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REVIEW ARTICLE

Geographically Isolated Wetlands: Why We Should Keep the Term

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Abstract Use of the term "isolated wetlands" in the U.S. Supreme Court's *SWANCC* decision created confusion, since it could imply functional isolation. In response, the term "geographically isolated wetlands" (GIWs) – wetlands surrounded by uplands – was introduced in 2003. A recent article revisits the term, concluding that it is a misnomer that adds to the confusion. Hydrogeomorphic (HGM) type and non-adjacency to jurisdictional waters are suggested as alternatives. To address this issue, I pose two questions: is there a need to identify wetlands surrounded by uplands and what to call them? Regarding the former, there is a legal/regulatory need resulting from the Court's *Rapanos* decision: to help determine whether such wetlands have a significant nexus with traditional navigable waters. There is also a scientific need to understand how the normal lack of surface water connectivity affects function. Regarding the second question, neither HGM type nor non-adjacency adequately identifies wetlands surrounded by uplands. I contend that "GIW" remains the most informative option. However, the term needs to be applied properly and researchers should emphasize that being surrounded by uplands does not imply hydrological or biological isolation. Further, conclusions from one GIW type should be extrapolated to other GIWs with great care.

Keywords GIW · Connectivity · Isolation · *Rapanos* · *SWANCC* · Waters of the US

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Introduction

The term "geographically isolated wetlands" (GIWs) was coined by Tiner (2003b) as part of a *Wetlands* special issue on isolated wetlands (Nadeau and Leibowitz, 2003). The term was meant to add clarity to the discussion on isolated wetlands, which became a major focus following the U.S. Supreme Court's 2001 *SWANCC* decision (531 US 159). Tiner (2003b) noted that "isolated wetland" was a relative term that could be defined geographically, hydrologically, or ecologically. Because establishing hydrological interactions and ecological relationships would require considerable effort, Tiner (2003b) suggested that the easiest approach would be to refer to such wetlands as geographically isolated, and that the simplest definition of a GIW was a wetland completely surrounded by upland. He noted that while most wetland scientists would agree that there is no such thing as an ecologically isolated wetland, there are wetlands that are completely surrounded by upland.

In that same special issue, Leibowitz (2003) observed that using hydrological or ecological criteria to categorize wetlands as isolated or non-isolated was problematic, because isolation and connectivity are not discrete characteristics but occur as a continuum. However, he noted that wetlands can be discretely categorized based on whether or not they are completely surrounded by upland. Therefore, Leibowitz (2003) recommended that ecologists adopt Tiner's (2003b) definition and use the term "geographically isolated wetlands," listing three main advantages over other definitions: (1) it avoided hydrologic or ecologic processes that were difficult to assess in the field, (2) it avoided the need for arbitrary decisions in ambiguous situations (for example, making a permit decision during the dry season that depends on whether a surface water connection occurs during other times), and (3) most wetland scientists were comfortable using the three-

parameter approach of wetland vegetation, soils, and hydrology to draw boundaries between wetlands and uplands. Finally, Leibowitz (2003) stressed that GIWs can vary in their degree of hydrologic and biotic connectivity; in other words, geographic isolation does not equate to functional isolation.

More than a decade after the publication of the special issue, Mushet et al. (2015) revisit the term "geographically isolated wetlands". They argue that the term is a misnomer and does not reflect the continuum from fully connected to fully isolated, that it implies functional isolation, and it can facilitate incorrect generalizations. Further, Mushet et al. (2015) argue that the term has added confusion to scientific discussions. They then offer several alternatives for referring to such wetlands.

There are two questions that must be addressed in debating this issue: Is there a need to identify wetlands that are completely surrounded by uplands? And, if so, then what do we call them? I believe that the answer to the former is an unequivocal yes and, regarding the latter, argue that the GIW term should continue to be used, although it needs to be applied properly.

Is There a Need to Identify Wetlands Surrounded by Uplands?

