U.S. Clean Water Act Policy vs. Wetland Science - Nexus or Not?

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INTRODUCTION

This is a historical overview of the role that wetland science has played in regard to wetland management policy in North America. The major focus will be U.S. based since this is where wetland science has a direct link to policy and vice versa. From an international perspective – please see the book- *Sustaining the World's Wetlands: Setting Policy and Resolving Conflicts* (Smardon 2009). The linkage of wetland science to policy has not always been symbiotic as one can see from this article, but even the problematic nexus issues are instructive. This author relied heavily upon Environmental Law Institute's *National Wetland Newsletter* from 1986 to 2016 as a major guide to policy versus wetlands science issues besides relevant journal articles, books, and other sources. For an in depth look at the history of U.S. wetlands and for coastal wetlands, readers are referred to *Discovering the Unknown Landscape: A History of America's Wetlands* (Vileisis 2012) and *Tidal Wetlands Primer: An Introduction to Their Ecology, Natural History, Status, and Conservation* (Tiner 2013), respectively.

U.S. EARLY HISTORY OF WETLAND SCIENCE AND POLICY – FUNCTIONS AND VALUES?

The value of wetlands as waterfowl habitat played a key role in influencing U.S. wetland policy. The U.S. Fish and Wildlife Service report in 1956 (Shaw and Fredine 1956) and a series of later reports in the 1960s (Tiner 2013) highlighted the decline of waterfowl habitat. Besides increased water pollution, the findings of this census and public concern about heavy losses of coastal marshes eventually led to the need for the Clean Water Act (CWA) of 1964 and amendments in 1977 that required federal U.S. Army Corps of Engineers permits for wetland alterations beyond those contiguous with traditional navigable waters. Further concern for continued wetland losses also eventually led to the 1986 Emergency Wetlands Resources Act (PL 99-645), which was enacted to promote wetlands conservation through acquisition (Scozzafava et al. 2007). This act plus the CWA Section 404 strengthened support for the U.S. Fish and Wildlife Service's National Wetlands Inventory (NWI) and for producing wetland status and trends reports at ten-year intervals. This has significance, as the NWI became the base inventory for the continental U.S. and for reporting the amount of wetland loss or gain over time – a type of monitoring program.

Moving beyond wetland value for wildlife habitat became a major focus for U.S. wetland research after passage of CWA Section 404 amendments in 1977. One of the best compendiums of wetland functions and values was compiled in the conference proceedings at Lake Buena Vista Florida in 1978, which addressed a very broad view of wetlands (Greeson et al. 1979). One of the first multi-attribute assessment methods was developed by a team of scientists from the University of Massachusetts - Joseph Larson, Frank Golet, Richard Healy, Tirith Gupta, John Foster, and me (Larson 1976; Smardon 1975, 1978). This assessment system considered water supply, aesthetic, recreational and educational values of inland wetlands in Massachusetts as well as wildlife habitat values. It even incorporated an economic model for projecting wetland values over time (Gupta and Foster 1975). It was a predecessor to wetland ecosystem service valuation and was utilized as a building base for other regional wetland assessment systems (World Wildlife Fund 1992).

WETLAND DELINEATION - WHEN IS WET LAND A WETLAND?

One of the key issues involved with the National Wetlands Inventory and the federal and state wetland permitting programs is 'when is wet land a wetland' and how do we determine the boundary of the wetland? Because of the continued loss of wetland area nationally and regionally and the lack of standardized practices for identifying and delineating wetlands for federal permits, both the Corps of Engineers and U.S. EPA developed wetland delineation manuals in the mid-1980s (USCOE 1987; Sipple 1985, 1988). These two agencies have joint responsibility for regulating wetlands under the CWA. Neither manual was required for use for regulatory purposes but was used for field-testing. After a year of field-testing both manuals, the two agencies met to discuss findings and with the expectation to reach agreement on a consistent delineation approach. The USDA Soil Conservation Service and U.S. Fish and Wildlife Service were invited to the meeting given their respective expertise in hydric soils and wetland identification and mapping.

