Wetlands: A Review

With Three Case Studies: The People's Republic of China, The United States of America, and Ethiopia

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Literature Review

Recognition of the economic value and environmental services provided by wetlands is a relatively new concept. In the United States, wetland protection efforts really began with the institution of the Clean Water Act in 1972 and the Carter Administration. In the developing world, efforts have either not yet begun or are relatively recent. As an example, China instituted wetland protection and restoration policies in 2005; however, other countries such as Ethiopia have nearly no regulation. In this paper, I intend to 1) define wetlands, 2)discuss policy and regulatory frameworks that are in place to manage and restore wetlands and 3)present three case studies that provide examples of the implementation of these policies.

Definition

An internationally agreed upon definition of wetlands is unavailable. However, the common and overriding theme of most definitions consists of some component related to hydrologic conditions (Zedler and Kercher 2005, Moore 2008). Despite this, the degree and extent of conditions constituting a wetland is not widely agreed upon (Zedler and Kercher 2005, Ramsar 2011). This is exemplified in a definition from Niering, in which he describes wetlands as areas in which water controls both the environment and associated biota of an area (1985). Regardless of the ecosystem discussed, water is ultimately a primary factor, along with sunlight and nutrient availability, that determine plant life. Likewise, plant life and water are common factors affecting the distribution of other organisms in an area, since water is a necessary

component to sustain life, in addition to plants providing shelter and/or food. Therefore, Niering's broad-reaching definition should be carefully considered. This idea is supported by Moore (2008), who suggests that it is in fact possible to define what a wetland is, but notes a single definition would not justify to the diversity of wetland types that exist.

Perhaps one of the best current definitions of a wetland, at minimum for the context of this paper, was that set by the Ramsar Convention. The Ramsar Convention on Wetlands (1971) produced an international, intergovernmental treaty which defined wetlands somewhat broadly. Article 1 states that wetlands include

"…areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters"

(Ramsar 2011)

Furthermore, the area of land covered by this treaty was later expanded in Article 2, providing that wetland areas

… "may incorporate riparian and coastal zones adjacent to the wetlands and islands or bodies of marine water deeper than six meters at low tide lying within the wetlands."

(Ramsar 2011)

The Ramsar Convention, as well as its implications, shall be discussed in the next section. Despite not having a consistent, concise definition agreed upon commonly by international parties, the definition prescribed by the Ramsar is perhaps the closest substitute, although

noted to be too broad to have the precision necessary for further scientific inquiry (Keddy 2000). However, this will serve as the foundational definition whenever the term "wetland" is used in this paper in order to best encapsulate wetlands on a global scale.

The Ramsar Convention

As earlier noted, the Ramsar Convention, officially named *The Convention on Wetlands of International Importance especially as Waterfowl Habitat,* plays a large international role for wetlands and their conservation. The first intention of the agreement sought to protect waterfowl habitat through the conservation and wise use of wetlands. This was soon realized to be somewhat narrow, and has been further broadened to include all aspects of wetland conservation, as well as recognizing the systems as crucial to biodiversity conservation and the well-being of human communities. The treaty, which now encapsulates 1,916 "wetlands of international importance",

> "embodies the commitments of its member countries to maintain the ecological character of their Wetlands of International Importance and to plan for the 'wise use', or sustainable use, of all of the wetlands in their territories…and furthermore, the conservation and wise use of all wetlands through local, regional and national actions and international cooperation, as a contribution towards achieving sustainable development throughout the world."
>
> (Ramsar 2011)

These areas currently span an approximate area of 187,044,576 hectares (462 Million Acres) over 160 nations which have agreed to the treaty and its terms, covering virtually all geographic regions of the planet. To put the size of this area into further context, the entire surface area of the "wetlands of international importance" covers a spanse larger than the surface area of France, Germany, Spain and Switzerland combined. The significance of this treaty is exemplified in that this is the only ratified global environmental treaty dealing with a particular ecosystem to date (Ramsar 2011). Moore further states on the importance of the Ramsar Convention, noting that it was created to conserve wetlands not only on a purely local level, but rather on a global scale (2008).

Classification

Classification of wetland types can be a very in-depth and complicated process, because the more one considers the variations in wetland characteristics, the more categorizations can be created. However, such in-depth processes would be outside the scope of this paper. In lieu of this digression, one of the most basic classification schemes shall be considered compared to a more advanced system, which will illustrate the point of how complex these classifications can truly be. There are four main types of wetlands in a basic system of classification: swamp, marsh, bog, and fen (Keddy 2000). The following descriptions are based upon a synopsis of literature by Keddy (2000) and Moore (2008):

Swamp (Carr)- "A wetland community dominated by trees with a developed leaf canopy, which have invaded from nearby areas into herbaceous marshes and fens, rooted in hydric soils, but not peat; Examples include tropical mangrove swamps and bottom-land forests in floodplains.

Marsh- A wetland community dominated by herbaceous plants, usually emergent through water and rooted in hydric soils, but not peat; Examples include cattail marshes around the Great Lakes and reed beds around the Baltic Sea.

Bog (Schwingmoor)- A wetland community dominated by sphagnum moss, sedges, ericaceous shrubs or evergreen trees rooted in deep, sometimes uncompacted peat; Examples include blanket bogs which cover mountain sides in Europe and floating bogs which cover the shores of many lakes in temperate and boreal regions.

Fen- A wetland community usually dominated by sedges and grasses rooted in shallow peat, often with considerable water movement through the peat; Examples include the extensive peatlands in northern Canada and Russia, as well as smaller seepage areas throughout the temperate zone."

Keeping these four basic types of wetlands in mind, more advanced classification systems such as those used by the Ramsar Convention and Cowardin, et. al should be considered for comparison. In this system, there are five main wetland systems, each with their own specific subdivisions. The five systems, based upon observations from both Ramsar and Cowardin, et. al are:

Marine- coastal wetlands including coastal lagoons, rocky shores, and coral reefs;

Estuarine- including deltas, tidal marshes, and mangrove swamps;

Lacustrine- wetlands associated with lakes;

Riverine- wetlands along rivers and streams; and

Palustrine- meaning "marshy" - marshes, swamps and bogs.

