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REVIEW ARTICLE

Geographically Isolated Wetlands: Rethinking a Misnomer

David M. Mushet · Aram J. K. Calhoun · Laurie C. Alexander · Matthew J. Cohen · Edward S. DeKeyser · Laurie Fowler · Charles R. Lane · Megan W. Lang · Mark C. Rains · Susan C. Walls

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Abstract We explore the category "geographically isolated wetlands" (GIWs; i.e., wetlands completely surrounded by uplands at the local scale) as used in the wetland sciences. As currently used, the GIW category (1) hampers scientific efforts by obscuring important hydrological and ecological differences among multiple wetland functional types, (2) aggregates wetlands in a manner not reflective of regulatory and management information needs, (3) implies wetlands so described are in some way "isolated," an often incorrect implication, (4) is inconsistent with more broadly used and accepted concepts of "geographic isolation," and (5) has injected unnecessary confusion into scientific investigations and discussions. Instead, we suggest other wetland classification systems offer more informative alternatives. For example, hydrogeomorphic (HGM) classes based on well-established scientific definitions account for wetland functional diversity thereby facilitating explorations into questions of connectivity without an a priori designation of "isolation." Additionally, an HGM-type approach could be used in combination with terms reflective of current regulatory or policymaking needs. For those rare cases in which the condition of being surrounded by uplands is the relevant distinguishing characteristic, use of terminology that does not unnecessarily imply isolation (e.g., "upland embedded wetlands") would help alleviate much confusion caused by the "geographically isolated wetlands" misnomer.

Keywords Adjacency · Connectivity gradients · Hydrogeomorphic classification · HGM · Rapanos · SWANCC · Wetland classification · Wetland connectivity

Introduction

It has been over a decade since the state of scientific understanding of isolated wetlands was synthesized in a special

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D. M. Mushet (✉)
US Geological Survey, Northern Prairie Wildlife Research Center, 8711 37th Street SE, Jamestown, ND 58401, USA
e-mail: dmushet@usgs.gov

A. J. K. Calhoun
Department of Wildlife, Fisheries, and Conservation Biology, University of Maine, Orono, ME 04469, USA

L. C. Alexander
US Environmental Protection Agency, Office of Research and Development, 1200 Pennsylvania Ave NW (8623-P), Washington, DC 20460, USA

M. J. Cohen
School of Forest Resources and Conservation, University of Florida, Gainsville, FL 32611, USA

E. S. DeKeyser
School of Natural Resource Sciences, North Dakota State University, Fargo, ND 58108, USA

L. Fowler
School of Law, University of Georgia, Athens, GA 30602, USA

C. R. Lane
US Environmental Protection Agency, Office of Research and Development, Cincinnati, OH 45268, USA

M. W. Lang
Department of Geographical Sciences, University of Maryland, College Park, MD 20742, USA

M. C. Rains
School of Geosciences, University of South Florida, Tampa, FL 33620, USA

S. C. Walls
US Geological Survey, Southeast Ecological Science Center, 7920 NW 71st Street, Gainesville, FL 32653, USA

issue of *Wetlands* (Vol. 23, No. 3, September stal). This comprehensive review was catalyzed by a U.S. Supreme Court (2001) decision in the case of the *Solid Waste Agency of Northern Cook County v. U.S. Army Corps of Engineers,* 531 U.S. 159 (2001) (*SWANCC*). The Supreme Court's decision effectively removed Clean Water Act (CWA) protection of "isolated, intra-state, non-navigable waters" in cases where such protection was based solely on use by migratory birds (i.e., the Migratory Bird Rule). The decision also indicated that such waters could be protected under the CWA if there was a "significant nexus" with downgradient "navigable waters" (Downing et al. 2003). This decision brought the issue of wetland "isolation" to the forefront of discussion in the wetland science community (Nadeau and Leibowitz 2003).