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The consensus of the four agencies was that they should work cooperatively to prepare a single federal manual for wetland delineation that could be used by all agencies for regulatory purposes as well as for mapping wetlands for resource conservation and management. The new wetland delineation manual was developed by an interagency committee in 1988 (Federal Interagency Committee for Wetland Delineation 1989); it combined existing methods used by the four agencies into a consistent methodology. It was officially adopted by the Corps and EPA as the national standard for identifying wetlands regulated through the CWA on January 19, 1989 (https://www.epa.gov/cwa-404/memorandum-agreement-determiniation-geographic-jurisdiction-section-404-program-and). This was the first time that a consistent approach would be used to identify wetlands for federal regulatory purposes nationwide. Since a variety of approaches had been used before it was a given that this would have expanded the area of wetlands to be covered under waters of the U.S. under Section 404 of the CWA. Also as expected, it was met with uproar and lawsuits from land developers, farmers, and mining industries. Given this outcry, Congress threatened to deny the Corps its operating budget if it continued to use this manual so the Corps then adopted its 1987 manual as the mandatory national standard for delineating jurisdictional wetlands. To address forthcoming concerns about the scientific basis for the Corps 1987 manual given inconsistencies in its application, the National Research Council was tasked by Congress to address the issue of defining wetland characteristics and boundaries. Wetland scientists met for over a year, visited wetlands throughout the U.S. and heard testimony. Key issues revolved around wetland hydrology and soils as they defined growing conditions for wetland vegetation. Still there were disagreements amongst the wetland scientists and some felt that the report – *Wetlands: Characteristics and Boundaries* (National Research Council 1995) was not well received by Congress. The end result was support for the 1987 Delineation manual (USACOE 1987) with recommendation that it be regionalized. Consequently, the Corps worked to produce regional supplements to the delineation manual across the country: Alaska, Arid West, Atlantic and Gulf Coastal Plain, Caribbean Islands, Eastern Mountains and Piedmont, Great Plains, Hawaii and Pacific Islands, Midwest, North Central and Northeast, and Western Mountains, Valley and Coast (https://www.usace.army.mil/Missions/Civil-Works/Regulatory-Program-and-Permits/reg_supp/). These supplements contain the list of wetland indicators (hydrophytic vegetation, hydric soils and wetland hydrology) and the procedures for analyzing vegetation and for addressing problematic situations where such indicators are weak or lacking and disturbed areas (e.g., drained sites). For more on the topic of wetland delineation see *Wetland Indicators: A Guide to Wetland Formation, Identification, Delineation, Classification, and Mapping* (Tiner 2017).

WETLAND ASSESSMENT FOR FUNCTIONS AND VALUES

With the creation of the Section 404 wetland permit program by the U.S. Army Corps of Engineers plus state wetland permit programs in about one half of the U.S. states, the overriding policy issues became when to allow wetland alteration, what were the values and functions lost, and how should such loss be compensated or mitigated? As pointed out by Frank Golet (1986) one of the co-authors of the national wetlands classification system (Cowardin et al. 1989), major questions in the 1980s were:

- What is the justification for initial wetland alteration and when is it unavoidable;
- What are the criteria for selecting "best " mitigation options;
- The issue of uncertainty of projected results as well as certainty of adverse impacts;
- How to address replacement and substantiation of lost values and how to address specific values and functions lost;
- The importance of the wetlands setting;
- How to address net loss of wetland area, which is a common consequence;
- How to address cumulative impact of isolated mitigation projects;
- The issue of short term versus long term perspective;
- How to assess the comparability of original and replacement wetlands.

