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CONSIDERING PERSISTENCE IN THE LANDSCAPE WHEN TRACKING WATER QUALITY BENEFITS OF CONSERVATION PRACTICES

Reid D. Christianson

Department of Crop Sciences, University of Illinois at Urbana-Champaign
AW-101 Turner Hall, MC-046, 1102 South Goodwin Avenue, Urbana, IL, USA 61801-4730
Email: ReidDC@illinois.edu

Abstract

All management activities associated with our land-use choices have various levels of impact on receiving water resources, as well as different life expectancies. This work was done as part of efforts to account for progress being made on conservation practice implementation in the United States Mississippi River Basin towards meeting water quality goals. However, the concept is global, and pertinent wherever water quality initiatives exist. A major part of this work was to determine the persistence of a suite of water-related conservation practices in our landscape by using established design criteria and recommended lifespans. Results show that accounting for persistence could increase our annual estimates of conservation practices area treated by 25 to 30%. Since annual estimates are heavily dependent on the types of practices historically implemented in a given area, regional evaluation of practice lifespan is recommended. Ultimately, accounting for long-lived conservation activities provides a better representation of historical and current efforts to mitigate environmental pollution from agriculture.

Introduction

With the prevalence of agriculture across the globe, mitigating environmental impacts is needed. In New Zealand, around 40% of the land use is deemed agricultural (Wilcock, 2013), and the USA consists of approximately 44% (Trading Economics, 2020) making the spatial extent of these land uses substantial. Additionally, the nitrogen and phosphorus delivery from these land uses is large (Wilcock, 2013; Robertson and Saad, 2019). Measurement of improved water quality in the stream network is the ultimate measure of success, though this can take a long time to reliably measure (Cawthron Institute, 2019) due to variability in rainfall and runoff dynamics impacting stream flow and water quality. With this in mind, developing other methods of accounting for efforts to mitigate nutrient pollution to water from agricultural activities is a critically important task.

Agricultural conservation practices are incredibly important across the globe. New Zealand, in particular has had a substantial effort in mitigating negative environmental impacts of land management. All management activities associated with our land-use choices have various levels of impact on receiving water resources, as well as different life expectancies. This work was done as part of efforts to account for progress being made on conservation practice implementation in the United States Mississippi River Basin towards meeting water quality goals. However, the concept is global, and pertinent wherever water quality initiatives exist.

This work was done in support of the US Hypoxia Task Force (HTF), which is made up of twelve states in partnership with federal agencies and tribal authorities. The goal of the HTF is to reduce nitrogen and phosphorus loads to the Gulf of Mexico. The specific objective of this work was to quantify the importance of including practice life in estimates of implementation effort.

Methods and materials

This work determined the impact of accounting for persistence of a suite of water-related conservation practices (Christianson, 2018a) in our landscape by using established design criteria and US Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS) recommended lifespans (Table 1). This defined life was included in a database to estimate area treated and nutrient reductions associated with known conservation practices and their performance (Christianson, 2018b).

Examples of lifespans are presented in Table 1, however, all practices had a suite of associated design criteria and assumptions. For example, depending on design, fencing livestock out of waterways may have a useful life of just one year or up to 10 or more years, if permanent installations are used. Many of these practices have associated nitrogen and phosphorus reduction efficiencies (Table 1). To be useful in large scale aggregation efforts, these efficiency values are generalized and represent long-term average performance. Values presented in Table 1 include work done by the Waikato Regional Council (2015), the Iowa Nutrient Reduction Strategy (IDALS, IDNR, & ISU, 2016) and the Illinois Nutrient Loss Reduction Strategy (IEPA & IDOA, 2015), which were summarized by Christianson et al. (2018), and a recent science assessment report from Arkansas (FTN Associates, 2019).

Table 1. Example conservation practices to enhance water quality associated with agriculture.