In their paper, Mushet et al. (2015) state that instances where the condition of being surrounded by uplands is the relevant distinguishing characteristic of a wetland are rare. I do not agree with this assertion, and argue that there are two primary reasons for the identification of wetlands that are surrounded by uplands. First, there is the legal/regulatory imperative that resulted from the *SWANCC* and *Rapanos* (547 U.S. 715) U.S. Supreme Court cases, as discussed by Mushet et al. (2015; also see Downing et al. 2003, 2007; Leibowitz et al. 2008). Under Environmental Protection Agency (EPA) and Army Corps of Engineers post-*Rapanos* guidance, wetlands that are adjacent (bordering, contiguous, or neighboring) to traditional navigable waters (TNWs) are considered waters of the U.S. and subject to the Clean Water Act (CWA; 40 CFR 230.3). Adjacent wetlands that directly abut "relatively permanent" (at least seasonal) tributaries of TNWs are jurisdictional under the Justice Scalia standard (547 U.S. 715). For a wetland that is not adjacent to such waters – including wetlands adjacent to less than seasonal tributaries – Justice Kennedy's standard as applied under the *Rapanos* guidance requires that the wetland have a significant nexus to a TNW to be considered a water of the U.S. Specifically, the waterbody must "either alone or in combination with similarly situated lands in the region, significantly affect the chemical, physical, and biological integrity of other covered waters more readily understood as 'navigable'" (547 U.S. 715). However, under the recent Clean Water Rule (80 FR 37054), EPA and the Corps concluded that wetlands adjacent to tributaries of TNWs, interstate waters, or the territorial seas as a class have a significant nexus to these waters, as supported by an EPA review of the scientific literature (U.S. EPA 2015). This means that case-by-case determinations are not needed for these adjacent wetlands. For wetlands that are not adjacent, case-by-case determinations of significant nexus are needed if they are members of five subcategories (prairie potholes, Carolina bays, Delmarva bays, pocosins, or western vernal pools in California) or are within 1219 m of the ordinary high water mark or high tide line.

The Kennedy decision means that a wetland that is not adjacent needs to have some sort of connectivity with a TNW to qualify as a water of the U.S. (although Kennedy also observed that it could be the absence of a hydrologic connection that creates the significant nexus, for example, by enabling a wetland to retain floodwaters or pollutants; 547 U.S. 715). Mushet et al. (2015) recognize the need for research on the connectivity issue. However, they argue that the focus should be on non-adjacent wetlands, rather than on GIWs. While the Kennedy decision does apply to all non-adjacent wetlands, the reason for emphasizing GIWs is that establishing connectivity for GIWs is especially problematic. A non-adjacent wetland can be hydrologically connected to a stream or river through either a surface channel, a non-channelized swale, or through groundwater flowpaths, or it can be hydrologically isolated from the stream or river (Fig. 1). The latter three categories lack surface outlets and could be considered GIWs, i.e., wetlands that are completely surrounded by uplands. Connections between these wetlands and TNWs are difficult to determine because they do not appear on National Wetland Inventory (NWI; http://www.fws.gov/Wetlands/NWI/index.html) or National Hydrography Dataset (http://nhd.usgs.gov/) maps or typically available remote sensing products, and because many of these connections can only be observed during infrequent events. Demonstrating that these wetlands are connected to TNWs through groundwater or biological connectivity is similarly difficult. Although it is not always possible to identify surface channels through remote sensing or geographic information system (GIS) products, due to poor resolution (Lang et al. 2012), hydrologic connectivity for wetlands with surface channels (Fig. 1a) can always be determined through a site visit. Thus, there is a legal/regulatory need to identify GIWs as a group that requires their connectivity to be determined (U.S. EPA 2015), and a need for tools that can determine their connectivity. Since all adjacent GIWs qualify as waters of the U.S. (40 CFR 230.3; 80 FR 37054), this information is particularly needed for non-adjacent GIWs (Fig. 1) that are either prairie potholes, Carolina bays, Delmarva bays,