Furthermore, these classifications can be further categorized into systems and subsystems based upon location, as well as substrate as evidenced in Figure 1 from Cowardin, et. al:

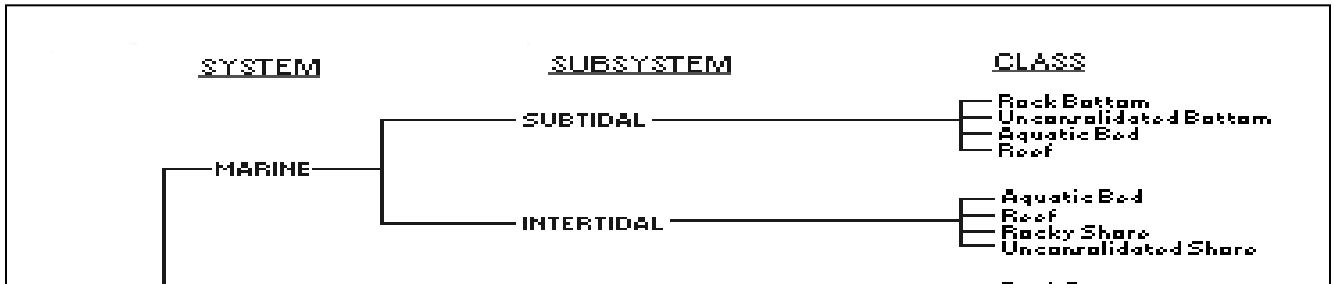

Figure 1. The Cowardin classification of wetland systems; one of the best known and widely used in the United States and adopted internationally by the Ramsar Convention (Cowardin et al., 1979)

can be, and further explains why difficulty exists in precisely defining what a wetland is.

Distribution

Next, a discussion on the global distribution of wetlands past and present is crucial to understand the full context of the ecosystems which will be further detailed in the case studies

section of this publication. According to Keddy (2000), there are three reasons which make wetland mapping difficult on a global scale. First, wetlands cover a relatively small area of the landscape. Second, their distribution cannot be mapped at a suitable scale, as they are often distributed in small patches or strips throughout biomes. Finally, biomes can contain a wide array of wetland types, and that great variability exists across an entire biome (Keddy 2000). (A biome is a broad, regional type of ecosystem characterized by distinctive climate, soil, and biota)

Despite the challenges noted by Keddy, some researchers have sought to quantify and map wetland distribution, but results are highly varied. Vymazal (2011) evidences this in his comparison of three estimates from Matthews and Fung, Aselman and Crutzen, and Lehner and Döll; the paper by Matthews and Fung (1987) estimated that wetlands cover an area of 6.8 million km^2, including 1.5 million km^2 of rice paddies. Aselman and Crutzen (1990) posed a similar estimation of wetland area, proposing that they cover 6.9 million km^2, including rice paddies in their estimate as well. Lehner and Döll (2004) sought to make further estimations of wetland area using technological advances such as Geographical Information Systems (GIS) which were achieved after the two previous studies were published. Lehner and Döll (2004) estimated wetlands to cover an area between 8.3 million km^2 and 10.1 million km^2 worldwide. Figure 2, produced by Keddy (2000), provides a general preliminary picture of the distribution of wetlands from a variety of different studies.

According to some sources, wetlands presently exist on only half of the land area where they historically occurred due to modification and reclamation (World Wildlife Fund 2004). Some argue that because few nations have historically accurate maps, these estimates may not necessarily be exact (Zedler and Kercher 2005).

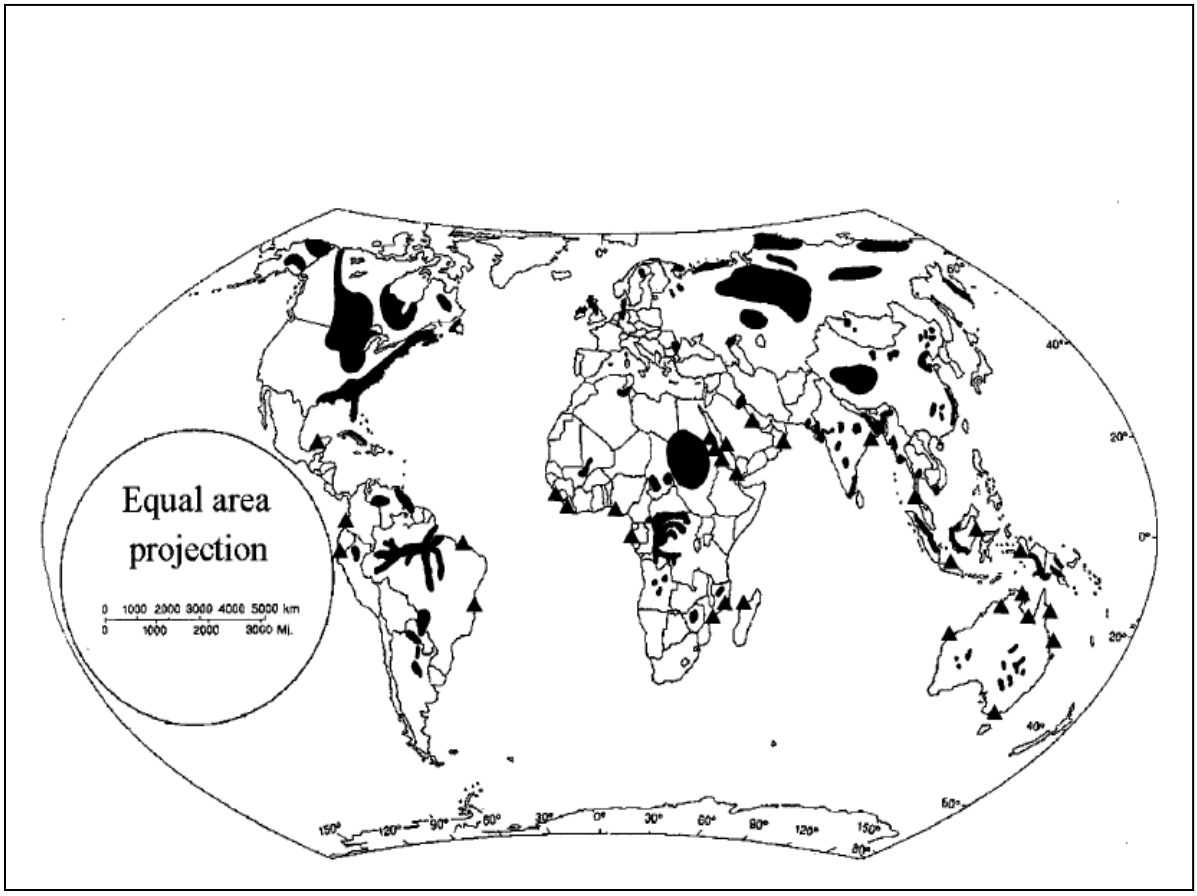

Figure 2. A general distribution of wetlands on a global scale based upon frequency or occurrence. The highlighted areas represent zones of an upland and wetland matrix where the greatest densities of wetlands occur, with triangles representing mangrove swamps. (Keddy, 2000)