Practice	**Life (suggested)[@]**	**New Zealand Reduction (%)[#]**		**USA Reduction (%)[*]**	
		Nitrogen	Phosphorus	Nitrogen	Phosphorus
Wetlands	15	17%	50%	50%	0%
Riparian Buffer	15	10%	35%	90%[^]	50%
Stream Exclusion (fencing out stock)	5	10%	35%	10%	15%
Post-crop mgmt./ Cover Crop	1	25%	50%	30%	30%
Prescribed Grazing	1	10%	50%	10%	15%
Conservation Tillage	1	10%	50%	0-10%	50%

@ Based on suggested life from USDA NRCS
# Waikato Regional Council (2015).
* General estimates based on strategies developed by selected states
^ This is for groundwater interacting with the buffer root zone

When performance is used along with life, estimates of cumulative benefits of implementation over time can be made. Practice life has been generalized by the USDA, NRCS (Table 2); however, generalized quantification of performance has not been done for many of the practices that may provide water quality benefits due to regional difference in performance or design standards. That said, many studies and watershed/water quality models have integrated estimates of water quality estimates for subsets of the practices shown in Table 2, though those have not been presented here.

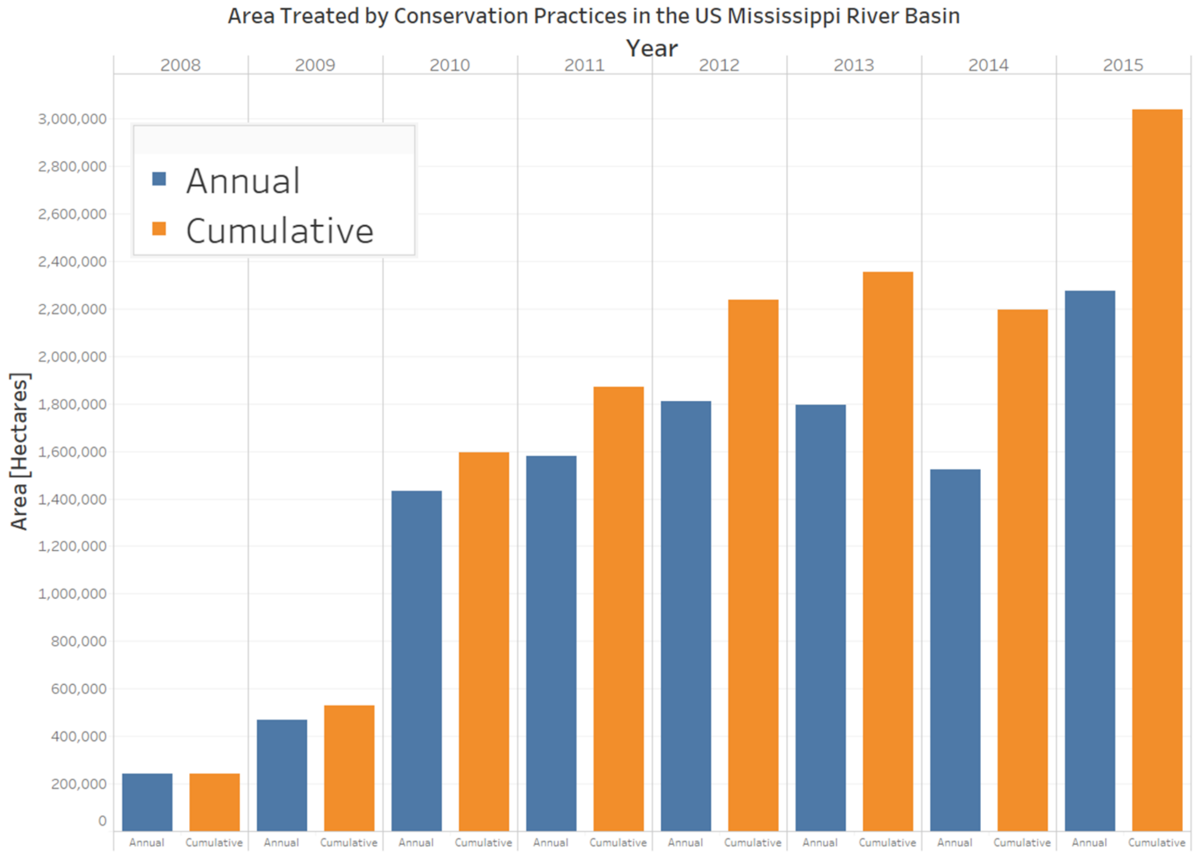
Data on conservation practices implemented were obtained from the USDA, NRCS as part of a memorandum of understanding between the NRCS and the HTF. These data included information from the Environmental Quality Incentive Program (EQIP) and the Conservation Stewardship Program (CSP), two of USDA's largest environmental programs. Funding values were used to develop state average cost per unit of implementation, which was used during data quality control to replace erroneous entries when needed. Finally, the area impacted by edge-of-field conservation practices (i.e., wetlands) was estimated from detailed state-specific data or based on large USDA datasets. These have not yet been published and are considered a work-in-progress.