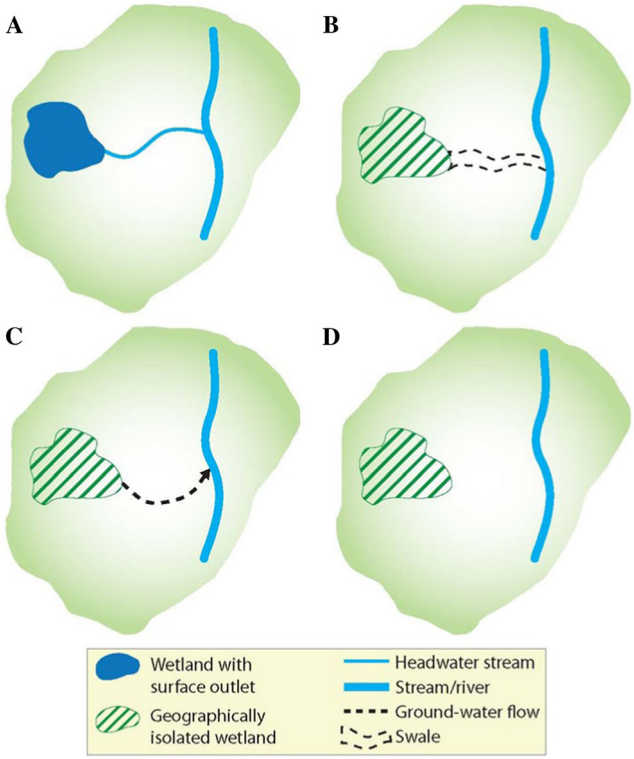

Fig. 1 Types of hydrologic connections between non-adjacent wetlands and streams or rivers. **a** A wetland connected to a river by surface flow through a headwater stream channel. **b** A wetland connected to a river by surface flow through a nonchannelized swale. Such a wetland would be considered geographically isolated if the swale did not meet the Cowardin et al. (1979) three-attribute wetland criteria. **c** A geographically isolated wetland connected to a river by groundwater flow (flowpath can be local, intermediate, or regional). **d** A geographically isolated wetland that is hydrologically isolated from a river. Note that in **a-c**, flows connecting the wetland and river may be perennial, intermittent, or ephemeral (Source: U.S. EPA 2015)

pocosins, or western vernal pools in California, or that are situated within 1219 m of the ordinary high water mark or high tide line.

The second reason why we should identify wetlands that are completely surrounded by uplands is because their apparent isolation from other waterbodies leads to interesting and fundamental scientific questions that need to be addressed relative to their functional role in the watershed. Winter and LaBaugh (2003) referred to wetlands that were not connected by streams to other surface waterbodies as isolated and, with regards to *SWANCC*, felt that "Defining isolation on the basis of surface-water connections is a reasonable and obvious approach" (Winter and LaBaugh 2003, p. 532). Yet they acknowledged that such wetlands could be hydrologically connected to these waterbodies through groundwater or overflow during wet climatic conditions. The clear implication is that wetlands that are connected to the river network by a channelized stream have higher surface water connectivity than those that are only connected during extreme conditions. Thus, the question of where GIWs stand on the isolation-connectivity continuum (Leibowitz 2003) has arisen as a bona fide subject for scientific investigation. As a result of the 2003 special issue and subsequent studies, a much better understanding of the connectivity of these systems has emerged (e.g., Subalusky et al. 2009; Min et al. 2010; Wilcox et al. 2011; Lane et al. 2012; Lang et al. 2012; Shaw et al. 2012; Nilsson et al. 2013; Golden et al. 2014; McLaughlin et al. 2014; Van Meter and Basu 2014; Golden et al. 2015; Marton et al. 2015; McDonough et al. 2015; Rains et al. 2015), although much still needs to be learned about how connectivity varies regionally, over time, and by type of connectivity (e.g., hydrological vs. biological).

What Should we Call Wetlands Surrounded by Uplands?

