Supplementary Information

The Potential of Carbon Markets to Accelerate Green Infrastructure Based Water Quality Trading

Braden J. Limb (1), Jason C. Quinn (1), Alex Johnson (2),
Robert B. Sowby (3), Evan Thomas*(2)

1. Mechanical Engineering
Colorado State University
Fort Collins, CO, USA

2. Mortenson Center in Global Engineering and Resilience
University of Colorado Boulder
Boulder, CO, USA
ethomas@colorado.edu

3. Department of Civil and Construction Engineering
Brigham Young University
Provo, UT, USA

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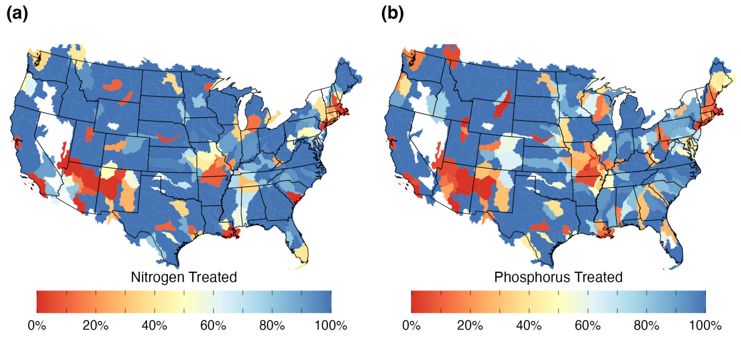
Additional methods and results are presented in this Supplementary Information section. Six subsections are included. The first subsection provides details on the total nutrient loads that green treatment technologies can achieve in the US. The second subsection details the optimum green infrastructure deployment across the contiguous United States (CONUS). The third subsection provides the results for the global warming potential (GWP) of gray and green treatment technologies across the CONUS. The fourth subsection details the total costs for gray and green technologies across the CONUS along with maps for carbon financing potential considering a $20 per tonne-CO2e carbon credit price and the net different between the costs of each technology if carbon financing is included. The fifth nutrient subsection provides a comparison between the minimum cost and minimum emission green treatment scenarios verses grey treatment technologies. The sixth subsection provides additional details on the methods used for this analysis. The seventh subsection provides additional details on the assumptions used for green treatment methods LCA estimates.

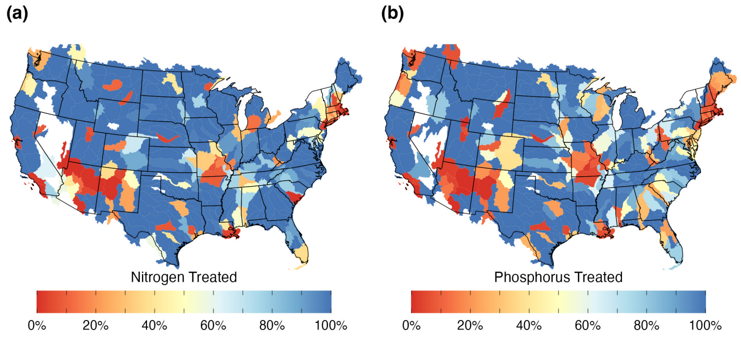
Supplementary Discussion 1: Nutrient Remediation Potential of Green Infrastructure

This analysis considers 7 primary green nutrient remediation methods, all of which are implemented on agricultural farmland. These include 3 barrier treatment methods which are applied at the edge of the field (saturated buffers, woodchip bioreactors, and constructed wetlands) and 4 land treatment methods (nutrient rate reduction, split nutrient application, cover crops, and no-till farming). Additionally, combinations of the green treatment methods were also considered which resulted in 63 unique combinations of green treatment methods being evaluated. Each green nutrient treatment method had unique infrastructure requirements, agricultural land limitations, and nutrient removal efficiencies. Therefore, each green treatment method could treat different quantities of nitrogen and/or phosphorus. Maps of the nutrient treatment percentage in each waterbasin can be seen in Supplementary Figure 1 for the Level 2 scenario, Supplementary Figure 2 for the Level 3 scenario, Supplementary Figure 3 for the Level 4 scenario, and in Main Article Figure 1 for the Level 5 scenario.

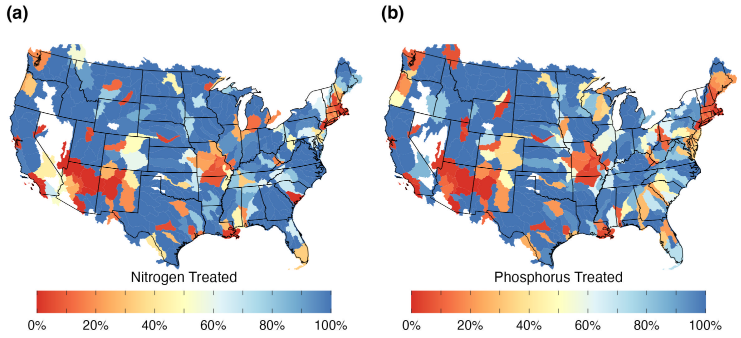
Supplementary Figure 4 illustrates the total nutrient treatment which each green treatment method, or combination of methods, could achieve for the Level 2 scenario (a), Level 3 scenario (b), Level 4 scenario (c), and Level 5 scenario (d). Also provided is the maximum treatment potential of green treatment methods if the most productive treatment method is selected in each waterbasin and the percent of the required nutrient treatment necessary to achieve desired nutrient concentration goals in the CONUS. In total, 31.7% (530,255 tonnes N yr^{-1}) and 20.8% (54,110 tonnes P yr^{-1}) of the desired nitrogen and phosphorus treatment could be achieved using green infrastructure, respectively, for the Level 5 scenario. For the Level 2 scenario, Level 3 scenario, and Level 4 senario; results show that 36.8% (403,913 tonnes N yr^{-1}) and 22.5% (39,453 tonnes P yr^{-1}), 35.3% (447,888 tonnes N yr^{-1}) and 21.1% (50,147 tonnes P yr^{-1}), and 32.4% (505,953 tonnes N yr^{-1}) and 21.0% (52,457 tonnes P yr^{-1}) of the desired nitrogen and phosphorus treatment could be achieved using green infrastructure, respectively. The primary reason why green treatment methods cannot achieve higher nutrient treatment loads is due to limited agricultural land in the watershed, low nutrient removal efficiencies (which results in large land requirements), and limitations on geographic deployment (i.e., saturated buffers and woodchip bioreactors can only be used in locations with tile drainage which is predominately used in the corn belt, but not elsewhere in the US). This can be seen in Supplementary Figure 4 because the treatment methods with high nutrient removal efficiencies and limited geographic constraints tend to remove the most nutrients (constructed wetland + cover crops for nitrogen and all land treatment methods for phosphorus).