Dr. Golet went on to state that the role of value assessment in wetland mitigation "should not be used in simple before and after value comparison for mitigation projects" (Golet 1986, p. 4). Such questions led to the development of a myriad of wetland assessment systems most of which are reviewed in WWF's *Statewide Wetlands Strategies: A Guide to Protecting and Management the Resource* (WWF 1992) as well as Fennessy et al. (2004) and also reported in Dorney et al. (2018). The WWF source included: wetlands classification schemes such as Cowardin et al (1979 - the national wetland classification system for the U.S.; maps and national databases such as the U.S. Fish and Wildlife Service's National Wetlands Inventory (NWI); data sources on wetland status and trends such as the U.S. Fish and Wildlife Service status and trends reports (every ten years); rapid methods for evaluating, ranking or categorizing wetlands (which will be treated in more detail below) and data intensive methods for individual wetlands.

Rapid methods for evaluating wetlands can divide into methods intended for use in any area in the coterminous U.S. and methods developed for specific or particular regions. The methods intended to be used across the U.S. prior to 1992 include 1) the *Habitat Evaluation Procedures* (HEP) developed by the U.S. Fish and Wildlife Service (1980) - a very detailed process of assessing habitat impacts to selected fish, wildlife and invertebrates and is still in use and 2) the *Habitat Assessment Technique* (HAT) developed by Cable et al. (1989) that addresses only breeding bird habitat and requires extensive field work.

Paul Adamus and Lauren Stockwell (1983) developed a national system of wetland evaluation (WET) for the Federal Highway Administration in 1983. In 1987, it was adapted by the U.S. Corps of Engineers (Adamus et al. 1987). This system used the wetland literature to develop a series of indicators which then could be used to evaluate the following functions; groundwater recharge, groundwater discharge, flood flow alteration, sediment stabilization, sediment toxicant removal, nutrient removal /transformation, production export, aquatic diversity abundance, and wildlife diversity/abundance. Once these functions are assessed – they then are modified by their social significance and the wetland's effectiveness or capacity and opportunity to provide the various functions. The U.S. Corps of Engineers at the Waterways Experiment Station (Vicksburg, Mississippi) tried to regionalize this system but it is not extensively used these days.

Another national wetland assessment system developed in the early 1990s by the U.S. Environmental Protection Agency (Abbruzzese et al. 1997) was to be used at a watershed scale. Indicators are developed within any given watershed to assess the functions of wetlands within a watershed landscape. The system was tested in the states of Washington (Abbruzzese et al. 1990a) and Louisiana (Abbruzzese et al. 1990b) but was not heavily used because of the lack of watershed-based wetland science for any given application area. At the same time two Cornell University scientists were working on methods for assessing cumulative impact to wetlands within a watershed (Bedford and Preston 1998).

The next advance in wetland assessment came with the development of the hydrogeomorphic (HGM) approach created by East Carolina State University Professor Mark Brinson (1996 and Brinson et al. 1994). This system classifies wetlands based on abiotic properties that produce differences in functioning (e.g., where the wetland sits in the landscape, for example, upland depressional versus floodplain). The system also maintains a clear policy-science separation as societal issues are dealt with only after functional assessment. Third the HGH approach uses reference wetlands - sites that have the known variation in sub class function to rank wetlands. It is the major biophysical functions that are assessed and not social values or functions. The HGM system, used by the U.S. Corps of Engineers and some states, is highly data intensive and has been criticized by others. Kusler and Niering (1998) were critical of HGM and other assessment systems in regard for the need of "holistic" assessment; limitations in terms of types of information and scale of analysis; the need for value as well as function assessment; and the need to be proven in regard to breadth of information, cost-effectiveness, practicality, understandability, and scientific accuracy (Kusler and Niering 1998, p. 14).

The U.S. Army Corps of Engineers had continued to develop the HGM system with National HGM models regional guidebooks and research but development of HGM profiles faded by 2002. Regional and state HGM classifications and keys were produced for several states including Colorado, North Carolina, Oregon, Pennsylvania, and Washington in addition to reference wetlands and regional guidebooks for California, Kentucky, North Carolina, Oregon and Pennsylvania (Cole and Kooser 2002). Corps district offices are still struggling with rapid assessment techniques that have utility for assessing impact and or loss of wetland functions and values. The HGM concept has been coupled with the Cowardin et al. (1979) wetland classification to produce landscape-level wetland functional assessments for watersheds and other regions using GIS and remotely sensed data (see Dorney et al. 2017 for examples).