Mushet et al. (2015) observe that "geographic isolation" is a well-established term in population genetics and evolutionary biology that refers to the prevention of gene exchange by barriers or distance; a usage suggesting that objects far from each other are more geographically isolated than objects located near each other. However, Tiner's (2003b) definition of geographically isolated wetlands is binary and so does not recognize this continuum, as noted by Mushet et al. (2015). More to the point, the Tiner (2003b) usage could imply that being surrounded by uplands represents an absolute barrier for organisms within the wetland. While this may be true for fish (Snodgrass et al. 1996; Babbitt and Tanner 2000) and other organisms that cannot travel over land, many species that use GIWs, such as amphibians (Gibbons 2003; Mushet et al. 2012), are not geographically isolated in this sense of the term. When I recommended that Tiner's (2003b) GIW definition be adopted (Leibowitz 2003), I was considering the term "geographic isolation" in a hydrological sense, rather than biological. Specifically, "GIW" was defined as a binary term that identified wetlands that were isolated from each other in the limited sense that they had no permanent surface water connections. Note that surface water connections would not be considered upland features if they occur at a frequency or duration large enough to cause a channel or result in hydric soils, wetland vegetation, or saturated or standing water during the growing season. Thus for a wetland to be surrounded by upland (i.e., a GIW), it must normally lack surface water connections, including perennial or intermittent flows (channelized or not).

One alternative suggested by Mushet et al. (2015) is that we refer to these wetlands by their hydrogeomorphic (HGM) type, e.g., depressional, slope, organic flat, or mineral flat wetlands. They correctly contend that – because HGM is a functional classification – this would provide more information on appropriate wetland functions and ecosystem processes than the term GIW. However, all of these HGM types may or may not have surface water inlets and outlets (Brinson

1993; Smith et al. 1995). Thus, use of HGM class would not distinguish GIWs from those having surface water connections, and therefore does not fulfill the needs I previously identified.

Mushet et al. (2015) further discuss a set of descriptors developed by Tiner (2011) that could bridge the gap between Brinson's (1993) functional HGM classification and the Cowardin et al. (1979) NWI classification. They conclude that systems are already in place that accurately reflect how different wetlands function in an interconnected landscape. In fact, Tiner (2011) uses the word "terrene" as a descriptor of landscape position that includes wetlands that are completely surrounded by uplands. Although this would seem to be a perfect alternative to GIW that avoids the potentially confusing use of the term "isolated" and has already been established in the literature, the terrene setting also includes wetlands that are not GIWs. Two examples of wetlands that are not GIWs but occur within the terrene setting are wetlands that are located along a river but not subject to frequent overflow, and wetlands that are a source of water to a river or stream but where the watercourse does not extend through the wetland (Tiner 2011). Given that terrene can include both GIWs and non-GIWs, use of this term would be an inappropriate alternative for GIW.

Mushet et al. (2015) also propose that distinguishing between adjacent and non-adjacent wetlands would be more useful than identifying GIWs for CWA purposes. One problem with this proposition is that, as noted by Mushet et al. (2015), not all GIWs are non-adjacent. A wetland located in the upland portion of a floodplain that is separated from the river by a berm would be a GIW but could also be adjacent (Downing et al. 2003). Thus, the term "non-adjacent wetlands" does not comprehensively cover all GIWs (see Fig. 4 in Mushet et al. 2015). Secondly, "adjacent" is a regulatory term that means bordering, contiguous, or neighboring (40 CFR 230). While bordering and contiguous are relatively straightforward, the term "neighboring" is not. It has been interpreted and implemented differently by different US Environmental Protection Agency Regions and US Army Corps of Engineers Districts due, in part, to a lack of a regulatory definition for "neighboring" (the recent Clean Water Rule remedies this situation by providing such a definition; 80 FR 37054). One of the distinct advantages of Tiner's (2003b) definition of a GIW as a wetland surrounded by upland is that it can be consistently determined on the ground using the three-parameter approach. In practice, GIWs may be identified by other means that are not necessarily consistent with this definition (Mushet et al. 2015). However, this is not a problem with Tiner's (2003b) definition, but with how it is applied.