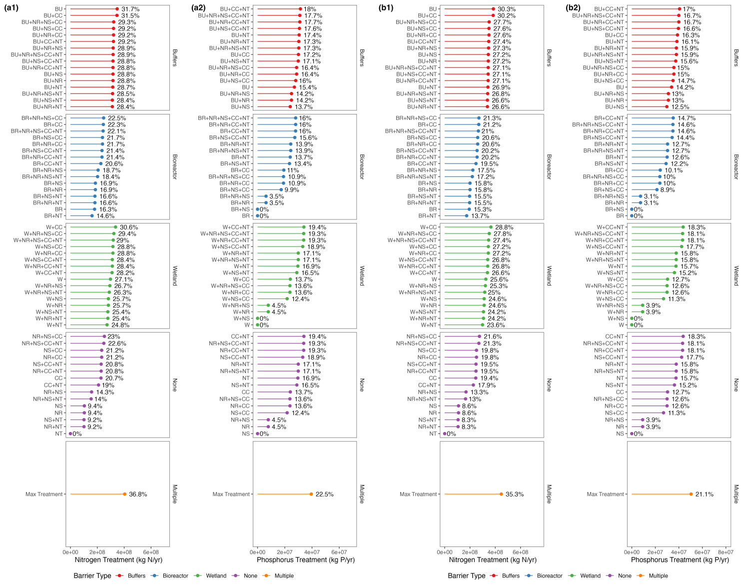
Supplementary Figure 1: Percent of Nitrogen (a) and Phosphorus (b) treatment possible for green treatment technologies in each waterbasin for the Level 2 scenario of reducing mean nutrient concentrations to 8 mgN L^{-1} and 1 mgP L^{-1}.



Supplementary Figure 2: Percent of Nitrogen (a) and Phosphorus (b) treatment possible for green treatment technologies in each waterbasin for the Level 3 scenario of reducing mean nutrient concentrations to 6 mgN L^{-1} and 0.2 mgP L^{-1}.

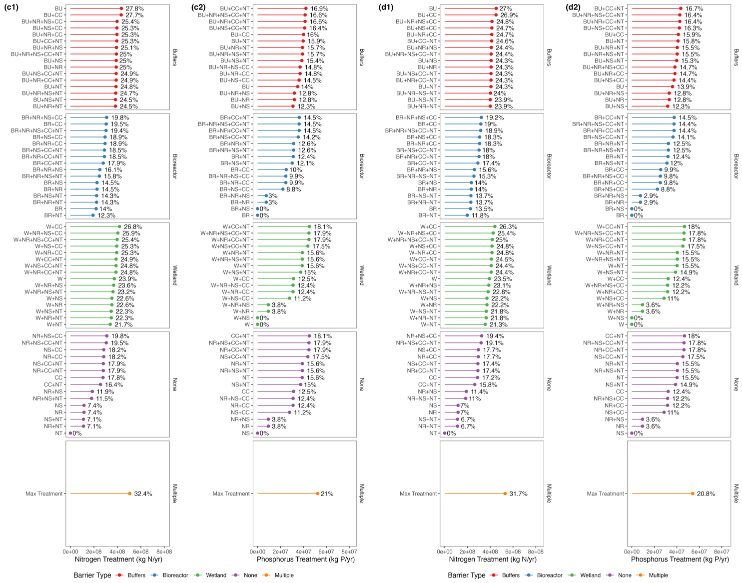


Supplementary Figure 3: Percent of Nitrogen (a) and Phosphorus (b) treatment possible for green treatment technologies in each waterbasin for the Level 4 scenario of reducing mean nutrient concentrations to 3 mgN L^{-1} and 0.1 mgP L^{-1}.