The Value of Wetlands

The loss of ecosystem services of wetlands can have both economic and environmental consequences. Multiple authors acknowledge a vast variety of literature has been published

attempting to give wetlands an economic value (Mitsch and Gosselink 2000, BenDor et. al 2008). However, it is important to note that these studies attempt to assign monetary values to the services and functions that are provided by wetlands (Spash 2000, Brander et. al 2006, Woodard and Wui 2001, Carlsson et. al 2003), but these values are difficult to quantify as they are somewhat subjective and subject to fluctuating economic markets This author of this paper agrees with the argument of Moore (2000), who acknowledges that economic values are something which must be inevitably used to legitimize conservation efforts of particular sites and regions; however, assigning monetary value comes with ethical and philosophical issues.

Figure 3 (World Wildlife Federation 2004) provides a non-exhaustive list of suggested wetland functions for consideration. Because all of these services hold variable importance to each individual, their value, whether economic, intrinsic, or a combination thereof, shall be left for the individual to decide.

Wetland Mitigation

Wetland mitigation and remediation attempts to restore ecosystem functions in compromised wetland ecosystems. Remediation projects replace or restore wetlands which have been severely degraded or removed from the landscape, and in some instances create artificial wetlands for aesthetic and/or use value. A simple example of an aesthetic wetland would be a man-made pond in a backyard. A use value wetland could be demonstrated by constructed wetlands used for wastewater treatment (Vymazal 2011).

Regardless of type, multiple authors criticize these efforts based on the difficulty of restoring complete functions to these landscapes. Roberts (1993), Kaiser (2001), and Whigham

(1999) present doubts on the effective capacity of remediated and constructed wetlands. These studies suggest that mitigation wetlands, although attempting to reproduce the same functions and ecosystem services as the original landscapes, often fall short of their intended goal.

Wetland Functions	
Regulation Functions	*Storage and recycling of nutrients*
	Storage and recycling of human waste
	Storage and recycling of organic waste
	Groundwater recharge
	Groundwater discharge
	Natural flood control and flow regulation
	Erosion control
	Salinity control
	Water treatment
	Climatic stabilization
	Carbon sequestration
	Maintenance of migration and nursery habitats
	Maintenance of ecosystem stability
	Maintenance of integrity of other ecosystems
	Maintenance of biological and genetic diversity
Carrier Functions	*Agriculture, irrigation*
	Stock farming (grazing)
	Wildlife cropping/resources
	Transport
	Energy production
	Tourism and recreation
	Human habitation and settlements
	Habitat and nursery for plant and animal species
Production Functions	*Water*
	Food
	Fuel wood
	Medicinal resources
	Genetic resources
	Raw materials for building, construction and industrial use
Information Functions	*Research, education and monitoring*
	Uniqueness, rarity or naturalness and role in cultural heritage

Figure 3. A non-exhaustive listing of general wetland functions (World Wildlife Federation 2004)

Case Studies

China

A short review of China's overall environmental quality and challenges is crucial to fully understanding the setting of wetland management and protection in China. China possesses the largest population in the world at 1.34 billion people, roughly 20% of the world's total (United States Central Intelligence Agency 2011, Liu and Diamond 2005). Many resources are needed to sustain such a large population, especially as consumer's demand increases. In China increased consumer spending is indicated by figures such as three-fold increase in the amount of house floor area per person while a marked decrease in household size between 1985 and 2000 (McElroy et. al. 1998 from Liu and Diamond 2005). These two aspects mean that people are living in larger quarters with fewer individuals, moving beyond a level of necessity to a level of greater luxury. In addition, the resources needed for these increased consumer demands are having international impacts on China's resource utilization.

With such a large population, China seeks to provide for the growing consumerist demands of its people and economy by reliance upon the environment and its resources. Its ecological footprint is the second largest by country in the world, ranking just behind the United States (Liu and Diamond 2005). Liu and Diamond perhaps best summarize the current environmental situation in China in the closing arguments of their publication by stating that:

> "China is lurching between accelerating environmental damage and accelerating environmental protection. Its large population and booming economy mean that China's

> lurches carry more momentum than those of other countries. In the past two decades, China has created an economic miracle. [It is hoped] that over the next two decades, China can also create an environmental miracle and set a good example for other nations to achieve both socioeconomic and environmental sustainability." (2005)

As clearly demonstrated by Diamond and Liu, China has many ecological issues which have not yet been addressed, particularly in the context wetland loss and conservation.

Wetland Loss

Natural wetlands occur on 3.8% of the Chinese landscape (660,000 km^2), accounting for approximately 10% of the global area of wetlands (An et. al. 2007, Liu and Diamond 2005). Between 1990 and 2000, 30% of China's natural wetlands were lost according to a study conducted to track the spread of the avian flu (Cyranoski 2009). The study conducted by Peng Gong utilized 10 years of satellite data to identify wetland locations, and resulted in Gong unknowingly creating the first ever comprehensive wetlands map for China. Furthermore, An et. al. (2007) estimate that of the natural wetland area lost in China over the past fifty years, China has lost 23.0% of its freshwater swamps, 16.1% of its lakes, 15.3% of its rivers, and 51.2% of its coastal wetlands. According to the Chinese Forestry Administration, there are multiple factors that seriously threaten wetlands and their survival, including reclamation, natural wetland transformation, environmental pollution, and unsustainable use of wetland resources (2006, from Wang et. al. 2008).