Mushet et al. (2015) use the term "upland embedded wetlands" several times to describe the basic characteristic of a GIW, i.e., a wetland surrounded by uplands. Although they do not formally offer this as an alternative to GIW, the term "upland embedded wetland" is less objectionable than their other two alternatives (HGM type and non-adjacency). It is clearly a neutral term that does not imply functional isolation and, because it is essentially Tiner's (2003b) definition with a different name, it is unambiguous and can be consistently applied on the ground.

Although "upland embedded wetland" is an appropriate and suitable term, I continue to recommend the use of the GIW term exactly *because* it includes the word "isolated". This goes back to the scientific question posed by these wetlands: does the fact that they are mostly isolated with respect to surface water affect their function? A lot of research might never have been done if these were called upland embedded wetlands and the issue of the continuum of spatial and temporal connectivity was never raised. The wetland literature is richer as a result of trying to better understand these wetlands – a search of the term "geographically isolated wetlands" on Google Scholar found almost 390 results since 2004 (access date 3/5/15), and Tiner's (2003b) paper alone has been cited over 160 times; also see Fig. 2 in Mushet et al. (2015).

Other Issues with the GIW Term

Mushet et al. (2015) cite Cowardin and Golet (1995) in stating that classification should be functionally relevant. However, classification can be defined more broadly as the "action or process of classifying something according to shared qualities or characteristics" (http://www.oxforddictionaries.com/us/definition/american_english/classification; accessed March 5, 2015); this definition does not require that the grouping be based on functional qualities or characteristics. In fact, while classifying objects based on shared functional characteristics is appropriate when the objects and their functions are well-established, here we are classifying, or defining, a type of wetland because we want to better understand and characterize the functional characteristics of this type of wetland. The scientific purpose of classifying wetlands in this fashion is to determine what, if any, generalizations can be made about GIWs.

Mushet et al. (2015) also criticize how GIWs are measured in practice. They cite four studies that used buffer distances from streams to distinguish between GIWs and non-GIWs, rather than making this distinction based on whether or not the wetlands were completely surrounded by uplands. I have several issues with this criticism. First, this is not a problem with the definition, but with how it is implemented. Whether or not a wetland is a GIW can be determined in the field by using the three-parameter approach (hydrophytic vegetation, hydric soils, and wetland hydrology) to evaluate whether the wetland is surrounded by upland (Leibowitz 2003). Because it is not always possible to make this assessment in the field –

especially when classifying large numbers of wetlands – GIS and/or remote sensing methods can be used to identify GIWs (e.g., Tiner 2003a; Lane et al. 2012). Like any type of scientific measurement, estimates based on remote sensing or GIS have inherent limitations due to error, including inadequate resolution (Lane et al. 2012). However, just as a light microscope is still useful for addressing certain types of questions, low resolution imagery can be useful for identifying GIWs and determining relative distribution patterns if error rates and the implications of any systematic biases are acceptable.

My second issue with their argument is that Tiner (2003a) used buffering specifically because there are instances where misregistration or inaccuracies between wetland and stream GIS layers cause a wetland to be offset from a stream that it is actually connected to. The buffering ensures that any such wetland would not be erroneously classified as a GIW (Frohn et al. 2009), and therefore represents an approach for providing a conservative estimate of GIW numbers. In other words, this minimizes errors of commission where certain non-GIWs are mistakenly classified as GIWs, but at the cost of errors of omission where certain actual GIWs are misclassified as non-GIWs. Finally, Mushet et al. (2015, p. 6) suggest that this use of buffers, rather than just mapping uplands, "brings into question the 'ease of use' argument presented by Leibowitz (2003) in promoting use of the GIW grouping." The "ease of use" argument was originally made specifically with respect to field implementation of the GIW definition. However, conducting a GIS buffer analysis to identify a GIW is still easier than alternative ways of defining isolated wetlands, such as determining the presence of biotic, groundwater, or infrequent surface water connections.

What can we Agree on?