(a) Level 2 Treatment

(b) Level 3 Treatment



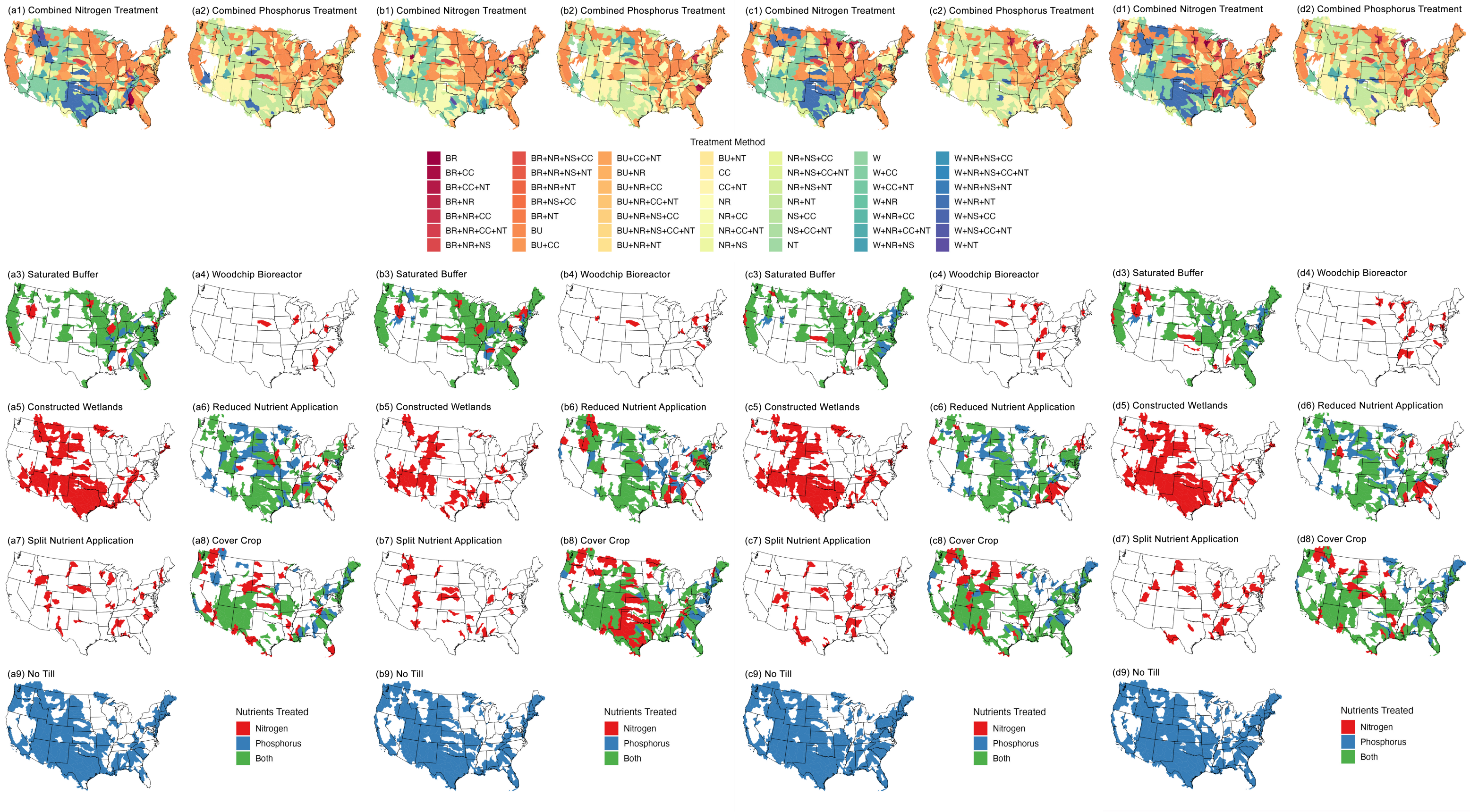
(c) Level 4 Treatment

(d) Level 5 Treatment

Supplementary Figure 4: Maximum Nitrogen (1) and Phosphorus (2) treatment capacity of each green treatment technology or combinations of green technologies for the Level 2 (a), Level 3 (b), Level 4 (c), and Level 5 (d) scenarios. Percentage represents the percent of the total load needed to reduce mean concentration of all watersheds to 8 mg N L^{-1} and 1 mgP L^{-1} for Level 2, 6 mgN L^{-1} and 0.2 mgP L^{-1} for Level 3, 3 mgN L^{-1} and 0.1 mgP L^{-1} for Level 4, and 2 mgN L^{-1} and 0.02 mgP L^{-1} for Level 5. Labels represent Saturated Buffer (BU), Woodchip Bioreactor (BR), Constructed Wetland (W), Nitrogen Rate Reduction (NR), Split Nitrogen Application (NS), Cover Crop (CC), No-Till farming (NT), and the maximum treatment possible when optimizing for the most productive treatment method in each watershed (Max Treatment). Green treatment technologies are separated by common barrier treatment method: Buffers (saturated buffer), Bioreactor (woodchip bioreactor), Wetland (constructed wetland), None (only land treatment methods), or Multiple (optimum treatment method used in each location).

Supplementary Discussion 2: Optimal Green Infrastructure Deployment Across the US

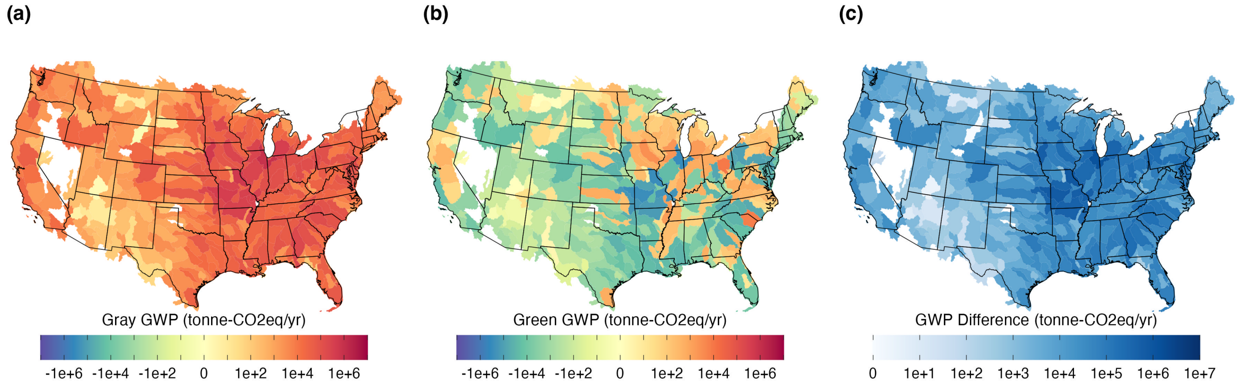
One of the primary goals of this study was to capture the geospatial intricacies of green nutrient remediation methods. As such, Supplementary Figure 5 illustrates the best green treatment methods to use in each waterbasin when prioritizing maximum nutrient treatment and minimum costs for the each of the nutrient treamtent scenarios scenarios. The results between the scenarios are similar. In all cases, saturated buffers, reduced nitrogen application, and cover crops are used widely for both nitrogen and phosphorus remediation. Constructed wetlands and split nutrient application are used for nitrogen treatment and no-till farming is used widely for phosphorus treatment. In total, 49 of the modeled 63 green treatment combinations are used for either nitrogen or phosphorus in at least one of the scenarios.



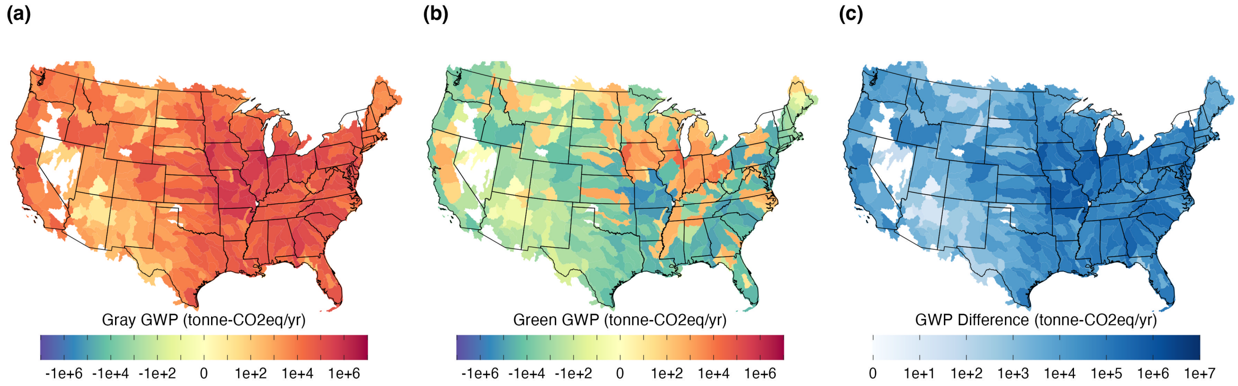
Supplementary Figure 5: Geographic variability of treatment methods for the optimized green treatment scenario prioritizing minimum cost for the Level 2 scenario (a), Level 3 scenario (b), Level 4 scenario (c), and the Level 5 scenario (d). Labels represent Saturated Buffer (BU), Woodchip Bioreactor (BR), Constructed Wetland (W), Nitrogen Rate Reduction (NR), Split Nitrogen Application (NS), Cover Crop (CC), and No-Till farming (NT).