A key theme emerging throughout the *Wetlands* special issue was that wetlands typically referred to as "isolated" were not, from either an ecological, hydrological, or physicochemical perspective, inherently isolated from other aquatic systems. In an effort to represent the manner of isolation more precisely, and by extension the ways in which they were clearly not isolated, Tiner (2003a) adopted the term "geographically isolated wetland," defined as a wetland that is completely surrounded by upland at the local scale (hereafter referred to as GIW). Leibowitz (2003) recommended that GIW be used as a replacement for "isolated wetland" in an effort to avoid the associated ambiguities inherent in the word "isolation." As defined by Tiner (2003a), GIWs consist of multiple wetland types including both natural and created wetlands formed in depressions (e.g., vernal pools, prairie potholes, playas, limesinks, and Carolina bays), on mineral and organic flats (e.g., fens and spruce-fir flats), along slopes (e.g., hillside seeps), within coastal dunes, on inactive river floodplains, and on active floodplains as depressional wetlands in well-drained riparian settings (Tiner 2003a). The common characteristic of GIWs is that they are surrounded by upland, not that they are isolated. In fact, Tiner (2003a, p #495) explicitly argued that many GIWs "are hydrologically connected to other wetlands and waters through subsurface or groundwater connections or by infrequent and/or short duration surface-water connections."

In addition to reducing confusion associated with the term "isolated wetlands," the original intent of the wetland science community in defining GIWs was to identify information gaps where additional research was needed to define better the functional role of these wetlands, particularly with regard to their effects on the chemical, physical, and biological integrity of "navigable waters" of interest to regulators and policymakers (Leibowitz and Nadeau 2003). Explorations into wetland function and effects on downgradient systems became increasingly important following a subsequent U.S. Supreme Court (2006) split decision in *Rapanos v. United States*, 547 U.S. 715 (2006) (*Rapanos*). In the split decision, Justice Kennedy stated that wetlands can be covered under the CWA "if the wetlands, alone or in combination with similarly situated lands in the region, significantly affect the chemical, physical, and biological integrity of other covered waters." However, it has become increasingly clear that while the original intent was well-founded, referring to wetlands as "geographically isolated" has done little to alleviate the implications of functional isolation that accompany the GIW terminology, as we present from an analysis of the recent literature in a later section. In fact, we posit that the GIW term and its associated categorization of wetlands served to obscure rather than clarify understanding of the complex relationships among interconnected aquatic ecosystems. We suggest that classification systems that account for functional differences among diverse wetland types (e.g., the Hydrogeomorphic [HGM] approach [Brinson 1993]) offer less ambiguous and more scientifically defensible alternatives that are less prone to misunderstanding. For the rare cases in which being surrounded by uplands is the relevant distinguishing characteristic, development of terminology that does not unnecessarily imply isolation (e.g., "upland embedded wetlands") would help alleviate much of the confusion caused by the "geographically isolated wetlands" misnomer.

"Geographic isolation" Does Not Acknowledge Connectivity Continua

Connectivity, and therefore isolation, refers to the degree to which entities are joined in a relationship. From a hydrological perspective, connectivity may be viewed as the degree to which water moves between uplands, wetlands, and downgradient waters (e.g., Lissey 1971; Winter and Rosenberry 1995; Wilcox et al. 2011). These movements can be readily observable surface-water flows (i.e., those that are persistent) or more subtle surface-water flows that occur at low frequencies, magnitudes, or durations such that no readily observable indicators are formed (e.g., a stream channel or delineable connection of wetland vegetation and soil). Crucially, water movement can also be along flow-paths that are difficult to observe, such as shallow sub-surface or groundwater flows. From a biogeochemical perspective, connectivity may be viewed as the degree to which chemical integrity of a stream, river, wetland, or other aquatic system of interest are influenced by surface water, groundwater, atmospheric, and biotic processes and functions within and among aquatic systems (e.g., LaBaugh et al. 1987; Goldhaber et al. 2011; Forbes et al. 2012). From an ecologic perspective, connectivity may describe how distance and landscape characteristics within and between aquatic habitats interact with species' dispersal and life history traits to affect movement, gene flow, or population dynamics (e.g., Newman and Squire 2001; Mushet et al. 2013; O'Connell et al. 2013). From a geographic perspective, connectivity may refer to the distance between wetlands, the presence of an impassable geographic barrier, or the geospatial arrangement of aquatic systems on the landscape (e.g., MacArthur and Wilson 1967; Wilcox 1989; Forman 1995). From each perspective, connectivity, and therefore isolation, occurs along a continuum rather than as a binary condition.

