GLOBAL WETLANDS IN DECLINE
Causes, Consequences & Solutions

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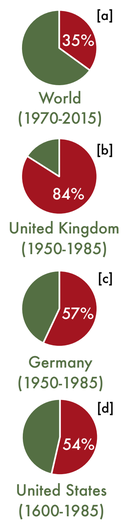
→ Wetlands have come under significant pressure in recent decades, resulting in the loss of many wet ecosystems around the world. What are the causes for this decline, its consequences and possible solutions?

Wetlands exist in many forms and sizes, much dependent on the environment and climate they find themselves in. Generally, wetlands can be defined as landscapes encompassing **both terrestrial and aquatic ecology**. They are flooded permanently or for significant periods and host countless uniquely adapted species, while also providing vital ecosystem services to communities all over the world.[1,2]



↑ Wetland losses in selected regions

Causes of Destruction & Degradation

Wetlands are currently disappearing at **3x** the rate of forests, yet are severely underreported. This loss can be observed everywhere, especially in countries in the global north over the last two centuries.[1,2]

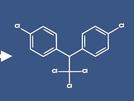
← This equals half the area of Germany every year.

Wet ecosystems are often found in coastal areas, estuaries or along flood plains and other **low-lying** areas, making them attractive for human uses, such as agriculture, commercial & residential developments, etc.[2]

Due to their location near waterways and/or limited drainage, they are especially susceptible to **pollution** taking the form of solid waste or chemical pollutants (such as fertilizers & pesticides). These reach wetlands through active dumping or fluvial transport and deposition.[1,3]

← Fertilizers like Phosphorus cause **eutrophication** in wetlands.

The insecticide **DDT** has polluted many wetlands. →

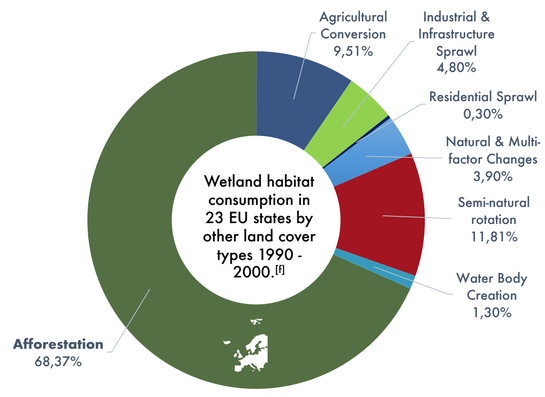


Persistent **negative cultural associations** with swamps and other wet ecosystems combined with the perceived threat of water borne **diseases** has resulted in wetlands often being disregarded, destroyed, and undervalued compared to other terrestrial ecosystems, such as forests.[2]

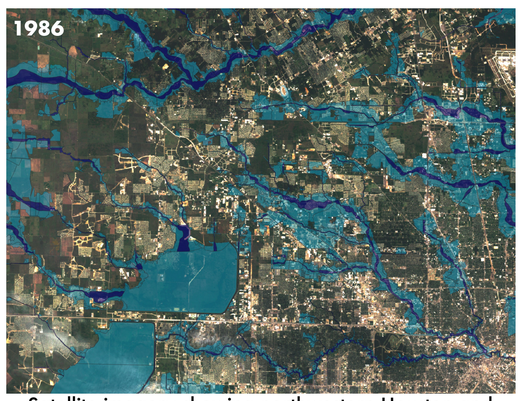
Various other factors also contribute: **Mining of peat** for fuel (the leading cause in northern Europe in the past), invasive species or increasing **climatic pressures** such as drought and sea level rise.[1,2]

← 24 cm of Sea level rise since 1880.[4]

↑ Drivers of global wetland deterioration by hydrology, climate pressures, land use change, and miscellaneous factors.[1,2,3,5,6] [e]



Land Use Change is the dominant driver of wetland loss and degradation.[1,5,6]

