SINGLE-IMPACT FICHE LANDSCAPE FEATURES

IMPACT: WATER QUALITY

Data extracted in May 2022
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Note to the reader: This fiche summarises the effects of Landscape features on WATER QUALITY. It is based on 9 synthesis papers[1], including from 24 to 140 primary studies.

1. WEIGHT OF THE EVIDENCE

CONSISTENCY OF THE IMPACT

The effect of landscape features on water quality is overall positive (i.e. increase of water quality).

The table below shows the number of synthesis papers with statistical tests reporting i) a significant difference between the Intervention and the Comparator, that is to say, a significant statistical effect, which can be positive or negative; or ii) a non-statistically significant difference between the Intervention and the Comparator. In addition, we include, if any, the number of synthesis papers reporting relevant results but without statistical test of the effects. Details on the quality assessment of the synthesis papers can be found in the methodology section of this WIKI.

- Landscape features in general (measured as percentage of natural area) have a significant positive effect on water quality compared to agricultural lands with lower percentage of natural area, according to 1 synthesis paper.
- Buffer strips have a significant positive effect on water quality (measured both as nutrient and pesticide removal) compared to cropland or grassland without buffer strips, according to 2 synthesis papers. Another synthesis paper reported relevant results, but this evidence is not statistically tested.
- Ditches and ponds were analysed together in 1 synthesis paper that reports a significant positive effect on water quality compared to cropland or grassland without ditches or ponds. Another synthesis paper reports relevant results for ditches, both for nutrients and pestidices removal, but this evidence is not statistically tested.
- Small wetlands have a significant positive effect on water quality compared to cropland or grassland without constructed small wetlands, according to 3 synthesis papers. 2 synthesis papers report a significant positive effect on nutrient (nitrogen and phosphorous) removal and 1 synthesis paper reports a significant positive effect on the reduction of acute ecotoxicity.

All selected synthesis papers included studies conducted in Europe (see **Table 2**).

Table 1: Summary of effects. Number of synthesis papers reporting positive, negative or non-statistically significant effects on environmental and climate impacts. The number of synthesis papers reporting relevant results but without statistical test of the effects are also provided. When not all the synthesis papers reporting an effect are of high quality, the number of synthesis papers with a quality score of at least 50% is indicated in parentheses. The reference numbers of the synthesis papers reporting each of the effects are provided in **Table 3**. Some synthesis papers may report effects for more than one impact or more than one effect for the same impact.

				Statistically tested			Non-statistically tested
Impact	Metric	Intervention	Comparator	Significantly positive	Significantly negative	Non-significant	
Increase water quality	Nutrient removal	Buffer strips	No buffer strips	2	0	0	0
		Ditches and ponds	Before ditches or ponds	1	0	0	1 (0)
		Small wetlands	Before small wetlands	2	0	0	0
Increase water quality	Water quality	Buffer strips	No buffer strips	1	0	0	1 (0)
		Ditches and ponds	Before ditches or ponds	0	0	0	1 (0)
		Landscape features in general	No semi-natural habitat features	1	0	0	0
		Small wetlands	Before small wetlands	1	0	0	0

QUALITY OF THE SYNTHESIS PAPERS

The quality of each synthesis paper was assessed based on 16 criteria regarding three main aspects: 1) the literature search strategy and primary studies selection; 2) the statistical analysis conducted; and 3) the evaluation of potential bias. We assessed whether authors addressed and reported these criteria. Then, a quality score was calculated as the percentage of these 16 criteria properly addressed and reported in each synthesis paper. Details on quality criteria can be found in the methodology section of this WIKI.

[1] Synthesis research papers include either meta-analysis or systematic reviews with quantitative results. Details can be found in the methodology section of the WIKI.

2. IMPACTS

The main characteristics and results of the 9 synthesis papers are reported in **Table 2** with the terminology used in those papers, while **Table 3** shows the reference numbers of the synthesis papers reporting for each of the results shown in **Table 1**. Comprehensive information about the results reported in each synthesis paper, in particular about the modulation of effects by factors related to soil, climate and management practices, are provided in the **summaries of the synthesis papers** available in this WIKI.

Table 2: Main characteristics of the synthesis papers reporting effects on water quality. The references are ordered chronologically with the most recent publication date first.