The conceptual placement of wetlands along continua of hydrological and biological connectivity has a long legacy. Leibowitz (2003) described gradients as an "isolation-connectivity continuum," and Euliss et al. (2004) described a conceptual framework they called "The Wetland Continuum." In combination, these concepts clarify the varying roles of wetlands within complex natural systems. However, the GIW definition is binary (i.e., either 100 % surrounded by upland or not (Tiner 2003a)) and, thus, implicitly ignores isolation-connectivity continua. This overly simplistic definition of geographic isolation does not take into consideration proximity to other aquatic systems, key ecosystem processes, landscape permeability and leakiness, dispersal abilities of biota, or other factors that contribute to varying degrees of connectivity and isolation. By using a binary definition of geographic isolation, it can be easily misconstrued that GIWs represent one extreme of an isolation-connectivity continuum. Indeed, GIWs span a range of hydrologic positions from precipitation-fed wetlands with little surface-water or groundwater inflow or outflow (e.g., ombrotrophic bogs) to wetlands on floodplains that regularly exchange water with an adjacent river or stream (Leibowitz et al. 2008), to seepage wetlands almost entirely dependent on groundwater flow (Tufford 2011).

"Geographic isolation" Does Not Equal Functional Isolation

Geographically "isolated" wetlands are rarely functionally isolated and, as such, are capable of providing most, if not all, of the functions ordinarily attributed to wetlands, such as water storage, nutrient retention/transformation, and living matter growth (Novitski et al. 1996). The biotic and abiotic processes that underlie these functions accumulate in the landscape because what happens in one wetland typically affects or is affected by processes occurring in other aquatic habitats (e.g., Leibowitz 2003; Euliss et al. 2004; Leibowitz et al. 2008; Smith et al. 2011; Golden et al. 2014). In fact, Leibowitz's (2003) seminal paper recommending GIW usage includes a section entitled "Are 'isolated' wetlands isolated?" wherein numerous examples of functional connectivity between GIWs and both aquatic and terrestrial habitats are provided. More recently, and in a similarly-titled paper ("Are isolated wetlands isolated?"), Smith et al. (2011) expanded on these arguments and offered examples of how "isolated" wetlands are functionally interconnected not only to other aquatic systems but also to society through the ecosystem services they provide. Tiner (2003a, p #494) stated "most, if not all, wetlands scientists would agree that there is no such thing as an isolated wetland from an ecological standpoint." In an analysis of the recent literature on geographic isolation, we adopt perspectives from hydrology, biology, biogeochemistry, and geography to underscore the caveat that "geographic isolation" in the GIW term was not, and should not be, equated with functional isolation. However, despite the great lengths to which Leibowitz (2003), Tiner (2003a) and others have gone to clarify that geographic isolation does not equate to functional isolation, this linkage often occurs within the wetland sciences (see examples discussed below).

"Geographic isolation" Facilitates Incorrect Generalizations

Referring to wetlands as "geographically isolated" despite the fact that GIWs are not categorically "isolated" based on hydrology, geochemistry, ecology, or even geography facilitates incorrect generalizations across the wetlands so grouped. Given that the criterion for designating a wetland as geographically isolated is simply that it is surrounded by upland (Tiner 2003a), wetlands in this binary grouping span the entire gamut of functional classes identified by Brinson (1993), with the possible exception of tidal fringe wetlands (Table 1). Even some riverine wetlands (sensu Brinson 1993) that directly exchange water with stream systems can be classed as GIWs if the area separating a riverine wetland from a stream or river channel does not meet the regulatory definition of wetland as used in U.S. Army Corps of Engineers (1987) methodology. Thus, knowing that a wetland is "geographically isolated"

Table 1 Major classes of wetlands in two hydrogeomorphic classification systems, Brinson (1993, as modified by Smith et al. 1995) and Semeniuk and Semeniuk (1995)

Hydrogeomorphic Classes	
Brinson (1993), Smith et al. (1995)	Semeniuk and Semeniuk (1995)
Depressional	Lake
Lacustrine fringe	Sumpland
Tidal fringe	Dampland
Slope	Playa
Riverine	River
Mineral soil flat	Creek
Organic soil flat	Wadi
	Trough
	Floodplain
	Barlkara
	Palusplain
	Paluslope
	Palusmont

imparts little implicit knowledge relative to the functioning of a wetland and its potential influence on other aquatic systems, thereby hampering efforts to perform unbiased explorations of connectivity among these systems. Even the generalization that GIWs are surrounded by uplands has been questioned as field surveys (e.g., Leibowitz and Vining 2003; Wilcox et al. 2011) and new, high resolution, remote sensing techniques (e.g., LiDAR; Lang et al. 2012) reveal surface connections among wetlands previously considered to be "geographically isolated" (Fig. 1).