An et. al. (2007) and others indicate that land reclamation has so far taken the largest role in wetland loss, estimated at 82% of all the loss in China. Most of this occured during the

past fifty years. The concept of land reclamation is not new in China. Documented land reclamation dates back to 770 BC, where people filled lakes and used them for agriculture during the fall and spring months of the Warring States Period in Chinese history (State Forestry Association 2002, from Wang et. al. 2008).

The Sanjiang Plain

The Sanjiang Plain of Northeast China presents an example of China's wetland loss due to reclamation. It is located in the Northeast portion of the Heilongjang Province, with its geomorphologic setting being a vast, low lying alluvial floodplain (EEPSEA 2009). World renowned for hosting many large, rare water birds such as globally threatened cranes (eg. The Oriental Stork [*Ciconia boyciana*], White-Napped Crane [*Grus vipto*], and Red-Crowned Crane [*Grus japonensis*]) (Zhang et. al 2009), it serves as well as a major site for migratory waterfowl. The most prevalent landscape types are wetland (0.9 million hectares, or 27% of Heilongjiang's wetlands) and cultivated land (4 million hectares, or 30% of Heilongjiang's cultivated land area).

An et. al. (2007) present that from 1825-2000, this plain lost an estimated 83.7% of its total wetland area from reclamation (Zhao 1999 and Deng et al. 2004, from An. et. al. 2007). Peng Gong (in Cyranoski 2009) estimates that wetland area in the Sanjiang dropped from 22,392 km^2 in 1990 to 10,114km^2 in 2000, a marked decrease of roughly 44% during that timeframe . Yang and Chen (2011) state that 51% of the wetlands of the Sanjiang have been lost in the last two decades. Consequently, the existing wetland area is only a small fragment of its historical extent, regardless of which estimate one might agree with.

The Sanjiang is now known for its widespread agricultural activity achieved through utilizing the reclaimed land as its foundation (Zhang et. al. 2009). According to Wang et. al. (2006, from Zhang et. al 2009), these lands have been developed at the cost of wetland loss for cultivated land and grain production development; More specifically, the area is renowned for mass production of high quality beans and rice.

Action

Despite considerable loss of wetlands like those of the Sanjiang Plain, China has begun to take action in the preservation and restoration of its natural wetland landscapes. In 2005 the State Forestry Administration of China released new policies in relation to wetlands. These policies included provisions and goals such as placing 90% of China's natural wetlands under protection by the year 2030, establishing regulations to return reclaimed croplands to wetlands (swamps, lakes), and allocating funds to restore natural wetlands (State Forestry Administration of China 2005, from An et. al. 2007).

In terms of protection, 145,000 km^2 of natural wetland area was protected as of 2003 along with 280 000 km^2 of marine and terrestrial ecosystems adjacent to the wetlands before passage of the 2005 policies. In order to reach their goal of 90% protection by 2030, 225 new wetland reserves were planned to be established by 2010 with an additional 135 by 2030 (no reports were found, despite many attempts by the author, to verify whether the 2010 goal was ever achieved). In terms of restoration, a minimum amount of $100 billion dollars US was appropriated to start 53 programs to restore and recreate an additional 14 000 km^2 of natural wetlands by 2030 (An et. Al 2007). As recently as 2008, the State Forestry Administration of

China also announced a $14.6 million dollar plan to begin a new wetland mapping project using remote sensing data, a crucial element in the organization of restoration, conservation, and wise use initiatives (Ecotourism, wetland national parks, etc.) of their country's wetlands (Cyranoski 2009). In summary of China's actions and promises regarding wetlands, An et. al (2007) comment that China now understands that their sustainable development is highly dependent upon natural wetland ecosystems, and the aforementioned policies attempt to ensure their protection and restoration.

Review

The Chinese government's efforts regarding wetlands have encountered both praise and skepticism. According to Cyranoski (2009b), many Western environmentalists tend to envy the "speed and lavishness" at which wetland conservation and restoration projects in China are proceeding at. This is understandable, as many Western nations devote extended periods of time to formulate regulations, appropriate funds, approve and review plans, and then finally put them into action (arguably due to many levels of bureaucracy and legislation). An example of this was exemplified in the difficulty of repairing Louisiana after Hurricane Katrina in 2005; the indecisiveness by the government, along with the conflict of individual rights/autonomy involved in forcible seizure of all of the land (in order to repair deltas and other infrastructure) has prolonged rebuilding (Cyranoski 2009b). This challenge remains evident as Louisiana still continues to rebuild after the hurricane's destruction.

In contrast to those praising China's wetland efforts remain other skeptic authors. Some warn that China has exhibited many weaknesses, particularly when it comes to receiving feedback from scientists and other critics on its ideas. Without consideration of this feedback, inefficient projects tend to occur. Others doubt China's ability to fully consider the consequences of their sometimes elaborate, "beautiful, and often breathtaking" projects (Cyranoski 2009b). These concerns are parallel to the wetland projects China is currently proposing; feedback from citizens and environmentalists alike may not be considered by the government, and the government could potentially cause reckless destruction with water diversion projects meant to restore wetland areas (Cyranoski 2009b).

The United States

In order to understand the current situation of wetlands in the United States, it is crucial to understand the history of how wetlands have been perceived from a cultural perspective, as well as how policy and regulation have developed in response over time. Multiple culturally historical examples depict wetlands with a negative connotation. Mitsch (2010) proposes numerous examples of how wetlands have been depicted as, "sinister and forbidding, and as having little value". Most notably, he notes how the famous scientist Carl Linnaeus, sometimes known as "the father of modern taxonomy", viewed the Lapland Peatlands comparable to the Styx of Hell. Much like the perception of Linnaeus, the United States Supreme Court decision of *Leovy vs. United States* (1900) described wetlands in their decision as a "fact which may be supposed to be known by everybody…that swamps and stagnant waters are the cause of malarial and malignant fevers, and that police power is never more legitimately exercised than

in removing such nuisances" (from Braddock 2007). In 1954, the movie *The Creature From the Black Lagoon* depicted a dark, mysterious, human-shaped creature emerging from a black, backwater swamp which was responsible for causing "havoc and death" (from Braddock 2007). These perspectives are exemplified in the US Swamp Land Acts of 1850 and 1855, which were the initial sets of laws granting states the ability to reclaim swamplands, prevent destruction from flooding, and eliminate mosquito breeding areas (Shaw and Fredine 1956, from Braddock 2007). These perceptions lead to a willingness in the American public to contribute to vast losses of wetlands totaling an estimated 53% of the original wetland area in the lower forty-eight states over a 200 year span (Dahl 1990, from Braddock 2007).