WHEN AND HOW TO MITIGATE

Even though we could delineate a wetland and conduct assessments of functions, values and impacts we were still losing wetland area and functions across the country so the next question became - is compensatory mitigation working under federal and state wetland permitting? From 1981 to 2008 the federal policy stated that when there are unavoidable wetland impacts and wetland area and functions are lost – required compensation should be on site and in-kind to replace lost area and functions. During the 1980s and 1990s many studies documented the lack of ecological effectiveness of replacement mitigation wetlands (e.g., Brown and Veneman 2001; Wilkinson et al. 2013). Again the National Research Council was tasked with reviewing compensatory wetland mitigation practice in the conterminous United States. The NRC committee examined the science behind wetland restoration and mitigation. The committee met five times in 2000 and visited actual mitigation sites in Florida, Illinois, and California (Zedler and Shabman 2001). The 2001 NRC report called upon regulatory agencies to "modify the boundaries of permit decision making in time and space" and advocated that mitigation" be conducted at watershed scale" (National Research Council 2001).

Two years later an interagency group released the *National Wetlands Mitigation Action Plan* (MAP 2002) with a goal of "no net loss" by undertaking a series of actions to improve the ecological performance and results of wetlands compensatory mitigation (Thomas and Lamb 2004). In May 2004 the Environmental Law Institute facilitated a meeting –*National Symposium on Compensatory Mitigation and the Watershed Approach* (https://www.eli.org/sites/default/files/eli-pubs/d14_10.pdf). The major objective of the meeting was to "identify and clarify what science says about making compensatory mitigation decision in a watershed context". Out of this symposium came a number of key points as part of this watershed approach, which included:

- Defining critical mitigation issues and objectives (Montgomery et al. 1995; Almendinger 1999; Lamy et al. 2002; Thomas and Lamb 2004);
- Having broad stakeholder participation (Gosselink et al. 1990; Llewellyn et al. 1996; National Research Council 2001; Lamy et al. 2002; Kershner 1977);
- Determining the appropriate scale and boundaries for analysis (Preston and Bedford 1988; Omerick and Bailey 1997; Griffith et al. 1999, Fennesy et al. 2004; Montgomery et al. 1995);
- The use of watersheds and basins as the unit of analysis (Montgomery et al. 1995; Kershner 1997; Lee and Gosselink 1988; Tiner et al. 2000);
- Assessing and understanding watershed and landscape functions (Montgomery et al. 1995);
- Understanding hydrologic equivalency (Bedford 1996); and
- Understanding relative ecologic significance.

MOVING TOWARD A WATERSHED APPROACH?

All of these points were to be incorporated in the U.S. EPA Synoptic Approach (Abbruzzese et al. 1997), which incorporates elements for site-specific assessments as well as prioritizing sites and designing mitigation and assessing performance. Although many scientists agree about the need for a watershed-based approach for wetland mitigation there were still issues regarding functional replacement versus biodiversity. Joy Zedler states that it is not clear that restored wetland services depend on biodiversity; three key wetland services - flood abatement, carbon sequestration and water quality enhancement - may not depend on diverse vegetation (Zedler 2005).

In order to improve the process of compensatory wetland mitigation and after almost two years of hearings and comments the Corps and EPA were charged with implementing the *Compensatory Mitigation Rule* (CFR 2008). This rule called for a "watershed approach" that would: 1) identify watershed needs, 2) identify potential project sites, 3) assess the potential of sites to meet watershed needs, 4) prioritize sites and 5) develop desired mitigation outcomes. As pointed out by Hershner (2013) the challenge to the wetland scientific community, given the assertion of goods and services from wetlands arise in part from the connection between wetlands and their landscapes: will wetland science provide practical and consistent advice for use of watershed scale assessment?