Regardless of what they are ultimately called, I wholeheartedly agree with Mushet et al. (2015) that there has been confusion regarding GIWs. This is due in part to how "geographic isolation" is used in the population genetics and evolutionary biology literature. Additionally, "geographic isolation" and "isolation" have been used interchangeably in the literature (see examples in Mushet et al. 2015), perpetuating the idea that geographic isolation is equivalent to functional isolation. Wetland scientists should continue to emphasize that being surrounded by uplands does not imply that a wetland is hydrologically or biologically isolated.

Mushet et al. (2015) make a valid point that referring to wetlands as geographically isolated may lead to incorrect generalizations, since GIWs can cut across nearly every HGM category. This is especially true since most studies have focused on depressional GIWs, yet conclusions have been applied broadly to all GIWs. Conclusions from one GIW type should be extrapolated to other GIW types with great care. I would take this a step further and recommend that we not generalize that all wetlands in certain categories – such as prairie potholes, vernal pools, and Carolina bays – are GIWs, given that these groups may contain wetlands that are not completely surrounded by uplands. For example, 56–94 % of semi-natural Delmarva bays were found to connect to a stream (Lang et al. 2012), even though this kind of wetland has been considered geographically isolated (Tiner 2003b).

Mushet et al. (2015) note that a wetland complex with surface water connections between its wetlands could be geographically isolated at the complex scale (i.e., the perimeter of the complex is surrounded by upland). A similar example is a wetland connected to a losing stream in a karst landscape; even though the wetland is not completely surrounded by upland, it could be considered geographically isolated since the wetland-stream system is completely surrounded by upland (Tiner 2003b). The opposite also occurs: Wilcox et al. (2011) provide the example of Texas Gulf Coast depressional wetlands that were individually surrounded by uplands but were connected as a complex to a waterway through an intermittent stream. Whether or not a wetland is surrounded by uplands is scale-dependent (Tiner 2003b).

Finally, I agree that the question of how wetlands function with respect to hydrologic and biotic connectivity and isolation is an important research area that should continue to receive attention. While a number of recent papers have begun to shed light on this topic (e.g., Subalusky et al. 2009; Min et al. 2010; Wilcox et al. 2011; Lane et al. 2012; Lang et al. 2012; Shaw et al. 2012; Nilsson et al. 2013; Golden et al. 2014; McLaughlin et al. 2014; Van Meter and Basu 2014; Golden et al. 2015; Marton et al. 2015; McDonough et al. 2015; Rains et al. 2015), much is still unknown. In particular, landscape-scale studies are needed that (1) evaluate the hydrologic and biotic connectivity of GIWs within different regional settings, (2) determine factors contributing to connectivity, and (3) consider how connectivity and isolation contribute to overall watershed function.

Conclusions

More than a decade after it was coined, Mushet et al. (2015) revisit the term "geographically isolated wetlands" and conclude that it is a misnomer. As alternatives, they suggest HGM type and whether or not the wetland is adjacent. I agree with many of the points made by Mushet et al. (2015), but disagree with their overall conclusions. At a minimum, Mushet et al. (2015) are throwing out the baby with the bath water: Not only do they argue against the GIW term, but they also assert that there is only a rare need for a term that denotes wetlands surrounded by uplands. I contend that there is a need to identify wetlands surrounded by uplands, both from legal/regulatory and scientific perspectives. Further, their argument

about how GIWs are measured in practice is not a problem with the definition, but with how it is implemented. I agree that the term "geographically isolated" can be confusing and has been misused in the wetlands literature. However, the alternatives suggested by Mushet et al. (2015) do not satisfy the legal/regulatory and scientific needs for identifying these wetlands. I recommend three steps to avoid confusion while highlighting that these wetlands normally lack surface water connectivity: (1) properly applying the GIW term, as originally proposed by Tiner (2003b) and recommended by Leibowitz (2003), (2) continuing to emphasize that being surrounded by uplands does not imply hydrological or biological isolation, and (3) extrapolating conclusions from one GIW type to others with great care. These steps should promote an improved understanding of how the lack of regular surface water connections affects the functional connectivity of these wetlands and the ecosystem services they provide.

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