"Geographically isolated wetlands" in Literature

Geographic isolation as an ecological concept has been widely used in the scientific literature. To explore how the concept of geographical isolation is most commonly used, we searched the Web of Science™ (WoS) using the search terms "geographic isolation" *OR* "geographically isolated." This search identified 1961 papers in which one or both of these terms appeared in the title, keywords, or abstract (Table 2). The top 10 journals in which these papers were published (*Molecular Ecology, Evolution, PLOS ONE, Molecular Phylogenetics and Evolution, Conservation Genetics, Proceedings of the National Academy of Sciences, Journal of Biogeography, Plant Systematics and Evolution, Biological Journal of the Linnean Society*, and *Heredity*) reflect this term's well-established use in ecology, population genetics, and evolutionary biology (i.e., prevention of gene exchange between populations by geographic barriers or distance [Mayr 1969]). Not surprisingly, of the 1961 papers found in our search 1206 also contained the term "genetic" or "evolution," reflecting the broad use of "geographic isolation" in the population genetics and evolutionary biology fields. By contrast, a similar WoS search using the terms "geographically isolated wetland" *OR* "geographically isolated wetlands" returned only 23 results. A less restrictive search that allowed the term "wetland" to appear separately from terms related to geographic isolation returned an additional 20 papers. Of these, only two used "geographic isolation" as defined by Tiner (2003a), 15 used the term in relation to demographic or genetic effects, and three were ambiguous (Table 2). Thus, use of "geographic isolation" as currently applied to wetlands in the scientific literature is largely inconsistent with its use in other areas of scientific research.

As noted above, one of the primary goals in promoting use of the GIW term in 2003 was to replace the ambiguous "isolated wetlands" term with one that did not connote functional (e.g., hydrologic or biotic) "isolation." To explore trends in the use of the term "isolated wetlands," we asked the question, "Has introduction of the GIW term been successful at curbing the use of "isolated wetlands?" To answer this question, we performed a WoS search using the search criteria ("isolated wetland" *OR* "isolated wetlands") *NOT* "geographically isolated" (Table 2). Whereas in our original search we identified 23 papers that used the GIW term, our search for "isolated wetland(s)" identified 205, with most papers being published after the GIW term was proposed in 2003 as a replacement for "isolated wetlands" (Fig. 2). Even more revealing, of the 147 papers in WoS citing at least one of four seminal papers on GIWs (i.e., Leibowitz 2003; Tiner 2003a; Tiner 2003b; Winter and LaBaugh 2003), 65 (44 %) used the term "isolated wetland" in the title, keywords, or abstract, while only 21 (14 %) used the term "geographically isolated wetland" (Table 2).

In short, introduction of the GIW term has apparently done little to curb use of the potentially misleading term "isolated wetlands" in the wetland sciences (Fig. 2). Additionally, we found that the terms "geographic isolation" and "isolation" in the broader sense are commonly used interchangeably in the wetland sciences. As an example, in a comprehensive review of hydrological methods to model the influence of GIWs on downstream waters, Golden et al. (2014, p #190) stated, "GIWs are traditionally considered 'isolated' because they often exhibit unmeasurable or limited hydrologic connectivity to surface waters: therefore, any wetland systems with these characteristics can be considered 'isolated.'" Similarly, in a study to remotely map potential GIWs in a 2600 km^2 area of central Florida, Frohn et al. (2009, p #931-932) stated, "Tiner … maintains that geographic isolation is the easiest way to determine isolation, because it defines the position of the

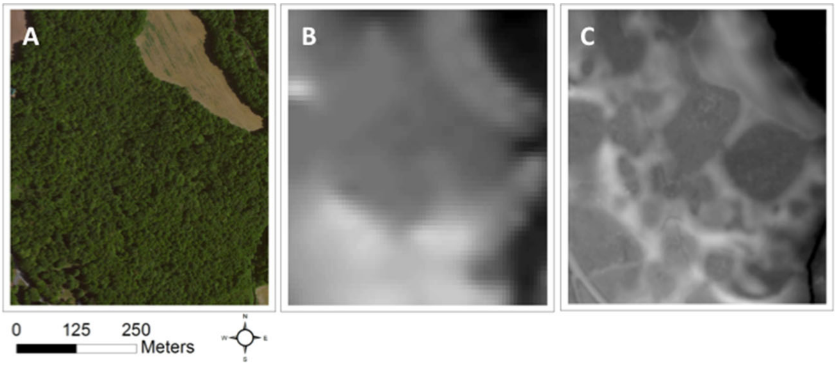

Fig. 1 Delmarva Bay wetlands are difficult to detect using (**a**.) aerial photography, or (**b**.) NED derived from USGS topo quads. However, (**c**.) Delmarva Bay wetlands and connections amongst Delmarva Bays and streams can be detected with LiDAR. Note the swales that connect one wetland to another and ditches connecting wetlands to streams