Redefining Wetlands- Public Perception

These actions continued until the Federal Water Pollution Control Act, better known as Section 404 of the Clean Water Act, was enacted in 1972 (to be further discussed later in this paper), and further supplemented by Executive Order 11990 during the Carter Administration in 1977. Braddock maintains that Carter's order shifted public perceptions on wetlands and their importance (2007). Furthermore, Carter issued this statement with his executive order, stating that

> "The Nation's coastal and inland wetlands are vital natural resources of critical importance to the people of this country. Wetlands are areas of great natural productivity, hydrological utility, and environmental diversity, providing natural flood control, improved water quality, recharge of aquifers, flow stabilization of streams and rivers, and habitat for fish and wildlife resources. Wetlands contribute to the production

of agricultural products and timber, and provide recreational, scientific, and aesthetic resources of national interest.

The unwise use and development of wetlands will destroy many of their special qualities and important natural functions…[The] alteration and destruction of wetlands through draining, dredging, filling, and other means has had an adverse cumulative impact on our natural resources and on the quality of human life."

(Woolley and Peters n.d.)

Redefining Wetlands- The Formation of a Sound Scientific Definition

After the value of wetlands was clarified by Carter and had changed public perception, a "legally binding and scientifically defensible" definition was needed to unite the cause of hydrologists, soil scientists, botanists, and others who were responsible for the protection and conservation of wetland habitats. This has arguably been the most difficult and critical component of conservation as the "battle over wetland protection and regulation has escalated" to its current state (Braddock 2007). After multiple attempts, the most comprehensive and widely accepted definition and classification for wetlands in the United States was developed by the United States Fish and Wildlife Service in 1979, and is more commonly known as the "Cowardin System". This system defines wetlands as,

" lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For purposes of this classification, wetlands must have one or more of the following three attributes:

> (1) at least periodically, the land supports predominantly hydrophytes [(plants that grow in water)] (2) the substrate is predominantly undrained hydric soil [(wet and periodically anaerobic)] and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of the year."
>
> (Cowardin, et. al 1979)

This definition holds an important role, serving as the basis for the first National Wetland Inventory of 1979. It is still used to this day as part of the delineation (identification) process of wetlands and their boundaries.

At the legislative and regulatory levels, an alternative definition from the United States Army Corps of Engineers and the United States Environmental Protection Agency is most common (Broddock 2007), stating that

> "Wetlands are those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions"
>
> (33 Federal Register 328.3 1982 and 40 Federal Register 230.3 1980, from Braddock 2007)

Concurrently, the definitions developed by Cowardin et. al, the United States Environmental Protection Agency, and the United States Army Corps of Engineers provide the

basis for what many in the United States call the “bible of wetland delineation”, officially known as the *1987 Army Corps of Engineers Wetland Delineation Manual*. The development of this manual will be further discussed later in discussion of Section 404 of the Clean Water Act. At this point, it is important to note that the publication legally defines the process by which the boundaries of an individual wetland are delineated in the field. These boundaries define areas of regulatory control or jurisdiction. To summarize the aims of the manual, it provides the technical guidelines for wetland delineation from Cowardin’s three base parameters (hydrology, hydric soils, and hydrophytic vegetation), and requires that all three parameters be present in order for an area to be considered a jurisdictional wetland.

The Clean Water Act

The development of wetland definitions allowed the 1972 Federal Water Pollution Control Act, better known as Section 404 of the Clean Water Act, to protect wetlands. Section 404 of the Clean Water Act “establishe[d] a program to regulate the discharge of dredged and filled material into the waters of the United States…[and] requires a permit before dredged or fill material may be discharged into waters of the United States,” (US EPA n.d.).

Although wetlands are not specifically mentioned in the act itself, they can be subject to Section 404 because they are hydrologically active enough at some point during the year to create the conditions noted in the definition of Cowardin et. al. As long as this hydrologic activity has a “significant nexus” (hydrologic connection) to another body of water, they are covered under this rule, as they play a role in the “waters of the United States” (US EPA n.d.). Under Section 404 B, the discharge of dredge or fill materials from incidental or negligible

sources are exempted from obtaining a permit. These include activities such as: normal farming practices, silviculture, ranching activities, or maintenance of structures in waterways; construction or maintenance of farm ponds, irrigation systems, drainage ditches, farm roads, forest roads, or mining roads. However, these activities do require a permit if they change the use, impair the flow, or reduce the reach of waters. Other activities under Section 404 are mandated to obtain permits, which include fill material for development (construction), water resource projects (dams and levees), infrastructure development (highways and airports), conversion of wetlands to uplands for farming and forestry, mining projects, and any other activity that would alter the use, flow, or reach of water. In the instance one of these activities must be completed, applicants for the permit must show that they have, where practicable, "taken steps to avoid wetland impacts, minimized potential impacts on wetlands, and provided compensation for any remaining unavoidable impacts," (US EPA n.d.).

Enforcement of Section 404

Multiple federal resource agencies are involved in enacting and enforcing Section 404. The United States Environmental Protection Agency is charged with legislative and regulatory matters in relation to Section 404, as well as delegation of authority over permitting and oversight of wetlands. This includes delegation to state and tribal authorities. They also maintain the power to veto decisions of the United States Army Corps of Engineers. Under the Clean Water Act, the Army Corps of Engineers is charged with the responsibilities of wetland delineation and permitting, and use the *1987 Army Corps of Engineers Wetland Delineation Manual* as their foundation. Finally, the United States Fish and Wildlife Service, in accordance

with the Fish and Wildlife Coordination Act, is charged with evaluating impacts on fish and wildlife for all federal projects, including those which fall under the jurisdiction of Section 404. (US EPA 2009)

Section 404 Conclusions

Section 404, as mentioned, plays a crucial role in the protection of wetland habitats, and has been a major item of attention in court cases and disputes at both the state and federal level. The federal court case of *Rapanos vs. United States* demonstrates this.

