

Metadata for SNAPP Flow Impacts Literature Review Datasets

Revised 2 July 2021

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SNAPPFlowImpacts_Forest_placeholder.xlsx

We conducted a “review of reviews” of the effects of forest restoration, afforestation, and deforestation on hydrologic metrics including the annual water yield and low flow. We did so because several previous studies, including: Bosch and Hewlett, 1982; Sahin and Hall, 1996; Stednick, 1996; Brown et al., 2005; and Filoso et al., 2017 had already reviewed the literature for the evidence regarding these effects. However, previous studies had not appropriately accounted for variance within sites vs. variance across sites, and the most recent reviews had included the results from previous reviews without clearly separating out overlapping sites between those reviews. Here, we took the sites from the reviews as the fundamental unit, ensuring that individual sites were not overcounted and allowing for proper investigation of the differences both within and across sites.

Studies of specific sites were included via the following criteria:

- Eligible interventions: Included studies investigated natural reforestation, afforestation including with plantations, forest loss through disease or infestation, and deforestation through human intervention. In cases of deforestation, we assumed that the effect would be symmetric--that is, increasing forest would have an effect of the same size but the opposite sign of reducing forest. Deforestation via fire was only accepted if the work focused on long-term responses, in order to remove short-term effects due to the complex chemistry and infiltration changes caused by the fire itself.
- Eligible outcomes: At least one quantitative measure of the changes in annual water yield/streamflow, low flow, peak flow, or groundwater level/recharge after the intervention. Outcome values were either extracted from text/tables or extracted from figures using WebPlotDigitizer.
- Eligible comparators: Experiments were required to include a control for the shift in hydrologic metric--in most cases this consisted of a paired watershed which helped isolate the intervention as the driver of shifts in hydrologic metrics. Before-after experiments were included in limited cases.
- Eligible study type: Included studies consist of reviews of field experiments investigating the effects of afforestation and deforestation published in peer-reviewed scientific journals. The reviews themselves searched through peer-reviewed scientific journals and government reports that measured the effects of these activities in well-controlled experiments.
- To avoid overcounting studies that appear in multiple reviews, individual site outcomes were selected from the reviews, and from primary sources when insufficient detail was listed in the review. The sites were then compared across reviews and replicated site outcomes were removed.
- Studies were excluded if there was not sufficient data in the review to determine the outcome and if no online or print versions of the original paper were available or only an abstract was available.

The following variables were summarized/coded for included forest studies:

- Citation
- Study ID
- Site ID
- Location (basin/watershed, latitude, longitude, text description)
- Basin/watershed area
- % forest cover in watershed
- Intervention category: afforestation/forest restoration or forest removal
- Control treatment
- Study design: before-after, control-impact, BACI
- Study duration
- Start year
- Metrics for annual water yield/streamflow
- Change in annual water yield/streamflow
- Metric for low flow
- Change in low flow
- Metric for peak flow
- Change in peak flow
- Metric in groundwater
- Change in groundwater

In the final dataset, the magnitude of change was linearly extrapolated to represent a 10% forest cover change to: 1) enable comparisons and combination of the changes across sites; and 2) to represent magnitudes of change more commonly encountered in nature-based solution contexts.

SNAPPFlowImpacts_Wetland_final.xlsx

Several previously published meta-analyses and reviews documented the hydrological functions of wetlands and provided a solid basis for this present 'review of reviews', including Acreman and Holen 2013, Bullock and Acreman 2003, Kadykalo and Findlay 2016, Meli et al. 2014, Moreno-Mateos et al. 2012. Individual studies were retrieved from Annex 1 of Bullock and Acreman (2003), Table E2 of Kadykalo and Findlay 2016, Supporting Information S1 of Meli et al. (2014) and Text S2 of Moreno-Mateos et al. (2012), screened for eligibility, and extracted data for quantification. Additional candidate studies were retrieved from a qualitative review conducted by one of the researchers in 2017 (Kang 2018). In total, data from 45 articles were included in the final 'review of reviews' dataset.

The following inclusion/exclusion criteria were applied during screening and data extraction:

- Eligible interventions: Interventions within watersheds with permanent wetlands and/or ephemeral areas that hold water seasonally, including protection, restoration, and constructed wetlands. Wetland drainage studies are included too to infer hydrologic roles of wetlands (for simplicity, we assumed that the effect would be symmetric; that is, protecting or restoring wetlands would have an effect of the same size but the opposite sign of draining wetlands). Floodplain wetland studies in Annex 1 of Bullock and

Acreman (2003) as this project attempted to focus on upstream wetlands in source watersheds only.