Table 2 Results of literature search on terms related to “geographic isolation” sensu Tiner (2003a) and sensu Mayr (1969). All search results were obtained from the *Web of Science*^{TM} *Core Collection* on the dates shown in the footnotes

1. How often does geographic isolation occur in titles, abstracts, or keywords?[1]	
• Search terms: (“geographic isolation” or “geographically isolated”)	961
• Number also containing (genetic* or evolution*)	111206 (61 %)
2. How many publications contain the term “geographically isolated wetland” (GIW) or “isolated wetland” (IW) in the title, abstract, or keywords?[2]	
• GIW search: (“geographically isolated wetland” *OR* “geographically isolated wetlands”)	23 (11 %)
• IW search: (“isolated wetland” *OR* “isolated wetlands”) *NOT* “geographically isolated”)	205 (89 %)
3. How many publications did we miss by placing quotes around the term GIW?[3]	
• Search: (wetland*) *AND* (“geographically isolated” *OR* “geographic isolation”) *NOT* (“geographically isolated wetlands” *OR* “geographically isolated wetland”)	
• GIW sensu Tiner 2003	2 (10 %)
• Demographic or genetic effects of geographic isolation	15 (75 %)
• Ambiguous	3 (15 %)
4. How many of the 147 papers that cite four seminal papers about GIWs and are in WoS contain the term GIW or IW in the title, abstract, or keywords?[4]	
• Number containing GIW	21 (14 %)
• Number containing IW	65 (44 %)
5. If we broaden the search, how are concepts of geographic isolation most commonly used in the wetlands literature?[5]	
• Search: (geographic* *AND* isolat* *AND* wetland*) *NOT* (“geographically isolated wetlands” *OR* “geographically isolated wetland”)	
• GIW (e.g., “wetlands termed ‘geographically isolated’ ”)	4 (5 %)
• Demographic or genetic effects of geographic isolation	75 (95 %)

[1] Search date: 11 May 2014. Results: 1961 records WoS

[2] Search date: 21 April 2014. Results: 23 records (GIW) and 205 records (IW)

[3] Search date: 10 May 2014. Results: 20 records. 2 refer to “GIW” sensu Tiner 2003, 15 refer to demographic or genetic effects of geographic isolation, 3 are ambiguous

[4] Search date: 08 May 2014. Results: 147 records. Publications that cite Tiner 2003a, 2003b; Leibowitz 2003, or Winter and LaBaugh 2003 and are in WoS

[5] Search date: 08 May 2014. Results: 79 records, excluding 26 records not relevant to topic (e.g., GIS in “isolated wetlands”, bacterial or genetic isolates, wetlands as dispersal corridors for non-wetland species)

wetland on the landscape, and defines an isolated wetland as a wetland that is completely surrounded by uplands.” Our use of these two examples is in no way a reflection of the quality of the science these authors presented or their knowledge of GIW concepts and issues. Rather, we use these two examples to illustrate how easily the GIW term can be misconstrued to imply “isolation” in general and, rather than serving to replace “isolated wetlands” in the scientific literature as recommended by Leibowitz (2003), the GIW term has facilitated its continued use.

“Geographically isolated wetlands” in Practice

One of the key arguments used by Leibowitz (2003) in recommending use of the GIW category was its simplicity and ease of use. To explore how the GIW grouping has been used in practice, we examined four papers on mapping GIWs recently published in *Wetlands,* Frohn et al. (2009), Frohn et al. (2012), Lane et al. (2012), and Martin et al. (2012). Each followed the Tiner (2003a) definition of geographical