Table 2. List of common water quality related conservation practices in the USA. Practice life from the USDA, NRCS were included. A more comprehensive list can be found at https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1076947.pdf.

Category	Practice Name	Life (years)
Animal Agriculture	Access Control	10
	Access Road	10
	Animal Mortality Facility	15
	Closure of Waste Impoundment	15
	Composting Facility	15
	Heavy Use Area Protection	10
	Prescribed Grazing	1
	Stream Crossing	10
	Waste Storage Facility	15
	Waste Treatment Lagoon	15
Edge-of-Field	Channel Bank Vegetation	10
	Constructed Wetland	15
	Denitrifying Bioreactor	10
	Filter Strip	10
	Grade Stabilization Structure	15
	Grass Waterway	10
	Irrigation System, Tailwater Recovery	15
	Riparian Forest Buffer	15
	Riparian Herbaceous Cover	15
	Saturated Buffer	10
	Sediment Basin	20
	Streambank and Shoreline Protection	20
	Structure for Water Control	20
	Water and Sediment Control Basin	10
	Wetland Creation	15
	Wetland Enhancement	15
	Wetland Restoration	15
In-Field	Conservation Crop Rotation	1
	Contour Buffer Strips	5
	Contour Farming	5
	Cover Crop	1
	Drainage Water Management	1
	Nutrient Management	1
	Residue and Tillage Management - No-Till	1
	Terrace	10
Land Use	Conservation Cover	5
	Critical Area Planting	10
	Land Retirement	50
	Tree & Shrub Establishment	15
	Windbreak/Shelterbelt Establishment	15

Results and discussion

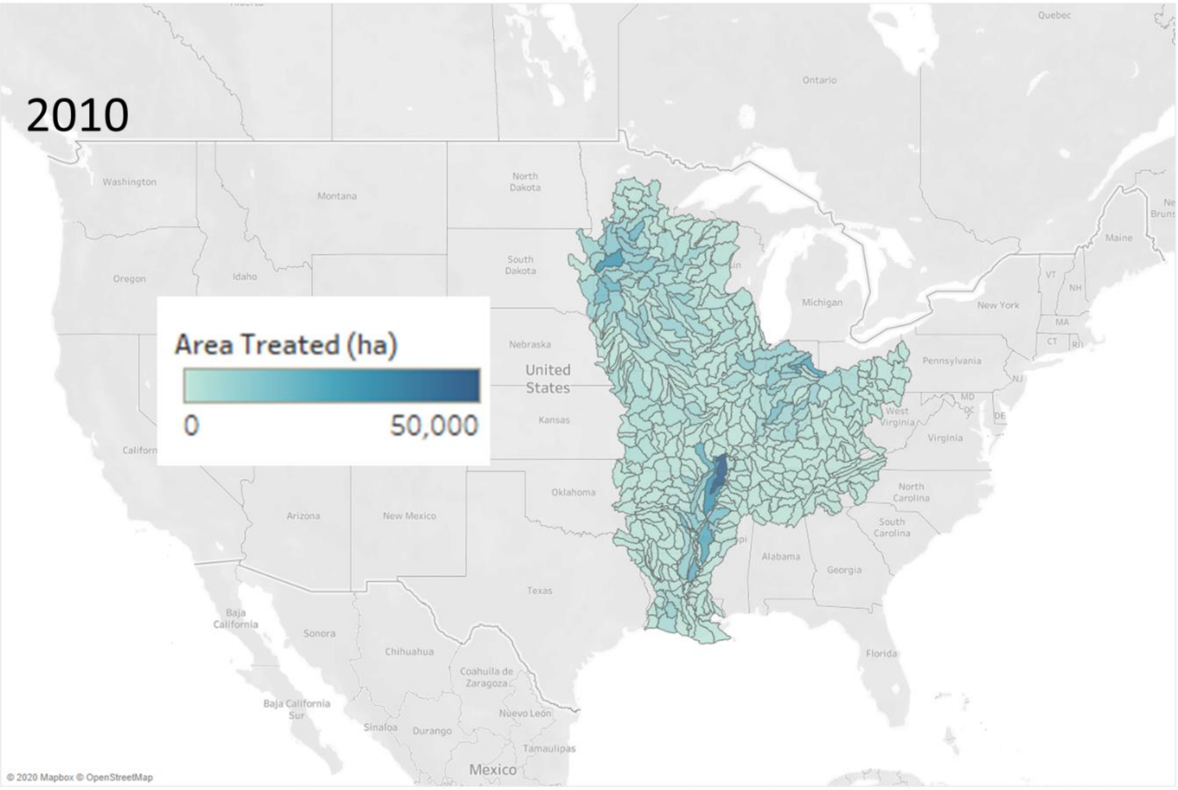
Results show that accounting for persistence could increase our annual estimates of conservation practice area treated by 25 to 30% (Figure 1). Assuming implementation of structural and annual practices continues as-is, the difference between the annual and cumulative bars is likely to reach a steady state as new practices are being installed and older practices are reaching end of life. Since the onset of this dataset was 2008, steady state conditions would be expected between 2028 and 2033 since many of the structural practices have a 10 to 15 year life. The upward trend over time indicated continued increase in funding and adoption of agricultural conservation practices related to water quality.