Rapanos vs. United States

Rapanos vs. United States addressed the jurisdiction of the "waters of the United States," as referred to earlier Section 404 of the Clean Water Act. More specifically, isolated wetlands (wetlands not near or adjacent to a navigable body of water) were the target of this case. The United States sued Rapanos (after multiple cease and desist orders), charging them with discharging fill material without a permit into 54 acres of wetlands scattered across multiple counties in Michigan which they owned. They filled the wetlands in order to make the land more conducive to development (Duke Law 2005). Rapanos argued that because their wetlands were connected via man-made surface water connections (pipes and ditches) only, their wetlands did not fall under the jurisdiction of the United States. They claimed that because the wetlands did not directly abut a navigable waterway, Section 404 of the Clean Water Act could not be enforced. However, the district court did not agree with the argument of Rapanos, stating that because the surface connections on the property linked to tributaries that eventually connected with navigable waterways, they were considered adjacent wetlands.

Rapanos appealed this decision, only to be once again denied by the Sixth Circuit Court of appeals, which affirmed the district court's decision that the Clean Water Act has jurisdiction over wetlands with a "significant nexus" to the waters of the United States. Furthermore, they stated that Section 404 of the Clean Water Act did not require that wetlands abut a navigable waterway in order to fall under jurisdiction.

Eventually, this case reached the Supreme Court in 2005, where the previous court decisions were overturned. "Significant nexus" was ruled to deal with adjacency of a wetland to a navigable body of water, rather than a mere hydrological connection to a navigable waterway. Furthermore, it was determined that the United States Environmental Protection Agency and United States Army Corps of Engineers were overstepping their regulatory power in enforcing incidents where no significant nexus (adjacency to a navigable water body) was present.

Ethiopia

Before discussing the challenges of wetland management and the current state of wetlands in Ethiopia, it is beneficial to note the observations of Abebe, who states that,

> "while rates of wetland loss are documented for the developed world, the limited study of these ecosystems in countries like Ethiopia leaves us with little to say. Wetland loss is evident wherever major developments like dams, irrigation schemes, and conversion projects are present in the developing world."

(2003)

This statement clearly demonstrates one of the greatest impediments to discussion of Ethiopian wetlands, which is the problem of a lack of published information. This lack of resources demonstrates a need for further study of Ethiopian wetlands to construct a baseline of knowledge. Multiple authors suggest that more information be published to improve wetlands management and protection in Ethiopia (Abunie 2003, Wonderfrash 2003, Hailu 2003, Woldu and Yeshitela 2003, Desta 2003, Haack 1996 and Vogt et. al. 2006 from McHugh et. al. 2007).

According to Cummings (1977, from Haack 1996), inadequate information is a common problem in lesser developed nations, causing issues in the evaluation of current and changing environmental conditions, and eventually leading to a lack of decision making or uninformed decision making. This lack of information becomes crucial, as wetlands play a vital role in the livelihoods of many people in developing nations via a variety of environmental services and socioeconomic benefits (Silvius, et. al 2000, and Millenium Ecosystem Assessment 2005, from Dixon 2008). Dixon and Wood (2008) comment that because of wetlands' ability to fulfill a wide range of environmental functions and produce multiple products that are socially and economically beneficial to local communities, they are becoming increasingly important and recognized as vital natural resources.

Consequently, this case study is a summary of the main topics from the few sources obtained on the subject, and by no means should be considered a comprehensive examination of the wetlands of Ethiopia.

Wetland Distribution in Ethiopia

Ethiopia exhibits a wide range of geologic formations and climatic conditions which create numerous wetland ecosystems including 12 rivers, eight major lakes, and many swamps and floodplains (Abunje 2003). Hillman lists a total of 77 wetlands in Ethiopia and the country of Eritrea, finding that Ethiopian wetlands span a 13,699 km^2 area, or roughly 1.14% of the country's land surface (1993, from Abunje 2003). Kindie (2001, from McHugh et. al 2007). estimates that area to be slightly less at 11,250 km^2, but still over 1% of the total surface area of the country. However, Wonderfrash (2003) maintains that Ethiopia is "endowed with an array of wetlands too numerous to be counted". He further comments that Ethiopia is often referred to as the "water tower of northeast Africa," as Ethiopia spans an entire watershed area between the Mediterranean Sea and the Indian Ocean (2003).

Wetland Use by Local Cultures

As noted earlier by Cummings (1977, from Haack 1996), wetlands play a crucial role in the well-being of citizens in lesser developed nations, with Ethiopia being no exception. According to Hailu (2003), wetlands are used by virtually all households in the Western Wellaga and Illubador zones directly or indirectly. The main uses are social/ceremonial reeds, medicinal plants, thatching reeds used for housing construction and granary roofing, domestic water supplies, dry season grazing land, water for livestock, temporary crop-guarding huts of reeds, cultivation, and craft materials (2003). Furthermore, minor uses such as establishing coffee and tree nurseries on wetland fringes, clay collection for pottery, and use of wetland tree bark for making ropes were also noted (2003). Dixon and Wood agree with Hailu, noting that *cheffe*

(*Cyperus latifolius)* is the dense reed vegetation used for roofing, craft material, fodder for cattle, and as a marketable commodity in a range of ceremonies and celebrations throughout the year (2008). The availability of the noted materials in these regions is extensive, as wetlands are noted to comprise 4-5% of the total landscape by multiple authors (Hailu 2003, Woldu and Yashitela 2003, Dixon and Wood 2008, Maconachie et. al 2008). In addition, these areas provide multiple ecological benefits such as water storage, sediment control, groundwater recharge, stream flow moderation, water filtration and purification, plant and fish products, biodiversity, and wildlife habitat (McHugh et. al. 2007).

Wetlands as a Clean, Reliable Water Supply

Edossa et. al. (2008) stress the importance of water resources from these wetlands, as the water supply in Ethiopia is among the lowest in Africa. Furthermore, they state that wetlands provide a crucial resource during the dry season, when those in rural regions of semi-arid and arid parts of the country must frequently travel great distances, sometimes 4-6 hours, to obtain water from areas not already exhausted by the prolonged dry season (2008).

Wood (2003) notes that the primary gatherers of water in Ethiopia are women, and that this increase to a woman's workload may have larger impacts because they are left with less time to fulfill domestic duties. This may lead to child malnutrition from lack of attention and could extend even further into family life, as women are then forced to obtain their water from local streams, which are more likely to be polluted (Wood 2003). This unsafe water may lead to even greater issues such as ill health among the entire family, which in turn affects farming and

other domestic and economic activities, reducing food security and lowering economic well-being (Wood 2003).