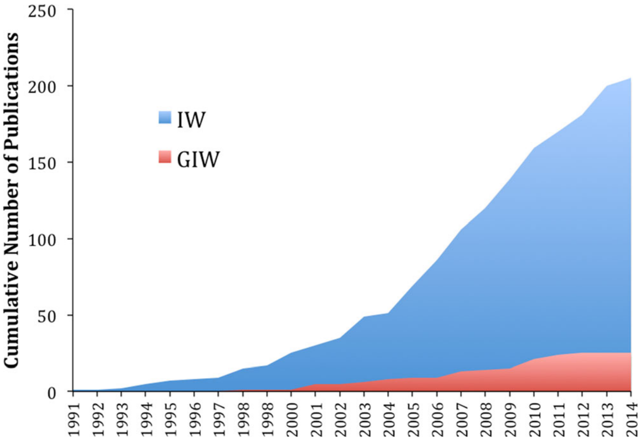

Fig. 2 Cumulative total number of publications using the term “isolated wetland(s)” or “geographically isolated wetland(s)”. Search results were obtained from the *Web of Science*^{TM} *Core Collection* on 21 April 2014

isolation (i.e., the condition of being completely surrounded by uplands at the local scale). However, all four found that currently available spatial data lacked adequate resolution and accuracy at the scale of the research question to adequately identify wetlands surrounded by uplands. As an alternative, an acceptable distance (i.e., buffer) between mapped wetlands and streams was used to identify wetlands that likely intersected or were proximate to streams and rivers. This buffering methodology was used instead of looking for wetlands that were surrounded on all sides by mapped uplands to mitigate the effect of map limitations on study findings (Lang et al. 2012). The methods developed in these papers are supportive of regulatory and policymaking information needs that often center on issues of proximity/adjacency (i.e., distances as reflected in the authors' use of buffers). These methods also are consistent with those used by Tiner (2003b), who used proximity to streams and rivers to exclude "non-isolated" wetlands when estimating GIW extent. However, they are not consistent with the GIW definition itself, which is not based on proximity to a stream or river but rather on upland embedment – a data layer unavailable at the scale crucial to many scientific investigations. Ironically, using distance buffers to quantify wetlands potentially losing CWA protection as a result of the *SWANCC* and *Rapanos* decisions likely provides better information than would have resulted from methodologies relying on "geographic isolation" because distance more directly relates to issues of adjacency than does the condition of being surrounded by uplands. Additionally, the need to map wetlands using distance based buffers around aquatic features rather than mapped uplands brings into question the "ease of use" argument presented by Leibowitz (2003) in promoting use of the GIW grouping.

Prairie Pothole Wetlands: A Case Study of Connectivity

We use the Prairie Pothole Region (PPR) of North America to illustrate the inadequacy of the current GIW catagory. The PPR is commonly characterized by its abundance of GIWs as most wetlands in the region are completely surrounded by uplands (Tiner 2003a). Yet, prairie pothole wetlands, which include hundreds of thousands of wetlands across a 700, 000 km^2 landscape (Fig. 3), are *not* hydrologically, geochemically, ecologically, or even geographically isolated from each other or from other aquatic systems. It has long been known that prairie pothole wetlands are hydrologically connected through local, intermediate, and regional groundwater flowpaths (Lissey 1971; Eisenlohr Jr et al. 1972; Sloan 1972). Solute concentrations in wetlands along these flow paths can differ markedly with wetlands that receive little or no groundwater input having extremely fresh water with low solute concentrations (LaBaugh et al. 1987). At the other end of hydrologically induced geochemical continua (Euliss et al. 2014) are wetlands that receive abundant groundwater discharge and can have solute concentrates exceeding those of the Earth's oceans (Hammer 1978).

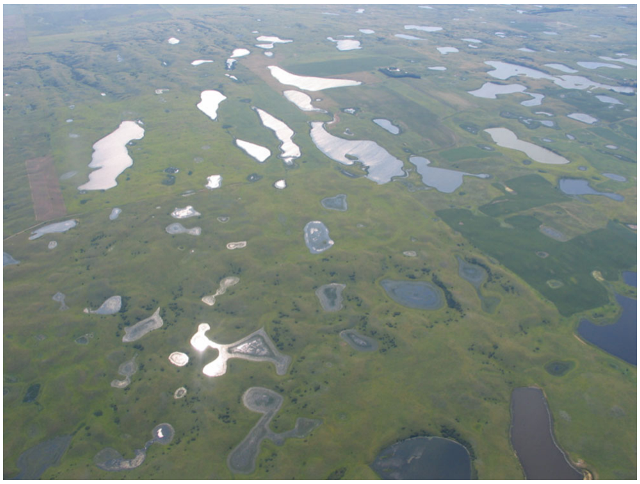

Fig. 3 Typical aerial view of "geographically isolated" wetlands embedded within the upland matrix of the Prairie Pothole Region landscape (Stutsman County, North Dakota)