WETLAND ECOSYSTEM SERVICES

Costanza et al. (1997) in their legendary paper calculated the ecosystem services provided by nature including wetlands, while the *Millennium Ecosystem Project* (2005) developed an ecosystem services overview specifically for wetlands. This report outlined provisional (food and water), regulatory (maintaining water quality), cultural (aesthetics and recreation) and ecosystem support (habitat and food chain) in regard to wetlands from an international perspective. In the U.S. there were two research efforts that focused on sustainable wetland management (Euliss et al. 2009a, 2009b) and on means of quantifying ecosystem services provided to human beneficiaries (Boyd and Kruprick 2009).

According to Euliss et al. (2009a) a meeting was convened in 2006 at Bosque Del Apaches National Wildlife Refuge (New Mexico) to develop a sustainable approach for wetland management focusing on underlying wetland processes. The other focus was on long-term sustainability of critical habitats within altered landscapes by restoring or simulating natural processes (Euliss et al. 2009b; Smith et al. 2008).

The National Research Council (2005) and the U.S. Environmental Protection Agency (2009) have embraced the idea of ecosystem service valuation as part of environmental decision-making since the early 2000s. Economists and social scientists were developing ecosystem valuation theory and metrics (Boyd and Krupnick 2008; Daily and Matson 2008). From 2010-2011 the US EPA-Corvallis laboratory research group held a number of workshops in Denver to bring together both biophysical and social scientists to develop metrics for assessing and valuing ecosystem services derived from water resources such as coastal estuaries, lakes, rivers and freshwater wetlands (Nahlick et al. 2012; Ringold et al. 2013). From these workshops the US EPA developed a landscape classification covering both uplands and water areas with generic ecosystem services and respective beneficiaries (Landers and Nahlik 2013). The appendices include detailed descriptions of ecosystem benefits and beneficiaries derived from rivers and streams, freshwater wetlands, lakes and ponds, estuaries and near shore marine areas, and open ocean areas plus upland landscapes. The question remains as to whether ecosystem services will become useful for actual accounting of benefits as part of wetland permitting and mitigation decisions.

WETLANDS, CLIMATE CHANGE, AND BLUE CARBON?

One of the most controversial issues with regard to wetland science and policy is whether coastal and inland wetlands are actually sinks or exporters of greenhouse gases as we look forward to climate change and disruption. Kusler and Burkett (1999) called attention to this issue by pointing out that wetland destruction could release stored carbon and methane into the atmosphere as well as loss of carbon sequestration. They also pointed out that wetland flora and fauna often respond dramatically to climate change including:

- Inducing small permanent changes in water levels;
- Inducing further wetland fragmentation; and
- Inducing further wetland stress.

They go on to emphasize that wetlands having a greater climate change risk are coastal and estuarine wetlands, tundra, peatlands, alpine wetlands, prairie potholes, depressional slopes, flats, and river and lake fringe wetlands. One of the best compendiums or books in this regard is *Climate Change Impacts on Freshwater Ecosystems* by Kernan et al. (2010).

William Mitsch (2013, 2016) states that there is a significantly higher sequestration in wetlands worldwide - estimated at 1Pg yr-1 (=1000 Tg. (Teragram) yr-1+ 10 g yr-1) based on new data. He developed a dynamic carbon model to address both carbon sequestration and methane emissions. Sixteen natural wetlands were used as inputs for simulation. Most of the 16 wetlands became "sinks of radiative forcing within 100 years" (Mitsch et al. 2013). A recent article by Moomaw et al. (2018) documents the role of wetlands in addressing climate change. They state "peatlands and vegetated coastal wetlands are among the most carbon rich sinks on the planet and sequestering approximately as much carbon as do global forests" (p. 183). They stress that wetland scientists need to clearly communicate this significant wetland carbon sequestration function as well as align wetland science with specific climate mitigation/adaption/resiliency wetland ecosystem services in order to be more effective in influencing climate change policy.