Supplementary Discussion 3: Global Warming Potential of Gray vs. Green Infrastructure

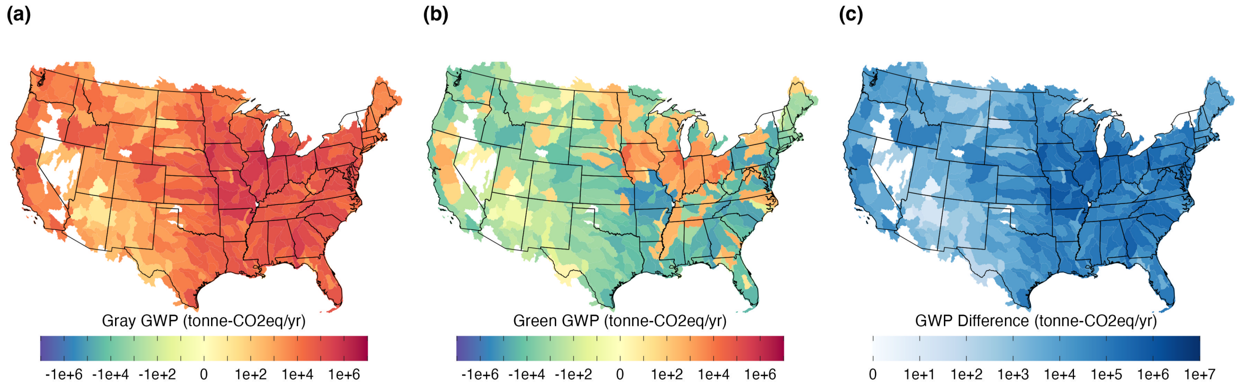
Similar results shown in the main article for the Level 5 scenario, Supplementary Figures 6, 7, and 8 show GWP of green versus gray technologies across the CONUS for the Level 2, Level 3, and Level 4 scenarios, respectively. In the Level 2 scenario, gray treatment technologies emit 11.9 MtCO2e while green treatment technologies sequester 3.4 MtCO2e annually which results in a annual carbon credit potential of 15.3 MtCO2e. In the Level 3 scenario, gray treatment technologies emit 17.4 MtCO2e while green treatment technologies sequester 3.8 MtCO2e annually which results in a annual carbon credit potential of 21.2 MtCO2e. In the Level 4 scenario, gray treatment technologies emit 18.5 MtCO2e while green treatment technologies sequester 3.9 MtCO2e annually which results in a annual carbon credit potential of 22.4 MtCO2e. Overall, GWP values are reduced in the Level 2-4 scenarios compared to the Level 5 scenario due to the reduction in nutrient treatment required.



Supplementary Figure 6: Continental United States global warming potential (GWP) in tonnes of CO2 equivalent emissions per year for removal of nitrogen (to 8 mg L^{-1}) and phosphorus (to 1 mg L^{-1}) using (a) gray treatment technologies (11.9 MtCO2e year^{-1}) and (b) green treatment technologies (-3.4 MtCO2e year^{-1}), and (c) net GWP representing potential carbon credit generation (15.3 MtCO2e year^{-1}).



Supplementary Figure 7: United States global warming potential (GWP) in tonnes of CO2 equivalent emissions per year for removal of nitrogen (to 6 mg L^{-1}) and phosphorus (to 0.2 mg L^{-1}) using (a) gray treatment technologies (17.4 MtCO2e year^{-1}) and (b) green treatment technologies (-3.8 MtCO2e year^{-1}), and (c) net GWP representing potential carbon credit generation (21.2 MtCO2e year^{-1}).

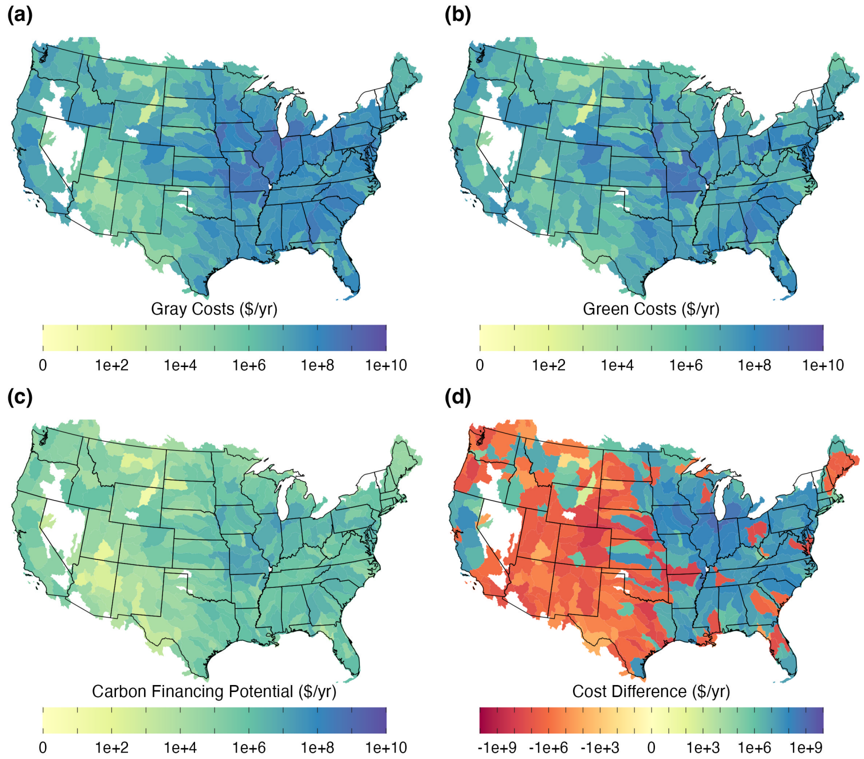


Supplementary Figure 8: Continental United States global warming potential (GWP) in tonnes of CO2 equivalent emissions per year for removal of nitrogen (to 3 mg L^{-1}) and phosphorus (to 0.1 mg L^{-1}) using (a) gray treatment technologies (18.5 MtCO2e year^{-1}) and (b) green treatment technologies (-3.9 MtCO2e year^{-1}), and (c) net GWP representing potential carbon credit generation (22.4 MtCO2e year^{-1}).