The dynamic nature of prairie pothole wetlands in response to a climate that cycles between periods of drought and deluge (Winter and Rosenberry 1998) necessitates adaptations by wetland-dependent biota that facilitate repopulation of wetlands following periods when they may dry. For example, many wetland invertebrates have adult forms that fly; others disperse through temporary surface connections that can form when water levels are high or have eggs that are dispersed by mechanisms similar to those of wetland plant communities; still others disperse by clinging to the fur or feathers of animals (Swanson 1984). All of these dispersal mechanisms provide ecological connections among aquatic habitats across the PPR's landscape (Euliss et al. 1999). Uplands surrounding wetlands also can contribute to wetland connectivity by providing dispersal corridors, nesting habitat, and feeding areas (Gibbons 2003; Batt et al. 1989. Mushet et al. 2011). Thus, the upland habitat between wetlands can be the conduit by which discrete wetlands are "connected" rather than "isolated."

Geographic distances between prairie pothole wetlands range from neighboring wetlands that often merge during high water years (Leibowitz 2003) to those where distances may actually be great enough to form a barrier to connectivity when viewed from a specific functional perspective (e.g., gene flow; Newman and Squire 2001). Additionally, the geographic position of wetlands along topographic gradients influences connections of wetlands to groundwater (Winter and Carr 1980; Swanson et al. 1988) resulting in effects on water chemistry and biota (Euliss et al. 2004). Being surrounded by upland does not mean that these wetlands lack overland water connections. Leibowitz and Vining (2003) estimated that 28 % of the prairie pothole wetlands in their study region had temporary surface water connections to other wetlands during the year of their study (1995). Similarly, at the Cottonwood Lake Study Area in Stutsman County, North Dakota, ten of the 17 wetlands within this wetland complex regularly contributed water to overland flows (Swanson et al. 2003). Only by the most basic definition (i.e., one based solely on the binary condition of being surrounded by upland or not) are some prairie pothole wetlands "geographically isolated."

It is important to note here that the originators of the GIW terminology also highlighted the multiple connections of wetlands falling into the GIW grouping. However, given the frequency with which the terms GIW(s) and "isolated wetland(s)" have been used interchangeably in recent literature, our case study serves as a needed reminder of the interconnected nature of these geographically "isolated" wetlands. Additionally, we use prairie pothole wetlands as our case study because these wetlands are commonly used as a classic example of GIWs. However, GIWs throughout the United States are also better described along continua of connectivity. For example, "geographically isolated" vernal pools in the northeastern U.S. and along the Pacific Coast, mid-continental playa wetlands, sinkhole wetlands in karst topographies, desert spring wetlands, Delmarva and Carolina Bay wetlands on the Atlantic coastal plains, and cypress dome wetlands in Florida all vary in their hydrologic, biogeochemical, and ecological connections to other aquatic systems.

Alternatives

The importance of having wetland class terminology that is understood throughout the U.S., if not globally, is that it provides a common language that conveys important generalizations about systems to not only the scientific community, but also to regulators and policymakers (Scott and Jones 1995). One of the most commonly used wetland classifications is the Cowardin classification system (Cowardin et al. 1979). This system groups wetlands based on vegetation type, substrates, hydrology, and water chemistry. However, other properties that are important for assessing wetland function, such as landscape position, are not included (Tiner 2011). Alternatively, Brinson (1993) introduced a system (modified by Smith et al. 1995) that places wetlands into unique functional classes based mainly on hydrology and geomorphology (the HGM approach), and Semeniuk and Semeniuk (1995) proposed a HGM classification designed to be applied globally (Table 1). Although these authors used different terminology for their wetland classes, each emphasized the functional importance of hydrology and geomorphic position. Smith et al. (2011) suggested that adopting a HGM perspective would facilitate consideration of ecosystem processes. Recognizing the value of functionally-based classifications as provided by HGM, Tiner (2011) developed a set of descriptors to bridge the gap between the HGM system of Brinson (1993) and the National Wetland Inventory (NWI) that uses the Cowardin et al. (1979) classification system. Thus, wetland classification systems are already in place to facilitate the ability of the wetland science community to refer to wetlands in a consistent manner, a manner that more accurately reflects the functional role of various wetland types in an interconnected landscape.