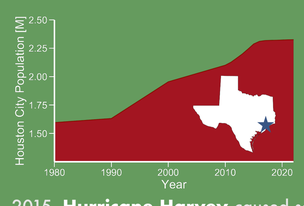


Satellite imagery showing northwestern Houston and local floodplains[12] ↑**1986**[g] & **2021**[h]↓

Case: Houston, TX

Houston, TX has seen a development boom in recent decades, leading to a significant growth in population and urban footprint.[7,8,9]

Suburban sprawl has displaced and destroyed many small wetlands in the area. These mostly consist of prairie potholes, and riverine/coastal forested wetlands. Between 1996 & 2010, more than **200 km²** of wetlands were lost in the Houston region.[7]

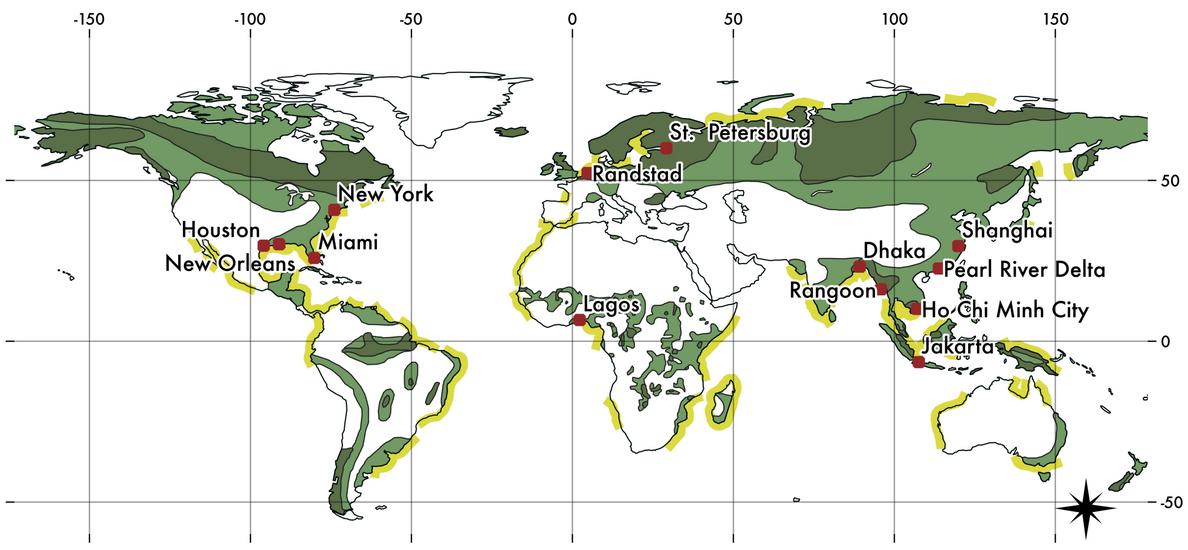


← Houston city population growth 1980-2021[i] (own illustration, after World Population Review)

2015, **Hurricane Harvey** caused severe flooding in the Houston region, damaging >204.000 residential buildings in Harris County.[10]

Developments inside the designated floodplains were mostly inundated, but flooding also spread beyond the floodplain, since the models did neither account for changes in climate, decrease in wetlands nor the **sealing of soils** with impervious surfaces.[7,11]

The immense flooding was later linked to the disappearance of **natural water retention areas**, such as wetlands, the explosion of sealed soils, lax guidelines and the failure to adequately compensate for these losses.[7,11]



Coverage >10% | Coverage 5-10% | Coastal Wetlands & Mangroves | Selected Metropolitan areas with significant wetlands

↑ Distribution of wetland ecosystems worldwide, showing terrestrial mires and peatlands, as well as coastal wetlands & mangroves. (Own illustration after Lappalainen (1996)[13])[i]

