POLICY BRIEF

How Much Are Tennessee Wetlands Worth?

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Wetlands provide a range of services that benefit humans. Estimating the total economic value of wetlands requires accounting for all of these services, even though most are not monetized through markets. Wetland values fall under four main categories (Boyer and Polasky 2004): (1) direct use values such as recreation and provision of food or fuel; (2) indirect use values such as nutrient retention, flood control, climate stabilization, and water filtration; (3) option value derived from potential future uses; and (4) existence values such as maintaining biodiversity and cultural heritage. Advances in nonmarket valuation have made it possible to estimate the value for many of these services in monetary terms, which can be summed to arrive at an estimate for total economic value.

To our knowledge, there have been no direct estimates for the total economic value of wetlands in Tennessee. Over the past several decades, however, numerous studies have attempted to estimate the value of freshwater wetlands generally. These studies differ in their geography, scale, dimensions of value, and methodology, all of which have a significant impact on results. Despite these variations, a focused and systematic review can provide a rough estimate for the range of likely values for Tennessee. We start by looking at the coarsest estimates (those that are based on many geographically heterogeneous studies), then we gradually refine the review to focus on studies that most closely match the characteristics of Tennessee. Finally, we synthesize the results into a lower and upper bound ($19,454 – 33,232) for the annual per hectare value of wetlands in Tennessee.

A small number of studies attempt to aggregate prior valuations into an 'average' total value per unit of wetland. A well-known example is the effort by Costanza et al. (1997) to estimate the total value of ecosystem services at a global scale. Regarding freshwater wetlands, they synthesized results from nine primary studies to derive an estimate of $19,580 ($34,402 in 2020 USD) for the annual value per hectare for swamps and floodplains. The services providing the largest contributions are water supply (39%), moderating extreme events (37%), cultural value (9%) and waste treatment (8%). The exercise by Costanza et al. (1997) can be thought of as an early example of benefit transfer, the general term for applying results from one or more primary studies to estimate value at a target site where primary data is unavailable. In subsequent years, benefit transfer methodologies have become increasingly sophisticated and the number of primary studies has grown.

To facilitate the expansion of benefit transfer, a few databases of primary valuation studies have been compiled. The most well-known was published in 2010 by The Economics of Ecosystems and Biodiversity (TEEB). The TEEB database contains valuation estimates for inland wetlands from 37 primary studies across 20 countries. The database was analyzed and summarized by de Groot et al. (2012), who report an annual value of $25,682 ($32,252 in 2020 USD) per hectare of inland wetland. Value is concentrated mainly in regulating water flows (22%), moderating extreme events (12%), waste treatment (12%), fish and wildlife habitat (10%) and recreation (9%). The study follows similar methodology to Costanza et al. (1997) so the results can be directly compared (Costanza et al. 2014). The total per hectare values are relatively consistent between the two studies, indicating that the 17 dimensions of value identified by de Groot et al. (2012) compared to 10 in Costanza et al. (1997) likely reflect the increasing ability to disaggregate and value ecosystem service endpoints.

The TEEB database received an update in 2020 and is now referred to as the Ecosystem Services Valuation Database (ESVD) (de Groot, Brander and Solomonides 2020). The updated ESVD contains inland wetland valuation estimates from 131 studies across 41 countries. Aggregating services and averaging across studies suggests that the 'average' annual value per hectare of inland wetlands is $48,647 (2020 USD). The largest contributors to value are moderating extreme events (27%), existence and bequest values (24%), food provision (12%) and regulating water flows (8%). The large increase in annual value compared to Costanza et al. (1997) and de Groot et al. (2012) appears to be driven mostly by the introduction of existence and bequest values in more recent studies and the expansion of studies in developing countries, where wetlands may play a more direct role in food provision.

The ESVD estimate is attractive because it synthesizes data from many studies. However, we may improve its applicability to Tennessee wetlands by narrowing our focus to studies that most closely resemble the geography, population and climate of Tennessee. To maintain a reasonable sample size, we filter the ESVD to include studies in North America and Europe. Following the methodology of de Groot, Brander and Solomonides (2020), we eliminate non-primary studies, studies that prohibit disaggregation because they simultaneously value multiple ecosystems or multiple services, and outlier values. This procedure ensures that the results will include per hectare value estimates for individual ecosystem services, adjusted for purchasing power parity and inflation to 2020 USD. We take the average value across each service, then sum to obtain an estimate of total annual value per hectare of wetland.