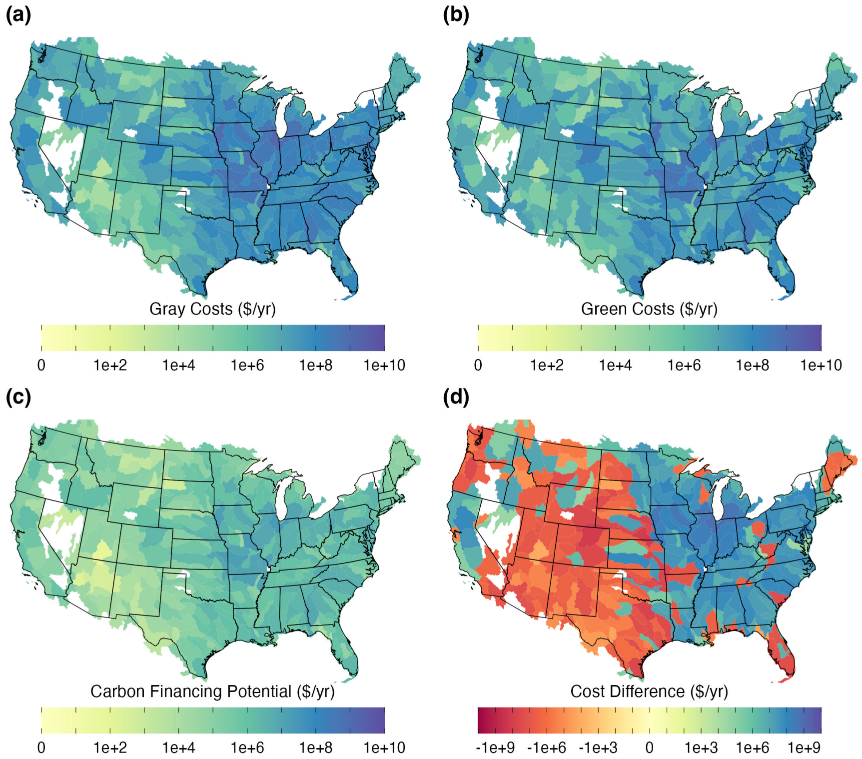
Supplementary Discussion 4: Carbon Financing Potential Green Infrastructure

Similar results shown in the main article for the Level 2 and Level 5 scenarios, Supplementary Figures 10 and 11 show costs of green versus gray technologies across the CONUS for the Level 3 and Level 4 scenarios, respectively. Nutrient treatment costs for the Level 3 scenario were \$18.3B year^{-1} and \$12.4B year^{-1} for gray and green technologies, respectively. Additionally, the carbon financing potential is \$424M year^{-1} assuming a carbon credit price of \$20 tonne-CO2eq^{-1} and the total savings of green treatment technologies when compared to gray treatment and including carbon financing potential is \$6.3B year^{-1}. Of the 315 waterbasins in the CONUS which required nutrient treatment, 166 (53%) had green treatment costs cheaper than those of the gray treatment technologies excluding carbon financing revenues. If carbon financing revenue is added, 176 (56%) of waterbasins had green treatment costs cheaper than gray treatment technologies. However, when evaluated as a percent of total nutrients treated in the CONUS, 84.3% of nitrogen and 73.0% of phosphorus is treated in waterbasins where green treatment costs are cheaper than gray treatment technologies when carbon financing revenues are excluded. These values increase to 85.7% of nitrogen and 77.0% of phosphorus treated in the CONUS in waterbasins which green technologies are cheaper when carbon financing revenues are included. Similar to the other scenarios, green treatment costs were largely impacted by the farmer incentive payments. On a national level, farmer incentive payments make up 50% (\$6.2B year^{-1}) of the total green treatment costs.

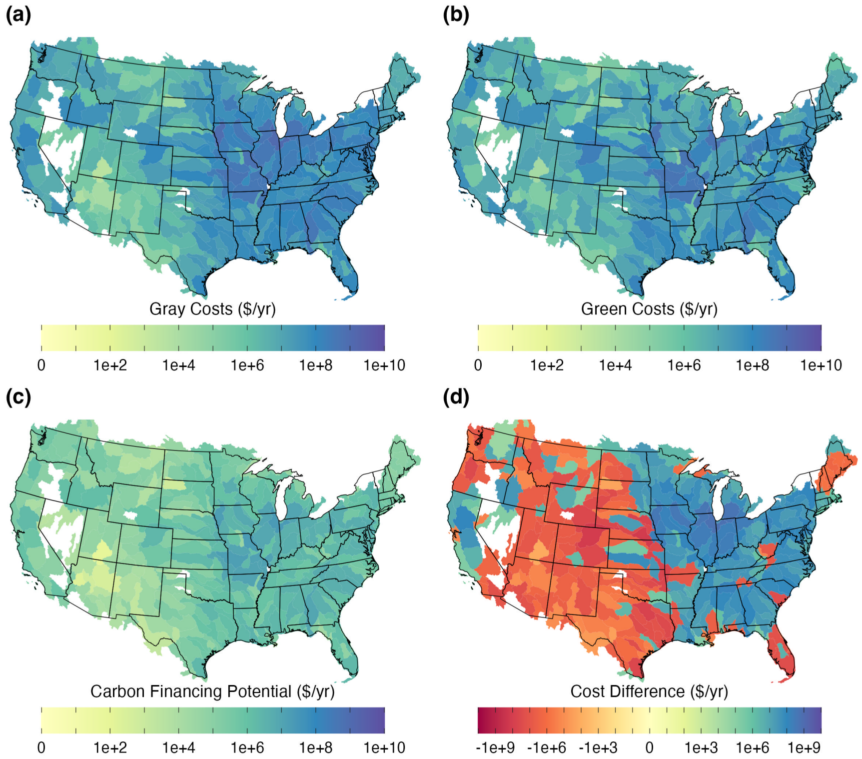
Nutrient treatment costs for the Level 4 scenario were \$19.5B year^{-1} and \$13.2B year^{-1} for gray and green technologies, respectively. Additionally, the carbon financing potential is \$449M year^{-1} assuming a carbon credit price of \$20 tonne-CO2eq^{-1} and the total savings of green treatment technologies when compared to gray treatment and including carbon financing potential is \$6.8B year^{-1}. Of the 315 waterbasins in the CONUS which required nutrient treatment, 163 (52%) had green treatment costs cheaper than those of the gray treatment technologies excluding carbon financing revenues. If carbon financing revenue is added, 173 (55%) of waterbasins had green treatment costs cheaper than gray treatment technologies. However, when evaluated as a percent of total nutrients treated in the CONUS, 82.1% of nitrogen and 73.6% of phosphorus is treated in waterbasins where green treatment costs are cheaper than gray treatment technologies when carbon financing revenues are excluded. These values increase to 86.1% of nitrogen and 78.5% of phosphorus treated in the CONUS in waterbasins which green technologies are cheaper when carbon financing revenues are included. Similar to the other scenarios, green treatment costs were largely impacted by the farmer incentive payments. On a national level, farmer incentive payments make up 49% (\$6.5B year^{-1}) of the total green treatment costs.



Supplementary Figure 9: Continental United States water treatment costs for removal of nitrogen (to 8 mg L^{-1}) and phosphorus (to 1 mg L^{-1}) using (a) gray treatment technologies (\$14.9B year^{-1}) and (b) green treatment technologies (\$10.0B year^{-1}), (c) Potential carbon market revenue (\$307M year^{-1} at \$20 per credit), and (d) net cost difference between gray and green treatment technologies when including carbon financing revenue (\$5.2B year^{-1}). Negative cost differences show waterbasins where green technologies are more expensive than gray technologies. White space designates waterbasins which didn't have wastewater treatment facilities or didn't require nutrient treatment.