In order to better integrate the amount of carbon storage in the world's ocean and coastal ecosystems, there has been development of protocols for determining "blue carbon" sequestration. Emmett-Mattox and Crooks (2014) report that the development of such protocols is key for conservation and restoration of such biogeochemical processes performed by coastal salt marshes, mangroves and seagrass beds. Examples of such protocols include:

- American Carbon Registry "Registration of Degraded Delta Wetlands of the Mississippi Delta Wetlands of the Mississippi Delta" Webinar December 12, 2012 https://tierraresourcesllc.com/wp-content/uploads/2014/01/ACR-Wetland-Rest-Meth-Webinar-12-12-12-COMBINED.pdf
- Verified Carbon Standard, "Baseline monitoring Methodology for the Rewetting of Drained Peatlands used for Peat Extraction, Forestry or Agriculture Based on GESTS) (greenhouse Gas Emissions Site Type) (see Tanneberger and Wichtmann 2011);
- Verified Carbon Standard " Methodology for Wetland Creation (see UNEP & CIFOR 2014)
- Verified Carbon Standard" Methodology for Tidal Wetland and Seagrass Restoration. http://verra.org/webinar-newly-approved-vcs-methodology-tidal-wetland-and-seagrass-restoration/

Further information on these carbon sequestration protocols can be seen in Mcleod et al (2011).

USING NEW TECHNOLOGIES TO IDENTIFY WETLAND CONNECTIONS AND TO MONITOR WETLAND CONDITIONS

Finally wetland science has progressed with the use of remote sensed technology and geographic information data systems – vital for keeping track of individual wetland conditions as well as larger scale watershed or regional landscape conditions. We have moved from the U.S. Geological Survey topographic maps and aerial photo interpretation initially used for the NWI in the 1970s and 80s (Cowardin et al. 1979; Cowardin and Golet 1995) to multi spectral imagery and geographic information systems of today (Tiner et al. 2015). A need for a surface waters and wetlands inventory (SWI) was created after the 2001 SWANNC Supreme court case where the hydrologic nexus of wetlands versus hydrologically isolated wetlands became an issue for nationwide wetland permitting. SWI system has a more complete geospatial data for surface waters and wetlands than the original NWI digital database, which did not include linear wetlands and watercourses mapped by NWI projects. Consequently SWI provides a more efficient means to determine flow and water movement in surface water basins, channels and wetlands (Dahl 2013). It was completed for 28 states and is publically available at http://www.fws.gov/wetlands/. A newer version of this product called NWI Version 2 adds buffered USGS hydrography data (e.g., linear streams) to the database (https://www.fws.gov/wetlands/data/Wetlands-Product-Summary.html). Adding these streams has greatly improved the utility of the data. Unfortunately the NWI data in this product are mostly from the 1980s (Figure 1). More support is needed to update this valuable program.

The U.S. EPA established the National Wetland Condition Assessment (NWCA) to keep track of the ecological condition of wetlands (Seronbetz 2016). The various components of the NWCA include the National Aquatic Resource Survey (NARS) for wadeable streams (2004), lakes (2007), rivers and streams (2008-2009) and coastal waters (2010) (available at https://www.epa.gov/national-aquatic-resource-surveys). As part of the reporting of the 2011 NWCA, there were two reporting documents (USEPA 2011a, USEPA 2011b). A second sampling was conducted in 2016 with the analysis of the change in wetland ecological conditions from 2011 to 2016 and a ranking of predominate stresses underway.

