, especially oxidized rhizospheres) within 12 inches of the surface;
c. iron and manganese concretions within the surface layer (A-horizon; mollic epipedon).
d. low chroma (gray-colored) matrix or mottles present immediately below the surface layer (A-horizon; mollic epipedon) and the crushed color is chroma 2 or less. (matrix color: ____________ mottle color, if present: ____________)
(*Note*: The native prairie region extends northward from Texas to the Dakotas and adjacent Canada.)

S8. Remains of aquatic invertebrates are present within 12 inches of the soil surface in nontidal pothole-like depressions.
Explain: ____
____

S9. Other regionally applicable, field-verifiable soil properties associated with prolonged seasonal high water tables.
Specify: ____
____

Other comments on soils indicators: ____
____

Additional Observations at Site

Direct and Indirect Signs of Water

__________ Surface water present (depth: __________)
__________ Free water in soil pit (depth: __________)
__________ Saturated soil (depth: __________)
__________ Oxidized rhizospheres (depth: __________)
__________ Water-stained leaves
__________ Sediment deposits
__________ Water marks (specify height: __________)
__________ Drift lines
__________ Scoured/bare areas
__________ Drainage patterns (describe: ____________________)
__________ Buttressed trunks (specify species: ____________________)
__________ Shallow root systems (specify species: ____________________)
__________ Other signs (describe: ____________________)

Wetland Wildlife Signs

__________ Crayfish chimneys
__________ Crab burrows
__________ Snails (specify: ____________________)
__________ Bivalves (specify: ____________________)
__________ Muskrat mounds
__________ Beaver lodges and dams
__________ Other (specify: ____________________)

* Gleyed colors are low chroma colors (typically chroma of 2 or less) formed by excessive soil wetness; other non-gleyed low chroma soils may occur due to (1) dark-colored materials (e.g., granite and phyllites), (2) human introduction of organic materials (e.g., manure) to improve soil fertility, (3) podzolization (natural soil leaching process in acid woodlands where a light-colored, often grayish, E-horizon or eluvial-horizon develops below the A-horizon; these uniform light gray colors are not due to wetness).