7 Benefits of healthy Wetland Ecosystems

1. Coastal & Flood **protection** (water absorption & erosion prevention) – Defense against rising sea levels.[1,14]
2. Clean and stable **water resources** (filtration/buffering) – The 'kidneys' of the landscape.[1,2]
3. Large-scale Storage & **Sequestration of Carbon** (peat formation & other anaerobic processes/conditions) – more than all forest ecosystems.[1,14,15]
4. Benefits from **high biodiversity** (stable ecosystems, fewer diseases/pests, spillover-effects on other ecosystems) – Up to **40% of all species** live and breed in wetlands.[1,16]
5. **Livelihoods** (e.g. Fishing, rice farming, tourism) – **More than 1 Billion people** depend on wetlands for their livelihoods.[1,2]
6. **Economic** benefits (materials, tourism, Paludiculture) – Wetlands provide far more **ecosystem services** than terrestrial ecosystems.[1,2,3,17]
7. **Cultural** benefits (recreation, culture, spirituality, identity).[1,2]

The RAMSAR convention lists & protects important wetlands around the world since 1971. There are currently >2400 sites.

Find out where you can find the site closest to you!

There are many **different types of wetlands**, each a unique mixture of topography, water chemistry, vegetation, hydrology, and nutrition resulting in a fluid typology. The most commonly defined types include peatlands (also mires/moors), marshes, mangroves, floodplains, and forested swamps.[2,3]

Peatlands	Marshes	Floodplains	Mangroves	Forested Swamps
Terrestrial Wetland (fresh water)	Coastal (salt) & terrestrial (fresh water)	Tidal (salt) and along rivers (fresh water)	Coastal Wetland (mostly salt/brackish water)	Terrestrial Wetland (fresh water)
Free of trees, moss dominates.	Free of trees, grasses dominate.	Regular flooding favors wetland vegetation.	Trees and hardy shrubs.	Similar to peatlands with trees.
Buildup of organic material forms and stores peat.	Salt marshes act as temperate versions of mangroves.	Extent of this wetland especially depends on local topography.	Mangroves provide strong coastal protection and benefits.	Buildup of peat with additional material from trees.
All humid climates.	All climates.	Rivers, coasts, and estuaries in all climates.	Found on tropical coasts.	All humid climates.
Rain-fed areas with slow runoff. Borneo, Subarctic, N Europe	Everglades, coasts.	Mississippi delta, Wadden Sea	Mekong, Ganges Deltas	American Coastal swamps

Consequences of Destruction & Degradation

Draining peatlands and other wetlands results in methane **emissions**, caused by the suddenly decomposing peat. Former wetland areas that experienced land use change contribute significantly to greenhouse levels in the atmosphere.[1,14,15,16,17]

Wetland drainage contributes **2x** the amount of carbon to the atmosphere as all of aviation. This equals >5% of greenhouse emissions. [15,18]

Burning of tropical peatlands to make room for **plantations** (esp. in Borneo) also adds significant amounts of carbon to the atmosphere. 2019 peat fires in Borneo emitted more carbon than the widely discussed forest fires in the Amazon rainforest, yet **remain underreported**.[14,19]

Drainage of peat soils can result in **land subsidence**, due to excessive removal of water and oxidation of peat. This damages structures on these soils, and low-lying coastal areas or potential floodplains become more vulnerable to floods, and sea level rise.[17,20]

← Extensive areas of the Netherlands are experiencing subsidence.[20]

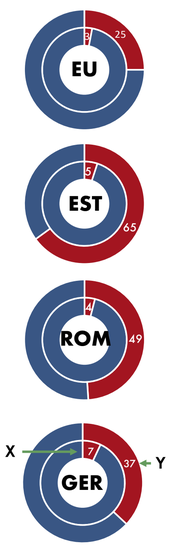
Removal – esp. on coasts and rivers – often results in **higher flood risks**, erosion and reduced resilience to storm surges and **sea level rise**.[1,10,20] (see Houston)