Reference number	Population	Scale	Num. papers	Intervention	Comparator	Metric	Conclusion	Quality score
Ref3	Croplands	Global	92	Effluent concentration	Influent concentration	Total nitrogen (TN)	Based on this statistical analysis, ditches and ponds effectively reduce total nitrogen, and the general removal rate is 38.7%.	69%
Ref6	Pilot and full-scale field studies on drainage mitigation measures in croplands	Global	42	Outflow from 1) Free water surface constructed wetlands; 2) denitrifying bioreactors	Inflow from 1) Free water surface constructed wetlands; 2) denitrifying bioreactors	1) Nitrogen removal efficiency; 2) Total phosforous removal efficiency	Data analysis showed that the load of nitrate was substantially reduced by drainage mitigation measures. As well, mitigation measures mainly acted as sinks of total phosphorus, but occasionally, also as sources.	94%
Ref8	Grazed dairy systems	Global	83	Riparian plantings	Grazed dairy pasture without trees	Run-off of sediment, nutrient or faecal bacteria	Authors found that riparian plantings reduce runoff of sediment, nutrients and/or faecal bacteria, resulting in improved water quality in streams. Reviewers' note: We labelled the results as uncertain due to the lack of statistical testing.	38%
Ref16	Terrestrial landscapes in rural, agricultural, mixed rural–urban or natural habitats regions	Global	121	High landscape complexity (percentage of natural area)	Low landscape complexity (percentage of natural area)	Water quality (concentrations of nitrogen, phosphorus, and sediments, etc.)	An increase in landscape characteristics such the percentage of natural habitat enhances the provision of services related to water quality. The meta-analyses reinforce the importance of considering landscape structure in assessing ecosystem services for management purposes and decision-making.	81%
Ref21	Croplands	Northern hemisphere	93	Outflow load	Inflow load	1) Outflow load of Total nitrogen (TN); 2) Outflow load of total phosphorus (TP)	Restored and created wetlands remain appropriate and potentially sustainable ecological engineering approaches for removing nutrients from treated wastewater and urban and agricultural runoff.	94%
Ref24	Cropland	Global	140	Outflow from ditches	Inflow into ditches	1) Nutrients mitigation power; 2) Pesticide mitigation power	Reviewers' note: We labelled the results for ditches as uncertain due to the lack of statistical testing.	25%
Ref32	Cropland	Global	24	Vegetated treatment systems	Pesticide concentration before the VTS	Reduction of acute ecotoxicity	Results from this meta-analysis confirm that VTSs constitute an effective risk mitigation method for reducing exposure levels of pesticides in downstream surface waters. However, their performance was variable, depending on their physical and hydrological characteristics and on the properties of the pesticides entering these systems.	56%
Ref33	Agricultural fields	Global	73	Outflow from vegetated buffers	Inflow into vegetated buffers	1) Efficacy N mass retention; 2) efficacy P mass retention; 3) Efficacy pesticide mass retention	Vegetated buffers are effective for removing N and P. Vegetated buffers showed high removal efficacy for pesticides. Based on our model, a buffer of 30 m could remove 93% of the pesticides from runoff. Buffers wider than 30 m do not appreciably improve the removal efficacy.	56%
Ref35	Landscapes with N antropogenic inputs	Global	45	Riparian buffers	Riparian buffers influent	N removal	Riparian buffers of various types are effective at reducing nitrogen in riparian zones, especially nitrogen flowing in the subsurface.	56%

Table 3: Reference numbers of the synthesis papers reporting for each of the results shown in **Table 1**.

				Statistically tested			Non-statistically tested
Impact	Metric	Intervention	Comparator	Significantly positive	Significantly negative	Non-significant	
Increase water quality	Nutrient removal	Buffer strips	No buffer strips	Ref33 and Ref35			
		Ditches and ponds	Before ditches or ponds	Ref3			Ref24
		Small wetlands	Before small wetlands	Ref6 and Ref21			
Increase water quality	Water quality	Buffer strips	No buffer strips	Ref33			Ref8
		Ditches and ponds	Before ditches or ponds				Ref24
		Landscape features in general	No semi-natural habitat features	Ref16			
		Small wetlands	Before small wetlands	Ref32			

3. FACTORS INFLUENCING THE EFFECTS ON WATER QUALITY

Table 4: List of factors reported to significantly affect the size and/or direction of the effects on water quality, according to the synthesis papers reviewed.