CONCLUSION

We have come a long way with wetland science but still have many unresolved questions. Sometimes there is congruence with wetland science and policy and sometimes not. Policy makers, especially at the national level, at times, are not attuned to wetland science results or find science not useful. Wetland scientists are often challenged by regulators to give them something with more immediate utility. The separation of wetland functions and values such as in the HGM assessment methodology maybe more useful for physical wetland mitigation but negates the social significance issue. The latter may have more political power in saving a wetland, as it is what affects people. Often times the best results are when wetland studies are co-produced with policy or regulators, thereby identifying a practical or operational use of the findings. ■

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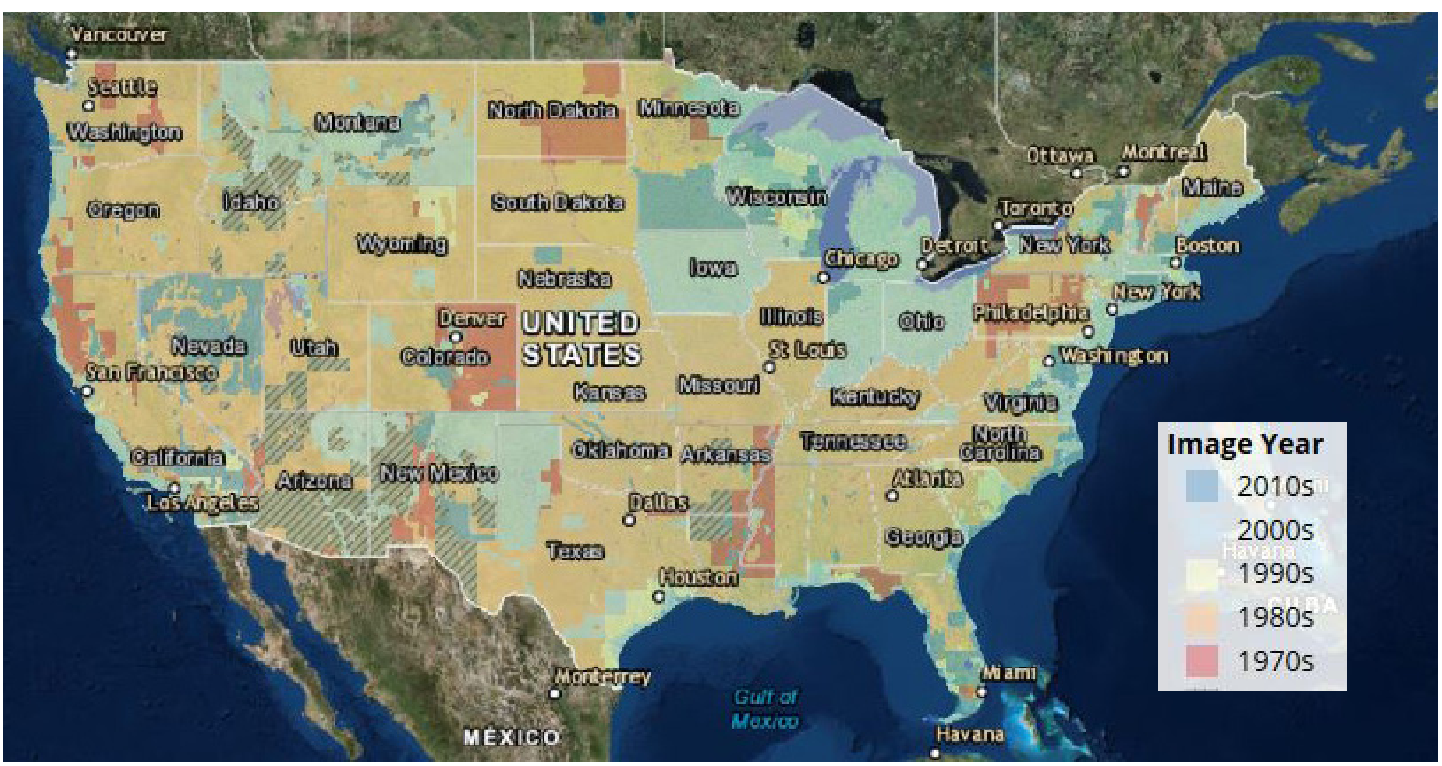
FIGURE 1. Date of imagery used in mapping wetlands for the National Wetlands Inventory. The data for most of the country are from the 1980s (tan areas). (Source: U.S. Fish and Wildlife Service, https://www.fws.gov/wetlands/data/Mapper.html, accessed November 2, 2018.)



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