Wetland Cultivation

A major factor limiting the availability of resources from wetlands in Ethiopia comes from extensive farming which has increased largely over the past century in the Western Wellaga and Illubador Zones (Dixon and Wood 2008). According to Maconachie, wetland cultivation in these zones may date as far back as the mid-19th century, and possibly centuries earlier (2008). Mulugeta maintains that cultivation of wetlands has existed here for at least eight decades, with an average cultivation of 23% of the total wetland area (Mulugeta 2004). During this time period, cultivation extended beyond the use of wetland margins to include much larger wetland areas-- complete drainage and cultivation is now commonplace throughout the region (Dixon and Wood 2008).

Coffee production in the early 1900's also placed pressure on starting further wetland cultivation, as more uplands were being used for its cultivation, making it necessary to expand into new portions of habitats (Solomon 1999, from Hailu 2003). This expansion was largely due to a food shortage because of drought conditions (Hailu 2003, Dixon and Wood 2008). According to Hailu, roughly 20% of the Illubador Zone wetlands were cultivated between 1986-1998, increasing drastically in 1999 to 35% or 7,100 hectares of the wetland area. Some of this might be accounted for by increased government pressure from 1974-1991 as food-sufficiency targets were set for the region, and those unwilling to cultivate their wetland plots risked losing them to those who were willing to do so (Dixon and Wood 2008). In addition, over 100,000

people were moved to the region by a government decision during a famine in 1984 (Dixon and Wood 2008). In 1999, the government increased their pressuring of farmers to cultivate wetlands in order to compensate for more drought-induced food shortages (Dixon and Wood 2008). Mulugeta states that 70% of the farmers in the area have participated in these activities at least once (2004), presumably due to this large amount of pressure put on farmers. Mulugeta further notes that more than two-thirds of the people in this region depend on agriculture as their principle source of income (2004). Today, wetland cultivation provides between 10%-20% of the annual food needs of the region, but can be as high as 100% during the summer months in some areas (Dixon and Wood 2008).

Wetlands as a Source for Housing

Complete drainage of wetlands leads to many issues regarding the local collection of sedges and reeds for roofing and housing, as only the rich can afford alternative building supplies (Wood 2003). According to Mulugeta (2004), local cultures have established some regulations for sustainable reed growth, thereby protecting wetlands to provide a high water table in order for reeds to grow. The concern is so large that 87.4% of people in one area thought that the greatest advantage to leaving wetlands uncultivated was the adequate and steady supply of reeds; this was valued even more than the loss of water (Mulugeta 2004).

Despite this effort to maintain the reeds, population pressures and food shortages have caused changes in the wetlands. 45% of the people Mulugeta surveyed observed reduced vegetation cover and volume of water in the wetlands (Mulugeta 2004). Although it is a common view that only the poorer members of society are responsible for this wetland

cultivation, this has been disproven. Wealthier groups often control or own these wetland areas, with middle-class farmers exploiting them the most and the poor being the least involved (Wood 2003). Wood maintains that wetland cultivation is resource sensitive, and that those who can afford oxen and money or food for daily laborers are those who are most successful (Wood 2003).

Summary and Further Research Prospectives

Unexamined by this report are the many complex political changes that have occurred in Ethiopia over time, particularly in relation to how politics have led to changes in the structure of wetland management on a local level. This relationship, as well as its transitions over time between the government and local wetland governance bodies, is a very complicated discussion, and its complexity is beyond the scope of this publication. However, significant research has been published in this area, and many authors maintain that these relationships have played a crucial role in the overall scope of wetland management, as well and caused social disparity among those competing for the use of wetlands. (For further information, see Dixon and Wood 2008, Edossa et. al 2008, Wood 2003).

To conclude, wetland management and protection in Ethiopia is best summarized by Wonderfrash, who states that despite the crucial importance of wetlands to Ethiopian survival and well-being,

> "there is little or no awareness of the current status, threats, or values of [Ethiopian] wetlands, or even the need for their conservation and sustainable utilization. Although there are individuals in various organizations with various

> expertise and awareness, no coordination exists between these organizations for the conservation, management, and wise use of wetlands in Ethiopia. At another scale, the mandates of stakeholder institutions to address wetland issues are not clearly defined. As a result, there is no entry point for one to initiate any effective wetland undertaking at the moment"
>
> (2003)

Critique of Wetlands Conservation and Loss in China, the United States, and Ethiopia

Nations around the world are struggling with wetland conservation and loss. The case studies of Ethiopia, China, and the United States offer a broad perspective on this issue due to various stages of development. In addition, each of these cultures places their own particular values on the functions of wetlands, as a source for housing materials and clean water, as a food supply, or as a store of intrinsic value.

A general pattern emerged when it came to finding sources. Generally, the lesser developed the nation, the longer it took to find sources for that nation. Ethiopia, the least developed nation of the three case studies, required a much more extensive literature review. Almost two full months were needed until all of the applicable sources were available for analysis. This was no surprise, as multiple authors noted that more research was desirable in Ethiopia in order to make educated decisions on needs. Due to this lack of published literature, it is difficult to estimate the original distribution of wetlands in Ethiopia and whether that

distribution has decreased over time due to anthropogenic influences. As completed research begins to inform others about the issues which persist there, it has the power to inspire others to investigate or conduct their own research in Ethiopia.

China also presented a very unique challenge regarding review of literature, as sources were overall quite limited. Although few authors noted the need for further research, it is clear that China also presents a case where more published studies are needed to make sound decisions. Of the literature collected, it is difficult to tell whether the authors of their papers are truthfully presenting the case (especially for government agency publications). Even a simple Google or Wikipedia search to compare website "hits" to general information in the reports yields little to no results. Recent media stories have noted that China is particularly strong in its censorship of material entering and leaving the country via the internet (especially Google). This may explain why informational sources were difficult to find and why few studies existed examining the same topic.

Finally, information about wetlands in the United States was found relatively quickly and a wide variety of sources existed supporting the findings of one another (multiple authors coming to the same or like conclusions).