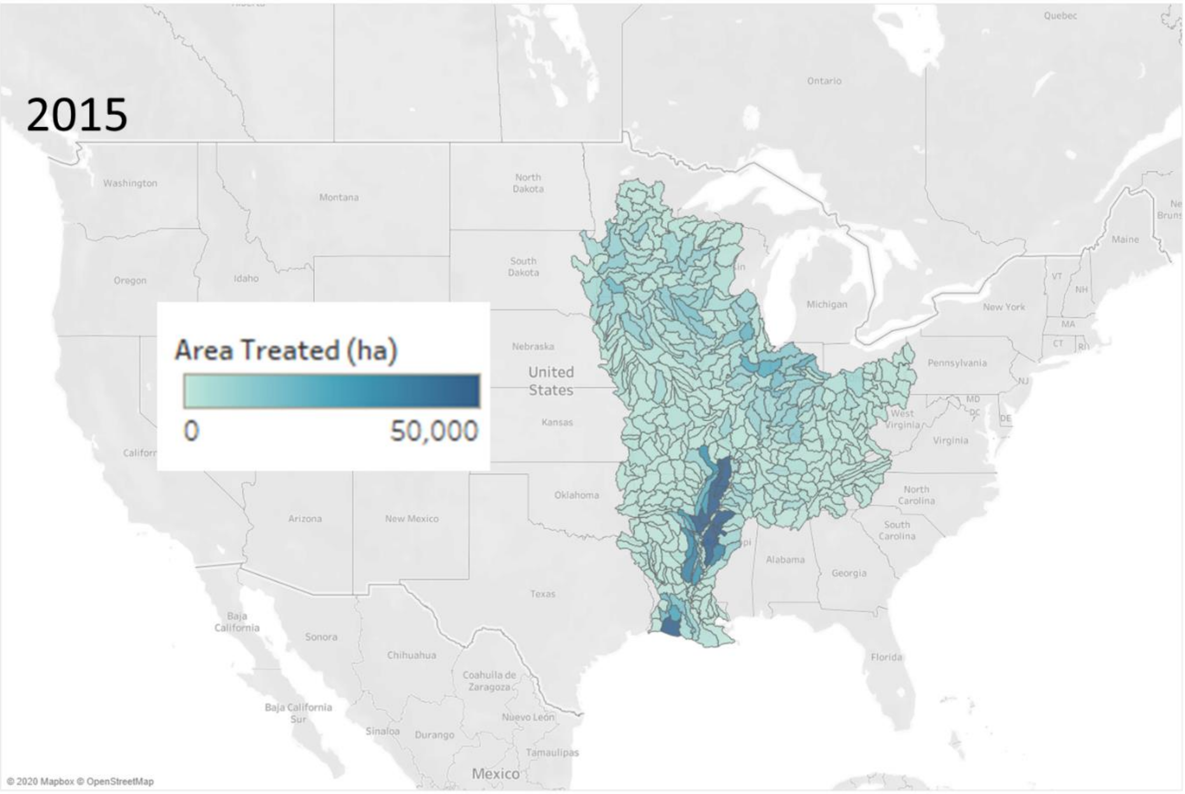
Annual and Cumulative for each Year (Sheet2 (1_EQIP_CSP_319 Practices 2008_2017_2.3.1)). Color shows details about Annual and Cumulative. The view is filtered on Year (Sheet2 (1_EQIP_CSP_319 Practices 2008_2017_2.3.1)), which excludes 2016 and 2017.