Factor	Reference number
Buffer vegetation type	Ref33 and Ref35
Buffer width	Ref33 and Ref35
Construction material	Ref3
Hydraulic loading	Ref21
Hydraulic loading rate	Ref21
Inflow concentration	Ref3 and Ref21
Temperature	Ref3 and Ref21
Vegetation presence in ditch	Ref3
Water flow path	Ref35
Wetland area	Ref21

4. KNOWLEDGE GAPS

Table 5: Knowledge gap(s) reported by the authors of the synthesis papers included in this review.

Ref Num	Gap
Ref3	In addition to the factors presented in this study, many other factors may also influence the TN removal rate, such as substrate material. Due to the lack of statistical data, this study did not elaborate on all these factors.
Ref8	The number of publications supporting a given relationship between on-farm woody systems and ecosystem services was often relatively low.
Ref21	Most studies are from Europe and North America; the size distribution of included wetlands may also be biased; most studies of nutrient removal in wetlands have been made during the years following wetland restoration or creation.
Ref33	The models would be greatly improved had there been enough information on buffer slope available in the literature.

5. SYNTHESIS PAPERS INCLUDED IN THE REVIEW

Table 6: List of synthesis papers included in this review. More details can be found in the summaries of the meta-analyses.

Ref Num	Author(s)	Year	Title	Journal	DOI
Ref3	Shen, W; Li, S; Mi, M; Zhuang, Y; Zhang, L	2021	What makes ditches and ponds more efficient in nitrogen control?	AGRICULTURE, ECOSYSTEMS AND ENVIRONMENT, 314, 107409.	10.1016/j.agee.2021.107409
Ref6	Carstensen, MV; Hashemi, F; Hoffmann, CC; Zak, D; Audet, J; Kronvang, B	2020	Efficiency of mitigation measures targeting nutrient losses from agricultural drainage systems: A review	AMBIO, 49, 1820-1837.	10.1007/s13280-020-01345-5
Ref8	England, JR; OGrady, AP; Fleming, A; Marais, Z; Mendham, D	2020	Trees on farms to support natural capital: An evidence-based review for grazed dairy systems	SCIENCE OF THE TOTAL ENVIRONMENT, 704, 135345.	10.1016/j.scitotenv.2019.135345
Ref16	Duarte, GT; Santos, PM; Cornelissen, TG; Ribeiro, MC; Paglia, AP	2018	The effects of landscape patterns on ecosystem services: meta-analyses of landscape services	LANDSCAPE ECOLOGY, 33(8), 1247-1257.	10.1007/s10980-018-0673-5
Ref21	Land, M; Graneli, W; Grimvall, A; Hoffmann, CC; Mitsch, WJ; Tonderski, KS; Verhoeven, JTA	2016	How effective are created or restored freshwater wetlands for nitrogen and phosphorus removal? A systematic review	ENVIRONMENTAL EVIDENCE, 5, 9.	10.1186/s13750-016-0060-0
Ref24	Dollinger, J; Dagès, C; Bailly, JS; Lagacherie, P; Voltz, M	2015	Managing ditches for agroecological engineering of landscape. A review	AGRONOMY FOR SUSTAINABLE DEVELOPMENT, 35, 999-1020.	10.1007/s13593-015-0301-6
Ref32	Stehle, S; Elsaesser, D; Gregoire, C; Imfeld, G; Niehaus, E; Passeport, E; Payraudeau, S; Schafer, RB; Tournebize, J; Schulz, R	2011	Pesticide risk mitigation by vegetated treatment systems: A meta-analysis	JOURNAL OF ENVIRONMENTAL QUALITY, 40(4), 1068-1080.	10.2134/jeq2010.0510
Ref33	Zhang, XY; Liu, XM; Zhang, MH; Dahlgren, RA; Eitzel, M	2010	Review of vegetated buffers and a meta-analysis of their mitigation efficacy in reducing nonpoint source pollution	JOURNAL OF ENVIRONMENTAL QUALITY, 39, 76-84.	10.2134/jeq2008.0496
Ref35	Mayer, PM; Reynolds, SK; McCutchen, MD; Canfield, TJ	2007	Meta-analysis of nitrogen removal in riparian buffers	JOURNAL OF ENVIRONMENTAL QUALITY, 36, 1172-1180.	10.2134/jeq2006.0462