Each of these countries presented their own unique issues on wetland conservation and loss. In the United States, the most developed of these nations, the most common issue now deals with wetlands regulation and permitting as more and more land is developed for industry, economy, and other reasons. Despite the lessons learned a century ago about the long-term costs of filling and dredging wetlands, popular culture still finds this practice acceptable. This is

even more surprising, as our country has established multiple regulations encouraging people not to do so and fining those who do without first getting consent.

From these observations, it remains clear that economics continue to dominate decisions related to wetland development in the United States. Even though the United States is arguably the most materialistic in the world, consumers still feel the need to buy more possessions, thereby consuming more natural resources.

The development of wetlands in the United States becomes almost unacceptable when juxtaposed to the case of Ethiopian wetlands, where the livelihood and well-being of many people relies on the ability of wetlands to continue to produce shelter, food, and water. It remains unclear from my compiled research whether Ethiopian wetlands are in a state of dire need, or are functioning as they always generally have. This demonstrates the main concern for Ethiopian wetlands—a lack of sound and widespread research; without this, it is difficult for action to be taken in protecting these environments and in working with local cultures to discover better alternatives or new solutions to meeting their needs.

Finally, some authors have expressed doubts on the ability of China to complete their planned wetlands conservation activities (Cyranoski 2009). The need to adopt adaptive management practices may also be great in that much of the technical expertise has not been gained. It is only imaginable that as populations and Westernization continue to increase in China, this will tax the already dwindling natural resources of the region and globally. Probably due to government censorship, it is challenging to make a sound determination of what really needs to be done in China to preserve their wetlands and effectively adopt external input.

To conclude, wetlands have acted as important habitats for many ecological and socio-economic reasons, and continue to do so. The challenges for their conservation are vast and situationally unique. Through arguments presented in this paper, I have found that more research is required in many parts of the world in order to better understand wetlands and the crucial role they play. The research which already exists is often not published, and research that is published is often not used by those implementing protection/restoration activities. Finally, the studies of this paper made it apparent to me that natural resource managers from all disciplines are needed to utilize their knowledge and expertise for conservation on an international scale, particularly in the case of wetlands; if we as managers only protect our immediate ecosystems and fail to acknowledge their global interconnectedness, our environment will fail to function as it naturally would.

Executive Summary

No internationally agreed upon definition of wetlands exists, but the definition of wetlands set by the Ramsar Convention is arguably the best definition to use on a global scale. The Ramsar Convention of 1971 plays a large international role for wetlands and their conservation today. The convention produced the only ratified global environmental treaty dealing with a particular ecosystem to date, which now protects roughly 462 Million Acres of wetlands, spanning every continent except for Antarctica. Both simple and complex schemes of wetland classification exist, but the classification system most accepted worldwide and in the United States is the system designated by Cowardin et. al (1979). Multiple authors have attempted to estimate the amount of global area where wetlands exist, ranging from 6.8-10.1

million km^2. However, the historical area that wetlands covered is thought to be double these estimates (World Wildlife Federation 2004). Wetlands can provide a wide range of ecosystem functions, offering potential aesthetic, intrinsic, and monetary value. Wetland mitigation and remediation projects attempt to restore damaged wetlands or create new wetlands to replace those destroyed. However, skeptics question if they provide even a fraction of the same functions or values of natural, undisturbed wetlands.

China has experienced vast wetland loss over the past 50 years, primarily due to land reclamation for agriculture. The Sanjiang Plain is just one example of this loss, which now is known for its booming agricultural industry. China has taken aggressive action in policy and fund appropriation to protect the few remaining natural wetlands it has left, as well as for restoration of wetland habitats which still can be saved. Western environmentalists praised the actions of the Chinese government for these policies, but many people still remain skeptical if these policies will be effective, or if China will accept feedback to improve its efforts. Skeptics worry that despite the promises of China's policies and actions towards wetlands, crisis and failure may occur; the need for adaptive management is not often facilitated under an authoritarian government. Despite the important nature of these aggressive new wetland policies, no available review exists that critiques if the Chinese government is following through on its pledge to conservation of wetland ecosystems.

Wetland protection in the United States has undergone many changes over the last 200 years. Although once considered "nuisances" and the main "cause of malarial and malignant fevers", President Jimmy Carter redefined the importance of wetland habitats in the United

States from a public perspective during his presidency. Concurrently, his efforts to create the Clean Water Act, specifically Section 404, gave the Environmental Protection Agency regulatory powers over the "waters of the United States", including wetlands. It also gave enforcement power to the Army Corps of Engineers, and charged them with the task of wetland delineation in order to define the boundaries of federal jurisdiction. To accomplish this, Cowardin et. (1979) created a comprehensive classification system used to create a basis for the *1987 Army Corps of Engineers Wetland Delineation Manual. Rapanos vs. United States* is a primary example of the escalating battle between wetland protection and land development in the United States since development of the Clean Water Act.

Multiple authors agree more research is needed to facilitate better discussion on the protection and conservation of Ethiopian wetlands, as very few studies currently exist. Despite this lack of information, wetlands play a crucial role in the lives of rural and urban populations. Social/ceremonial reeds, medicinal plants, thatching reeds used for housing construction and granary roofing, domestic water supplies, dry season grazing land, water for livestock, temporary crop-guarding huts of reeds, cultivation, and craft materials are all supplies obtained from local wetlands. Of these items, water, reeds, and food tend to be the most important. The water supply in Ethiopia is among the lowest in Africa, and wetlands provide this crucial resource during the dry season. Many in rural regions of semi-arid and arid parts of the country must frequently travel great distances, sometimes 4-6 hours, to obtain water from areas not already exhausted by the prolonged dry season. However, the loss of reeds is of greater concern to locals than water--87.4% of people in one area thought that the greatest advantage to leaving wetlands uncultivated was the adequate and steady supply of reeds. However,

wetland cultivation is a reality in many parts of Ethiopia, with wetlands sometimes providing up to 100% of the food supply during dry summer months. The Western Wellaga and Illubador Zones are primary examples of food demand increases, where roughly 20% of the wetlands were cultivated between 1986-1998, increasing drastically in 1999 to 35% or 7,100 hectares of the wetland area. However, the effects of wetland cultivation and other activities on the distribution and health of wetlands in Ethiopia is unknown, as little to no research has been published to quantify these effects.

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