Supplementary Figure 10: Continental United States water treatment costs for removal of nitrogen (to 6 mg L^{-1}) and phosphorus (to 0.2 mg L^{-1}) using (a) gray treatment technologies (\$18.3B year^{-1}) and (b) green treatment technologies (\$12.4B year^{-1}), (c) Potential carbon market revenue (\$424M year^{-1} at \$20 per credit), and (d) net cost difference between gray and green treatment technologies when including carbon financing revenue (\$6.3B year^{-1}). Negative cost differences show waterbasins where green technologies are more expensive than gray technologies. White space designates waterbasins which didn't have wastewater treatment facilities or didn't require nutrient treatment.



Supplementary Figure 11: Continental United States water treatment costs for removal of nitrogen (to 8 mg L^{-1}) and phosphorus (to 1 mg L^{-1}) using (a) gray treatment technologies ($19.5B year^{-1}) and (b) green treatment technologies ($13.2B year^{-1}), (c) Potential carbon market revenue ($449M year^{-1} at $20 per credit), and (d) net cost difference between gray and green treatment technologies when including carbon financing revenue ($6.8B year^{-1}). Negative cost differences show waterbasins where green technologies are more expensive than gray technologies. White space designates waterbasins which didn't have wastewater treatment facilities or didn't require nutrient treatment.

Supplementary Discussion 5: Cost and Emissions Comparison Between All Green and Gray Technologies

The primary goal of this work to was to evaluate the costs and GWP of nutrient remediation by building additional traditional wastewater treatment facilities (gray infrastructure) compared to green infrastructure. Supplementary Figure 12 shows the costs and GWP required to treat the maximum amount of nitrogen and phosphorus treatment possible with green treatment technologies and all gray treatment technologies considered for the Levels 2-5 treatment scenarios.

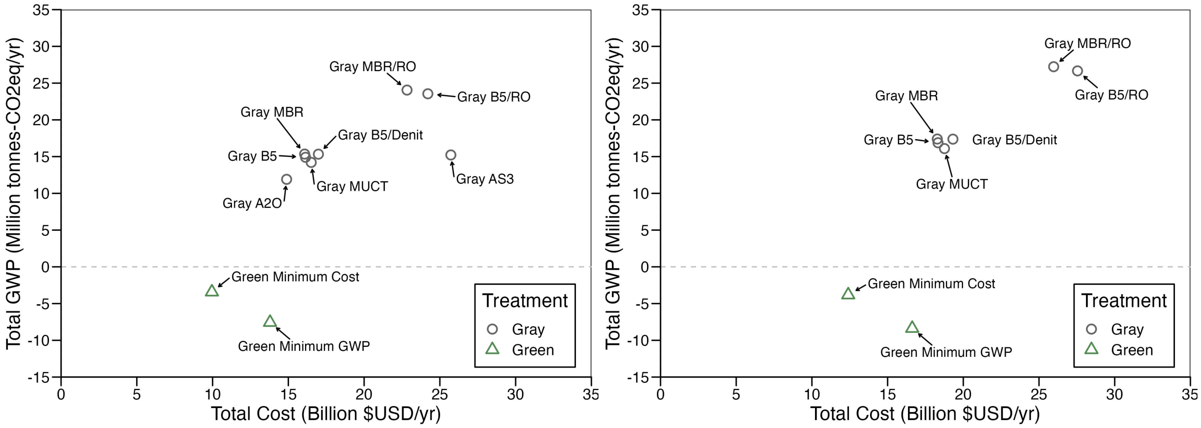
Results show that green treatment technologies have the potential to have both less costs and less GWP than gray infrastructure in both scenarios. This result correlates with existing literature on the subject [1, 2, 3]. In the Level 2 scenario, the minimum cost green treatment method has total costs of $10.0 billion yr^{-1} and total GWP of -3.4 MtCO2 yr^{-1} and the minimum emissions green treatment method has total costs of $13.8

billion yr^{-1} and total GWP of -7.6 MtCO2 yr^{-1}. In order to make the minimum emissions scenario financially competitive with the minimum cost scenario, a carbon price of $927 would be required. Comparatively, the cheapest and least environmentally damaging gray treatment method was Anaerobic/Anoxic/Oxic with total costs of $14.9 billion yr^{-1} and total GWP of 11.9 MtCO2 yr^{-1}.

In the Level 3 scenario, the minimum cost green treatment method has total costs of $12.4 billion yr^{-1} and total GWP of -3.8 MtCO2 yr^{-1} and the minimum emissions green treatment method has total costs of $16.6 billion yr^{-1} and total GWP of -8.4 MtCO2 yr^{-1}. In order to make the minimum emissions scenario financially competitive with the minimum cost scenario, a carbon price of $928 would be required. Comparatively, the cheapest gray treatment method was the 4-Stage Bardenpho Membrane Bioreactor with total costs of $18.3 billion yr^{-1} and total GWP of 17.4 MtCO2 yr^{-1}. The least environmentally damaging gray treatment method was the Modified University of Cape Town Process with total costs of $18.8 billion yr^{-1} and total GWP of 16.1 MtCO2 yr^{-1}.

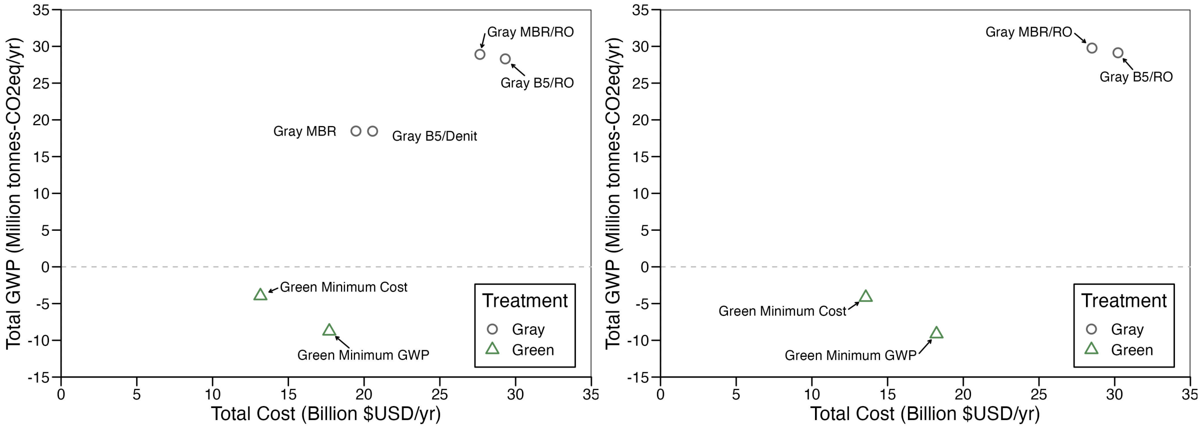
In the Level 4 scenario, the minimum cost green treatment method has total costs of $13.2 billion yr^{-1} and total GWP of -3.9 MtCO2 yr^{-1} and the minimum emissions green treatment method has total costs of $17.7 billion yr^{-1} and total GWP of -8.8 MtCO2 yr^{-1}. In order to make the minimum emissions scenario financially competitive with the minimum cost scenario, a carbon price of $946 would be required. Comparatively, the cheapest gray treatment method was the 4-Stage Bardenpho Membrane Bioreactor with total costs of $19.5 billion yr^{-1} and total GWP of 18.5 MtCO2 yr^{-1}. The least environmentally damaging gray treatment method was the 5-Stage Bardenpho with Denitrification Filter with total costs of $20.6 billion yr^{-1} and total GWP of 18.5 MtCO2 yr^{-1}.