Healthy wetlands filter polluted waters and recharge groundwater resources, so disturbances result in a **drop in water quality** and availability. This presents health-risks to communities that depend on these water resources. Subsequent land uses often mismanage water resources, resulting in standing ponds and other **health-risks**.[1,21,22]

Amphibians, non-marine mollusks, and freshwater fish are under severe pressure.[1] →

Biodiversity-losses that result from wetlands' destruction destabilize local ecosystems, livelihoods and food-security. **Zoonosis** also becomes more likely in disturbed ecosystems, making degraded wetlands breeding grounds for novel pathogens.[1,22]

Emission reduction potential from wetland restoration in selected countries in the European Union[k]



Rewetting just [X]% of agricultural land will save around [Y]% of greenhouse gas emissions from agriculture.

Steps towards Solution

Protect more of what is left and aim for no net loss to prevent further destruction, degradation, and extinction of species.
→ **Strengthen** legal & policy arrangements.[1,15,17]

Acknowledge the value of **ecosystem services** provided by wetlands, such as flood & coastal protection, water supply, fish, and culture & recreation.
→ Create economic & financial **incentives**.[15]

Monitor wetlands and update national inventories to support better decision-making and wise use.
→ Combine various techniques to track changes.[1]

Integrate effective wetland management plans into national efforts on sustainable development, and other efforts.[1,15,17]

Raise awareness globally about the decline and the benefits of wetland ecosystems, such as on World Wetland day, the **2nd of February**.[22]

Rewet drained peatlands and other wetlands on large scales in order to **sequester atmospheric carbon** indefinitely.
This can be financed through integration in emission trading or by providing benefits for long-term sequestered carbon.[1,15]

Support and share knowledge with **local communities** to help them make better and more sustainable use of and better decisions about local wetland resources and integrate diverse perspectives.[1]

Rethink agricultural practices on peat and other wet soils in order to decrease emissions and increase local biodiversity. **Paludiculture** is only one possible approach...[17]

→ Want to read more on the current state of the world's wetlands? The **Global Wetland Outlook** report is a good place to start!

→ **Paludiculture?** Learn how this innovative approach may enable sustainable agricultural use of peat soils here:

References:
[1] Ramsar Convention on Wetlands (2018). Global Wetland Outlook: State of the world's wetlands and their services to people. Gland, Switzerland.
[2] Mitsch, W J & Gosselink, J G (2015). Wetlands. Fifth Edition. John Wiley & Sons, Hoboken.
[3] Crandell, C J (2021). Wetland. Encyclopedia Britannica: https://www.britannica.com/science/wetland [Accessed 12.02.22]
[4] Lindsey, R (2021). Climate Change: Global Sea Level. *National Oceanic and Atmospheric Administration - Climate.gov*: https://www.climate.gov/news-features/understanding-climate/climate-change-global-sea-level [Accessed 05.02.22]
[5] European Comission et al. (2007). LIFE and Europe's wetlands - restoring a vital ecosystem. Publications Office.
[6] Galatowitsch S.M. (2018) Natural and Anthropogenic Drivers of Wetland Change. In: *Finlayson C., Milton G., Prentice R., Davidson N. (eds) The Wetland Book*. Springer, Dordrecht. https://doi.org/10.1007/978-94-007-4001-3_217
[7] Jacob, J S; Kirana P; Lopez, R & Biggs, H (2012). Houston-Area Freshwater wetland loss 1990-2010: https://agrilife.org/urbannature/files/2015/06/WetlandLossPub.pdf [Accessed 08.02.2022]
[8] Bajaj, V; Ma, J & Thompson, S A (2017). How Houston's growth created the perfect flood conditions. *The New York Times*: https://www.nytimes.com/interactive/2017/09/05/opinion/hurricane-harvey-flood-houston-development.html [Accessed 03.02.22]
[9] World Population Review (2022). Houston, Texas Population 2022 (Demographics, Maps, Graphs): https://worldpopulationreview.com/us-cities/houston-tx-population [Accessed 11.02.22]
[10] McGuire, K (2016). Houston's development boom and reduction of wetlands leave region flood prone. *Houston Chronicle*: https://www.houstonchronicle.com/news/houston-texas/houston/article/Houston-s-development-boom-and-reduction-of-8403838.php [Accessed 08.02.22]
[11] Hunn, D; Dempsey, M & Zaveri, M (2018). Harvey's Floods. *Houston Chronicle*: https://www.houstonchronicle.com/news/article/In-Harvey-s-deluge-most-damaged-homes-were-12794820.php [Accessed 10.02.22]
[12] FEMA (2021). National Flood Hazard Layer, Harris County: https://msc.fema.gov/portal/advanceSearch#searchresultsanchor [Accessed 03.02.22]
[13] Lappalainen, E (1996). Global Peat Resources. International Peatland Society, Jyväskylä.
[14] Hawken, P (2021). Regeneration - Ending the Climate Crisis in one Generation. Penguin Books, New York.
[15] International Union for the Conservation of Nature (2021). Peatlands and Climate Change: https://www.iucn.org/resources/issues-briefs/peatlands-and-climate-change [Accessed 09.02.22]
[16] United Nations Climate Change (2018). Wetlands disappearing Three Times Faster than Forests: https://unfccc.int/news/wetlands-disappearing-three-times-faster-than-forests [Accessed 07.02.22]
[17] Greifswald Mire Centre et al. (2020). Peatlands in the EU – Common Agriculture Policy (CAP) after 2020: https://www.greifswaldmoor.de/files/dokumente/Infopapiere_Briefings/202003_CAP%20Policy%20Brief%20Peatlands%20in%20the%20new%20EU%20Version%204.8.pdf [Accessed]
[18] Ritchie, H (2020). Climate change and flying: what share of global CO2 emissions come from aviation? Our World in Data: https://ourworldindata.org/co2-emissions-from-aviation [Accessed 11.02.22]
[19] Datta, A & Krishnamoorti, R (2022). Understanding the Greenhouse Gas Impact of Deforestation Fires in Indonesia and Brazil in 2019 and 2020. *Frontiers in Climate* 4. https://doi.org/10.3389/fclim.2022.799632
[20] Hoogland, J; van den Akker, J J H & Brus, D J (2012). Modeling the subsidence of peat soils in the Dutch coastal area. *Geoderma* 171-172(2012): 92-97. https://doi.org/10.1016/j.geoderma.2011.02.013
[21] Ramsar Convention (2008). Water-related diseases - WWD2008: https://www.informea.org/sites/default/files/imported-documents/wwd2008-a06%20disease.pdf [Accessed 12.02.22]
[22] World Wetlands Day (n.d.). World Wetlands Day - Home: https://www.worldwetlandsday.org [Accessed 07.02.22]
[23] Dahl, T E & Allord, G J (1996). History of Wetlands in the Conterminous United States. *National Water Summary on Wetland Resources; United States Geological Survey Water Supply Paper* 2425: https://water.usgs.gov/nwsum/WSP2425/history.html [Accessed 01.02.22]

Illustrations:
[a] Own illustration after United Nations Climate Change (2018).
[b] Own illustration after European Commission et al. (2007).
[c] Own illustration after European Commission et al. (2007).
[d] Own illustration after Dahl & Allord (1996)[23].
[e] Own illustration.
[f] Own illustration after European Commission et al. (2007).
[g] Own illustration. Landsat 5 image courtesy of the U.S. Geologic Survey & floodplains from FEMA (2019)
[h] Own illustration. Copernicus Sentinel data 2021 & floodplains from FEMA (2019)
[i] Own illustration after World Population Review (2022)
[j] Own illustration after Lappalainen (1996). Made with Natural Earth.
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