For North America and Europe, the ESVD contains 97 freshwater wetland ecosystem service value estimates that meet the above criteria from 21 studies across 8 countries. Summing the average values for each ecosystem service provides an annual valuation estimate of $33,232 per hectare. Moderation of extreme events is the largest contributor (53%), followed by regulation of water flows (16%) and opportunities for recreation and tourism (8%). Compared to the results obtained using the full ESVD, the North America and Europe subsample suggests significantly lower values for provisioning services, and somewhat higher values for regulating services. In addition, none of the North American and European studies were designed to capture existence and bequest values, though they may still exist.

Further filtering the ESVD to include only studies conducted in the United States results in just a few studies, with insufficient geographic and ecosystem service coverage to produce a meaningful valuation estimate. Nonetheless, it can be useful to highlight individual studies that are geographically proximate to Tennessee in order to validate or calibrate the generalized estimates reported above. Within the ESVD there is only one valuation study of inland wetland in the southeastern United States. As a supplement, we search the Environmental Valuation Reference Inventory (EVRI) and EconLit to identify other geographically relevant studies. These studies may not show up in ESVD because they are non-primary (e.g., benefit transfer), the methodology prevents disaggregating into individual ecosystem service values, or there is insufficient information (e.g., about the study area population) to estimate a standardized value.

We identify a total of three studies within the past 20 years explicitly valuing inland wetlands of the southeastern US. As part of an overall effort to value forest ecosystem services in Georgia, Moore et al. (2013) estimate the water regulation and supply benefits from forested wetlands in the state. Using benefit transfer, they find an annual value per acre of $4,635 and $8,196 (2009 USD) for rural and urban/suburban forested wetlands, respectively. Jenkins et al. (2010) combine data from existing studies with values obtained from emerging markets for ecosystem services to estimate the value of a limited set of ecosystem services from wetland restoration in the Mississippi Alluvial Valley. They report estimates of annual value per hectare, in 2008 USD, of $197 for greenhouse gas mitigation, $1,248 for nitrogen mitigation, and $16 for waterfowl recreation on the floodplains of Arkansas, Mississippi, and Louisiana. A final study estimates the value of water treatment services from Louisiana freshwater wetlands. Using an avoided cost approach, Ko et al. (2004) estimate $84 (2002 USD) is the annual value per hectare to treat municipal wastewater.

Table 1. Wetland ecosystem service valuation estimates from studies in the southeastern US

Authors Year State(s)	Moore et al. 2013 GA	Jenkins et al. 2010 AR, MS, LA	Ko et al. 2004 LA	Average
Climate regulation		171-222		197
Moderation of extreme events				
Regulation of water flows	13,901-24,581			19,241
Waste treatment		1,248	122	(685)
Opportunities for recreation and tourism		16		16
Sum				19,454

Note: Estimates are standardized from the original studies to annual value per hectare expressed in 2020 USD. Value in parentheses not included in sum to avoid double counting.

To facilitate synthesis, we standardize the results by adjusting estimates to annual value per hectare in 2020 USD. In addition, we use descriptions from the original studies to classify the ecosystem services into TEEB-defined categories. Table 1 contains the standardized results. Each ecosystem service definition used in Jenkins et al. (2010) and Ko et al. (2004) fit neatly into a single TEEB category. On the other hand, Moore et al. (2013) define “water regulation and supply benefits” as a bundle of regulating services spanning flood control, flow regulation, and waste treatment. The final column of table 1 summarizes the results of the three southeastern US studies by averaging each service within and then across studies. We sum the average values to arrive at a value of $20,139. However, since the value from Moore et al. (2013) cannot be disaggregated, we subtract $685 from the total to avoid double counting of waste treatment. The final estimate for the annual value of wetlands based on studies in the southeastern US is $19,454 per hectare.

In table 2 we compare three of the five estimates for total annual wetland value per hectare discussed above. The first two columns are derived from the ESVD. Column 1 utilizes the full database (de Groot et al. 2020) while column 2 synthesizes the results of studies conducted in North America and Europe. The final column contains the summarized results from table 1. We omit the results from Costanza et al. (1997) and de Groot et al. (2012), since the primary studies they used represent a subset of those in the updated ESVD.