In the Level 5 scenario, the minimum cost green treatment method has total costs of $13.6 billion yr^{-1} and total GWP of -4.2 MtCO2 yr^{-1} and the minimum emissions green treatment method has total costs of $18.2 billion yr^{-1} and total GWP of -9.1 MtCO2 yr^{-1}. In order to make the minimum emissions scenario financially competitive with the minimum cost scenario, a carbon price of $939 would be required. Comparatively, the cheapest gray treatment method was 5-Stage Bardenpho Membrane Bioreactor with Sidestream Reverse Osmosis Treatment with total costs of $28.5 billion yr^{-1} and total GWP of 29.8 MtCO2 yr^{-1}. The least environmentally damaging gray treatment method was 5-Stage Bardenpho with Sidestream Reverse Osmosis Treatment with total costs of $30.2 billion yr^{-1} and total GWP of 29.1 MtCO2 yr^{-1}.



(a) Level 2 Treatment

(b) Level 3 Treatment



(c) Level 4 Treatment

(d) Level 5 Treatment

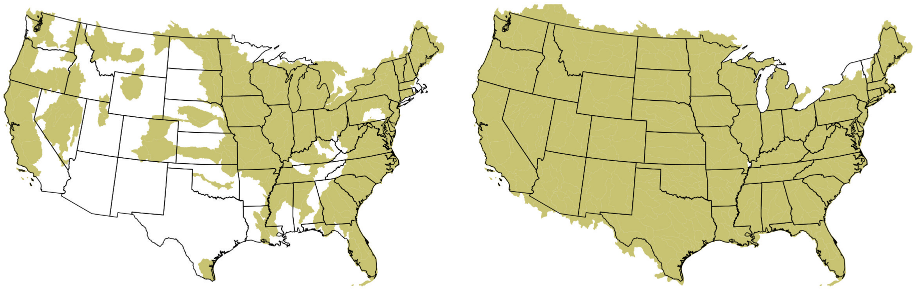
Supplementary Figure 12: Total Cost and Global Warming Potential (GWP) of the optimum Green treatment methods and each Gray treatment method to meet desired nutrient concentration limits for the Level 2 scenario (a - 8 mgN L^{-1} and 1 mgP L^{-1}), Level 3 scenario (b - 6 mgN L^{-1} and 0.2 mgP L^{-1}), Level 4 scenario (c - 3 mgN L^{-1} and 0.1 mgP L^{-1}), and Level 5 scenario (d - 2 mgN L^{-1} and 0.02 mgP L^{-1}). Gray treatment methods include Anaerobic/Anoxic/Oxic (A2O), Activated 3-Sludge System (AS3), 5-Stage Bardenpho (B5), Modified University of Cape Town Process (MUCT), Denitrification Filter (Denit), 4-Stage Bardenpho Membrane Bioreactor (MBR), and Reverse Osmosis Treatment (RO).

Supplementary Table 1: Land limitations placed on green treatment technologies.

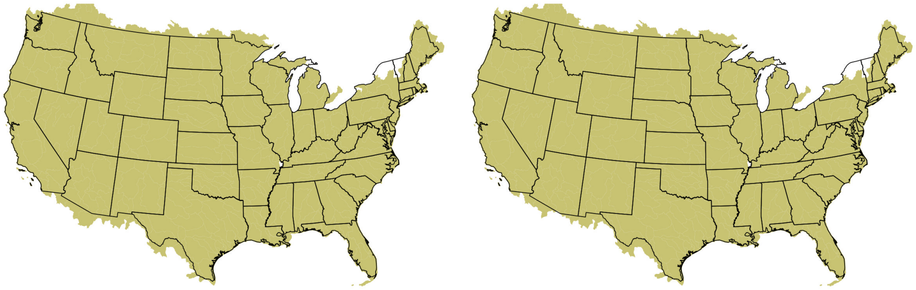
Name	Abbr.	Type	Tile Drain	Buffer	Wetlands	Fertilizer	Current Land Use (%)	Farmer Incentive Scaling
Buffers	BU	Barrier	Yes	Yes	No	No	0.01%	1/15
Bioreactors	BR	Barrier	Yes	No	No	No	0.01%	1/10
Wetland	W	Barrier	No	No	Yes	No	0.4%	1/40
N Rate Reduction	NR	Land	No	No	No	Yes	18.6%	1
Split N Application	NS	Land	No	No	No	Yes	18.6%	1
Cover Crop	CC	Land	No	No	No	No	Varies	1
No-till	NT	Land	No	No	No	No	Varies	1

Supplementary Methods 1

The following visualizations provide additional information about the methods used to complete this study. Supplementary Table 1 outlines which green technologies require what base technologies in order to be used within the waterbasin. Supplementary Figure 13 provides maps of the required technologies for the green treatment methods shown in Supplementary Table 1. Supplementary Figure 14 provides a diagram of the analysis process.