Figure 1. Comparison between tracking conservation practices annually vs cumulatively. Many practices are annual – meaning they only last a year, but many of the structural practices are persistent in the landscape, and accounting for them can significantly increase estimates of how much land is being treated with a conservation practice. Data were from the USDA's Environmental Quality Incentive Program and Conservation Stewardship Program. For more information please visit: http://draindrop.cropsci.illinois.edu/index.php/i-drop-impact/mississippi-river-basin-nutrient-loss-reduction-measurement-framework/conservation-practice-tracking/.

Aggregating these data by large watershed for two separate years – 2010 and 2015 (Figure 2), showed an increase in water quality related conservation practices in the lower third of the US Mississippi River Basin right along the Mississippi River. This area has historically implemented many structural practices with a lifespan longer than five years.



Map based on Longitude (generated) and Latitude (generated). Color shows Area Treated (ha) (Practices Applied (1_EQIP_CSP_319 Practices 2008_2017_2.3.1)). Details are shown for Location HUC 8 (Practices Applied (1_EQIP_CSP_319 Practices 2008_2017_2.3.1)) and Name. The data is filtered on State (Practices Applied (1_EQIP_CSP_319 Practices 2008_2017_2.3.1)), Program (Practices Applied (1_EQIP_CSP_319 Practices 2008_2017_2.3.1)) and General Practice Name (Practices Applied (1_EQIP_CSP_319 Practices 2008_2017_2.3.1)). The State (Practices Applied (1_EQIP_CSP_319 Practices 2008_2017_2.3.1)) filter keeps 12 of 12 members. The Program (Practices Applied (1_EQIP_CSP_319 Practices 2008_2017_2.3.1)) filter keeps CSP, EPA 319 and EQIP. The General Practice Name (Practices Applied (1_EQIP_CSP_319 Practices 2008_2017_2.3.1)) filter excludes Null.



Map based on Longitude (generated) and Latitude (generated). Color shows Area Treated (ha) (Practices Applied (1_EQIP_CSP_319 Practices 2008_2017_2.3.1)). Details are shown for Location HUC 8 (Practices Applied (1_EQIP_CSP_319 Practices 2008_2017_2.3.1)) and Name. The data is filtered on State (Practices Applied (1_EQIP_CSP_319 Practices 2008_2017_2.3.1)), Program (Practices Applied (1_EQIP_CSP_319 Practices 2008_2017_2.3.1)) and General Practice Name (Practices Applied (1_EQIP_CSP_319 Practices 2008_2017_2.3.1)). The State (Practices Applied (1_EQIP_CSP_319 Practices 2008_2017_2.3.1)) filter keeps 12 of 12 members. The Program (Practices Applied (1_EQIP_CSP_319 Practices 2008_2017_2.3.1)) filter keeps CSP, EPA 319 and EQIP. The General Practice Name (Practices Applied (1_EQIP_CSP_319 Practices 2008_2017_2.3.1)) filter excludes Null.

Figure 2. Cumulative area treated in 2010 (top) and 2015 (bottom) by large watershed in the US Mississippi River Basin Hypoxia Task Force States. Data from Christianson (2019).

Conclusions

Since estimates of area treated are heavily dependent on the types of practices historically implemented in a given area, regional evaluation of practice lifespan is recommended. In addition to information policy decisions, including practice life provides a more accurate representation of the level of implementation required to produce a measureable change in water quality. With the mix of structural and in-field practices used in the US Mississippi River Basin, considering conservation practice life will likely increase estimates of area treated by 25 to 30% over simply considering funded practices in a given year.

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