Table 2. Freshwater ecosystem service value estimates derived from studies at varying geographic scales

Geographic extent of studies	ESVD World	ESVD North America and Europe	Southeastern US
Provisioning services	**9,706**	**1,106**	-
Food	6,030	222	
Water	1,934	330	
Raw materials	1,682	11	
Genetic resources	60	543	
Regulating services	**19,185**	**25,468**	**20,123**
Air quality regulation	34	141	
Climate regulation	150	128	197
Moderation of extreme events	13,320	17,759	
Regulation of water flows	3,638	5,251	19,241
Waste treatment	2,043	2,189	(685)
Habitat services	**5,313**	**3,718**	-
Maintenance of life cycles of migratory species	1,886	1,886	
Maintenance of genetic diversity	3,427	1,832	
Cultural services	**14,442**	**2,940**	**16**
Aesthetic information	49	14	
Opportunities for recreation and tourism	2,660	2,692	16
Inspiration for culture, art and design	114	114	
Spiritual experience	1		
Information for cognitive development	120	120	
Existence and bequest values	11,498		
Sum	48,646	33,232	19,454

Note: All values are expressed as annual value per hectare in 2020 USD. Missing entries reflect gaps in data. The table is adapted from de Groot et al. (2012) and values in the World column are obtained directly from de Groot et al. (2020). Value in parentheses not included in sum to avoid double counting.

We consider the value obtained from studies in the southeastern US ($19,454) to be a lower bound for the total economic value of wetlands in Tennessee. It is attractive given the likely similarities in geography, climate, and population between Tennessee and the three primary studies. However, the similarities come at the expense of data availability. We are unable to obtain an estimate for several ecosystem services. It would be inappropriate, for example, to assume habitat services in Tennessee provide zero value. Additionally, the value of recreation and tourism is likely much higher in Tennessee than the $16 estimate from Jenkins et al. (2010), which only captured the value of waterfowl hunting.

An appropriate upper bound should contain estimates for all four ecosystem service categories. Both the global ($48,646) and North America and Europe estimates ($33,232) are candidates. We select the North America and Europe estimate, but consider it a conservative upper bound. Notably, no studies in North America and Europe are available to estimate existence and bequest values. If Tennessee wetlands derive any value from existence and bequest, the upper bound could be much higher. We choose not to adopt the global estimate because of potentially larger economic and cultural differences between Tennessee and the primary study countries.

Finally, it is important to note some limitations. First, there is measurement error associated with each of the primary studies we considered. Even a perfectly designed valuation study only provides an estimate of the true underlying value. Also, it is well known that ecosystem service valuations vary spatially and temporally. Transferring values across space and time, therefore, introduces an additional potential source of error. None of the studies we analyzed were conducted in Tennessee, only a few were in the southeastern US, and the ESVD contains freshwater wetland studies published as early as 1988. Increasing the homogeneity of the primary studies may decrease transfer errors, but it comes at the expense of data availability. Despite shortcomings, the range of potential values we identify for Tennessee wetlands provide useful information in the absence of a comprehensive primary study based in Tennessee.

References

Boyer, T., and S. Polasky. 2004. “Valuing urban wetlands: A review of non-market valuation studies.” Wetlands 24(4):744–755.

Costanza, R., R. d’Arge, R. de Groot, S. Farber, M. Grasso, B. Hannon, K. Limburg, S. Naeem, R.V. O’Neill, J. Paruelo, R.G. Raskin, P. Sutton, and M. van den Belt. 1997. “The value of the world’s ecosystem services and natural capital.” Nature 387(6630):253–260.

Costanza, R., R. de Groot, P. Sutton, S. van der Ploeg, S.J. Anderson, I. Kubiszewski, S. Farber, and R.K. Turner. 2014. “Changes in the global value of ecosystem services.” Global Environmental Change 26:152–158.

de Groot, R., L. Brander, S. van der Ploeg, R. Costanza, F. Bernard, L. Braat, M. Christie, N. Crossman, A. Ghermandi, L. Hein, S. Hussain, P. Kumar, A. McVittie, R. Portela, L.C. Rodriguez, P. ten Brink, and P. van Beukering. 2012. “Global estimates of the value of ecosystems and their services in monetary units.” Ecosystem Services 1(1):50–61.

de Groot, R., L. Brander, and S. Solomonides. 2020. “Update of global ecosystem service valuation database (ESVD).” FSD report No 2020-06 Wageningen, The Netherlands.

Jenkins, W.A., B.C. Murray, R.A. Kramer, and S.P. Faulkner. 2010. “Valuing ecosystem services from wetlands restoration in the Mississippi Alluvial Valley.” Ecological Economics 69(5):1051–1061.

Ko, J.-Y., J.W. Day, R.R. Lane, and J.N. Day. 2004. “A comparative evaluation of money-based and energy-based cost–benefit analyses of tertiary municipal wastewater treatment using forested wetlands vs. sand filtration in Louisiana.” Ecological Economics 49(3):331–347.

Moore, R., T. Williams, E. Rodriguez, and J. Hepinstall-Cymerman. 2013. “Using Nonmarket Valuation to Target Conservation Payments: An Example Involving Georgia’s Private Forests.” Journal of Forestry 111(4):261–270.