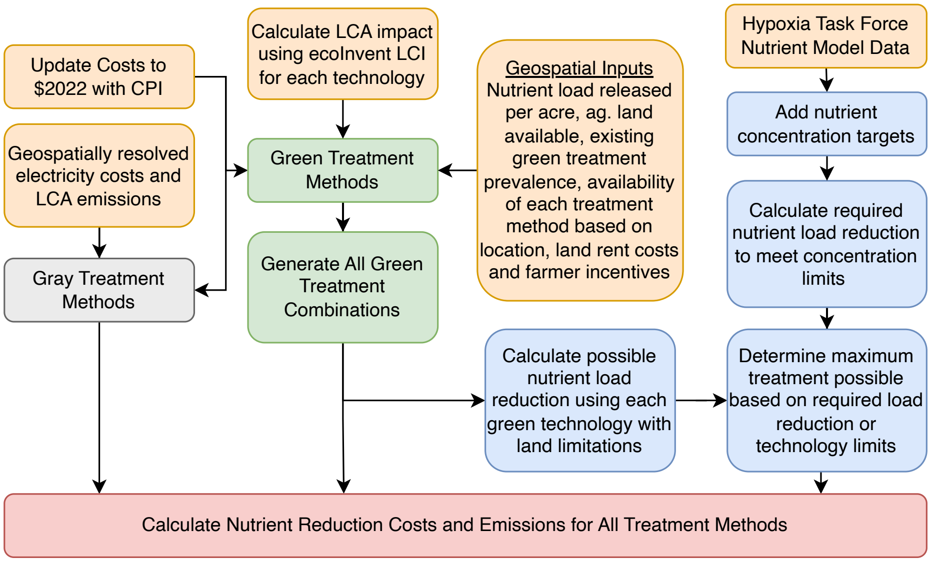

(a) Tile Drains

(b) Buffers


(c) Wetlands

(d) Fertilizer Application

Supplementary Figure 13: Green water treatment availability by waterbasin for technologies needing tile drainage (a), riparian buffers (b), wetlands (c), and supplemental fertilizer application (d). Data for waterbasin characteristics provided by the US EPA's EnviroAtlas [4].



Supplementary Figure 14: Diagram of the methods used for this study.

Supplementary Methods 2: Life Cycle Emissions of Green Treatment Methods

Because of limited literature on life cycle emissions of green nutrient treatment scenarios, the GWP of each was estimated using life-cycle inventory data from the EcoInvent 3.71 database, using cut-off analysis, accessed through the software openLCA 1.10.3 (https://openlca.org), and calculated using the Traci 2.1 impact assessment methodology [5, 6]. The GWP estimate for constructed wetlands includes direct land use change effects which were calculated using IPCC methodology [7]. Detailed assumptions for each of the treatment methods are presented in the following sections. The descriptions in the following sections are meant to be used in unison with the supplemental spreadsheet with LCA calculations. For all LCA estimates, calculations were performed for a 50 acre square farm with mean annual nutrient loss of 9.5 kg N acre-1 and 0.65 kg P acre-1 [8, 9]. Costs and emissions for green nutrient treatment technologies were assumed to scale linearly based on the number of acres treated, so the 50 acre farm was used to calculate per acre treatment emissions of all treated farmland. Additionally, all green treatment methods that needed a water control device were assumed to use one that was 9 feet tall, 1 foot wide, and 1 foot deep [10] per 50 acres treated.

Saturated Buffer

A saturated buffer is an alternative method to drain the excess water from a farm that uses tile drainage systems. Instead of releasing the runoff directly to a stream, the runoff is released through a riparian buffer using perforated tubing running parallel to the stream. This allows the soil to trap some of the excess nutrients in the runoff before reaching the waterway. Therefore, the environmental impact associated with saturated buffers included the perforated drainage pipe, the water control device, and the excavator needed to install the system. Buffers were assumed to have a 15 year life [11].

Woodchip Bioreactor

A woodchip bioreactor is a large filtration system that uses woodchips to denitrify agricultural runoff. Assumptions used for the LCA of a woodchip bioreactor were gathered from Christianson et al. [8]. It was assumed that a 10 yard long, 5 yard wide, and 3 yard deep bioreactor would be required to treat 50 acres of farmland. This results in 150 cubic yards of woodchips and 165 cubic yards of excavation needed for both the bioreactor and the water control device. Additionally, it was assumed that 6 mil thick plastic would line the bioreactor and it would be covered on top with landscaping fabric. Life cycle emissions were included for all of these components and a 10 year lifetime was assumed.

Constructed Wetland

A constructed wetland consists of building a wetland on part of the farm and running the agricultural runoff through the wetland to trap some of the nutrients. For this, part of farm needs to be converted to a wetland. It was assumed that the wetland size requirement was 2% of treated land plus 2X the wetland size for a buffer [12]. Therefore 6% of the treated land was required for wetland construction. Emissions were included for the wetland's excavation, straw required to help establish the buffer, and seed to start wetland growth. Additionally, direct land use change emissions were also included for constructed wetlands and calculations were performed using IPCC methodology [7]. For these calculations, it was assumed that the farm resided in a cold temperate and dry location and that high activity clay soil existed at the farm location. It was assumed that all above ground biomass was removed and burned prior to creating the wetland. A 40 year wetland life was assumed.

Nutrient Rate Reduction

Nutrient rate reduction consists of farmers applying the proper amount of fertilizer to their field, instead of over fertilizing which eventually leads to extra nutrients running off farms and into streams. A 26.3%

percent fertilizer reduction was assumed based on information provided by the University of Nebraska Board of Regents [13]. Reduced fertilizer use results in a net emissions savings compared to traditional nutrient applications because less fertilizer is required.

Split Nutrient Application

Split nutrient application consists of farmers applying part of their fertilizer in the fall and part in the spring. This results in more fertilizer being absorbed by the plants and soils which results in less nutrient runoff. Therefore, the only emissions associated with treatment method were assumed to be that a second fertilizer application.

Cover Crop

Cover cropping is a method to plant a crop of fallow soil to prevent excess nutrient runoff. In this case, it was assumed that ryegrass would be used as the cover crop and emissions associated with ryegrass production were calculated using the EcoInvent inventory and an assumed yield of 700 lbs of ryegrass per acre [14].

No-Till Farming

Conventional tilled farming involves turning over the first 6 - 12 inches of soil before crops are planted. This makes the soil easier to work with, but also removes plant matter from the soil surface and increases erosion risk. Conversely, no-till farming involves not tilling the soil before planting. Therefore, the emissions associated with no-till farming were assumed to be the avoided emissions from not tilling the farmland. Due to the various methods for no-till farming, emissions associated with other no-till practices such as additional weed killer application were not included.

Supplementary References

[1] Yaoze Liu, Bernard A. Engel, Paris D. Collingsworth, and Bryan C. Pijanowski. Optimal implementation of green infrastructure practices to minimize influences of land use change and climate change on hydrology and water quality: Case study in Spy Run Creek watershed, Indiana. *Science of the Total Environment*, 601-602, 2017. ISSN 18791026. doi: 10.1016/j.scitotenv.2017.06.015.

[2] Martin Jaffe. Environmental Reviews & Case Studies: Reflections on Green Infrastructure Economics. *Environmental Practice*, 12(4), 2010. ISSN 1466-0466. doi: 10.1017/s1466046610000475.

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