When addressing the need for a global classification of wetlands, Cowardin and Golet (1995) indicated that a "classification should be based in ecology, not regulatory concerns, and value-related biases should be avoided." These authors also advised that a classification should be "functionally relevant." However, we acknowledge that there are instances in which functionally defined classifications may not be suitable for regulatory categorization of wetlands. For example, determinations of jurisdictional status under the CWA are often dependent upon whether the wetland is "adjacent" (bordering, contiguous, neighboring) to other clearly defined "Waters of the United States," such as a traditional navigable water, interstate water, impoundment, tributary, or territorial sea (40 CFR §122.2). Therefore, if science is to be linked to policy, issues related to defining and determining wetland "adjacency" are at the forefront of scientific information needs. Use of the GIW category focuses attention away from defining adjacency by relying on the easily defined, although largely unrelated and often difficult to discern remotely, condition of upland embedment. In addition, groupings based on "geographic isolation" do not align uniquely into groupings based on adjacency (i.e., "adjacent" or "not adjacent," Fig. 4). Not all GIWs are "not adjacent;" a GIW situated on a floodplain or alluvial terrace setting may be surrounded by upland but meet the adjacency criteria. Likewise, wetlands that are "not adjacent" are not always GIWs;

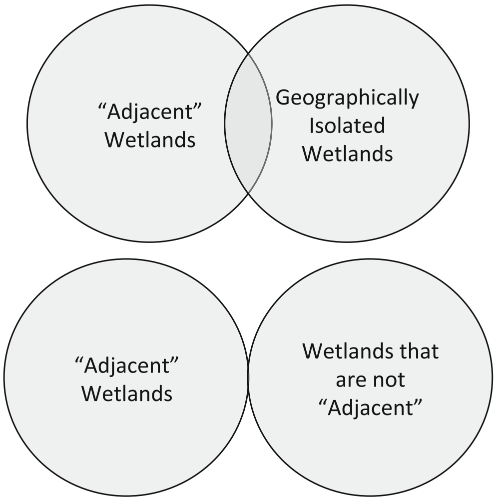

Fig. 4 Venn diagram depicting how sets containing "adjacent" wetlands and "geographically isolated" wetlands (*top circles*) overlap providing a poor fit for addressing information needs of regulators and policymakers. Groupings based on adjacency (*bottom circles*) provide groupings more unambiguously related to current information needs

two or more wetlands not adjacent to a stream or river might have significant surface water connections at a local scale, i.e., are not "geographically isolated," but at the scale of the complex be completely surrounded by uplands.

Further, wetlands are considered "Waters of the United States" if a "significant nexus" exists between the wetland in question and the chemical, physical, and biological integrity of "traditional navigable waters." In practice, such a nexus is assumed to exist between certain "adjacent" wetlands and traditional navigable waters, but for other "adjacent" wetlands and wetlands that are "not adjacent," it must be shown to exist on a case-by-case basis. Therefore, the scientific community can best contribute to this ongoing dialog by focusing efforts on studies related to connectivity between individual wetlands that are "not adjacent," or classes of wetlands that are "not adjacent," and downstream waters. Because GIWs occur in both "adjacent" and "not adjacent" settings, only after issues of "adjacency" have been adequately addressed can the scientific community realistically address issues of connectivity/isolation as related to wetlands that are considered to be "not adjacent." Therefore, for CWA purposes, we propose that wetland groupings based on adjacency, defined by functionally relevant distances from streams, lakes, and coastal waters, would provide information more directly relevant to decision makers than overly simplistic groupings based on "geographic isolation" (Fig. 4). Such groupings have already been partially developed through the spatial distance buffering techniques used in recent mapping efforts (e.g., Frohn et al. 2009; Frohn et al. 2012; Lane et al. 2012; Lang et al. 2012; Martin et al. 2012), representing important steps towards more ecologically realistic assessments of functional connectivity between wetlands and other types of aquatic ecosystems.

For the rare instances in which being surrounded by upland is the relevant distinguishing feature, development of terminology that does not unnecessarily imply isolation (e.g., "upland embedded wetlands") would help alleviate much confusion. Only with a significant change in how the scientific community refers to wetlands currently termed GIWs will wetland scientists be able to address clearly issues of wetland function relative to connectivity and potential isolation without having to first remedy confusion perpetuated by continued a priori designations of these wetlands as being isolated, geographically or otherwise.

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