- Eligible outcome: At least one quantitative outcome measured to indicate changes in annual water yield/streamflow, low flow, flooding, and groundwater level/recharge. Outcome values were either extracted from text/tables.
- Eligible comparators: Need to have a control treatment to permit inference about the level of flow impacts by wetlands. Including before/after (temporal comparisons), business-as-usual/no wetland, different sizes of wetland-interventions (spatial comparisons), comparison with other land-use types. Inflow-outflow measurements are excluded.
- Eligible study type: Primary research studies, published in peer-reviewed scientific journals or government reports, involving field-based experimental manipulations and observations. Only direct evidence of impacts should be included. Modeling studies can be included if they provided primary data (or used empirical measurements for calibration). Modelled studies in Table E2 of Kadykalo and Findlay (2016) were excluded as a result.
- Studies were further excluded if no online or print versions were available or only an abstract was available.

The following variables were summarized/coded for included wetland studies:

- Citation
- Study ID
- Site ID
- Location (basin/watershed, latitude, longitude, text description)
- Basin/watershed area
- Wetland area
- % cover of wetland in watershed
- Intervention category: protection, restoration, drainage, constructed wetland
- Control treatment
- Basis of inference (adopted from Bullock and Acreman 2003): with/without, drained, pair, multiple, same
- Scale: catchment, wetland, plot
- Study design: before-after, control-impact, BACI
- Study duration
- Start year
- Metrics for annual water yield/streamflow
- Change in annual water yield/streamflow
- Metric for low flow
- Change in low flow
- Metric for peak flow
- Change in peak flow
- Metric in groundwater
- Change in groundwater
- Text summary of wetland function statement

Magnitudes of change in the final dataset were normalized to a 10% wetland cover in a watershed, wherever wetland coverage data were available in the original paper, assuming linear relationship for simplicity. This is to enable comparisons and combinations of the changes across sites.

SNAPPFlowImpacts_agRangeDB_yyyymmdd.zip

Agricultural BMPs & flow impacts – literature search methodology

Scope

Objectives:

To identify, collate, and describe relevant published research relating to the impacts of selected agricultural best management practices (BMPs) on water quantity, including annual water yield, low flow, flooding, groundwater level/recharge, soil moisture, and infiltration;
To synthesize and produce an evidence matrix to present the findings.

Primary question:

What evidence exists regarding the effects/impacts of selected agricultural BMPs on water quantity?

Secondary question:

What gaps exist in current evidence base?

Population:

Empirical/project-level evidence from selected agricultural BMPs across the globe

Intervention:

Agricultural BMPs defined in the list of activities below

Comparator:

Before/after applying BMPs (temporal comparisons);
Business-as-usual/no BMPs, different BMPs (spatial comparisons);
Comparison with other land-use types

Outcome:

Any outcomes measured to indicate changes in annual water yield, low flow, flooding, groundwater level/recharge, soil moisture, and infiltration.

List of activities/interventions

Identified through expert interviews.

- 1) **Conservation tillage:** <https://www.sciencedirect.com/science/article/pii/B0123485304002708>
 - Conservation tillage/Minimum tillage/Reduced tillage

- Zero tillage/Zero-till/No-till
- Ridge-till/Ridge-tillage
- Strip-till/Strip-tillage
- Mulch-till/Mulch-tillage
- Zone tillage

2) **Vegetative strips/buffers:** adopted from <https://doi.org/10.1186/s13750-018-0126-2>

Searches

Bibliographic database:

The following bibliographic database(s) (academic sources) will be searched for studies using English search terms (non-English articles, where present, are typically catalogued with English titles, abstracts and/or keywords):

1. Web of Science Core Collections (<http://wok.mimas.ac.uk/>)

Search string:

A search string comprising the following English search terms will be used as a basis for searches within each of the above databases (adapt to database-specific syntax as appropriate).

a) Ag BMP terms

i. Tillage:

TS = ((no OR zero OR reduced OR conservation OR minim* OR ridge OR strip OR mulch OR zone) NEAR/1 till*)

ii. Vegetative strips:

TS = ((buffer NEAR/1 strip*) OR (grass* NEAR/1 strip*) OR (veget* NEAR/1 strip*) OR (riparian NEAR/1 strip*) OR (forest* NEAR/1 strip*) OR (un*cropped NEAR/1 strip*) OR (unmanaged NEAR/1 strip*) OR (grass* NEAR/1 buffer*) OR (veget* NEAR/1 buffer*) OR (riparian NEAR/1 buffer*) OR (river* NEAR/1 buffer*) OR (stream* NEAR/1 buffer*) OR (un*cropped NEAR/1 buffer*) OR (unmanaged NEAR/1 buffer*) OR (forest* NEAR/1 buffer*) OR (non*cropped NEAR/1 buffer*) OR (grass* NEAR/1 barrier*) OR (brush* NEAR/1 barrier*) OR (shrub* NEAR/1 barrier*) OR ("inva* species" NEAR/1 barrier*) OR (veget* NEAR/1 barrier*) OR (riparian NEAR/1 barrier*) OR (un*cropped NEAR/1 barrier*) OR (unmanaged NEAR/1 barrier*) OR (forest* NEAR/1 barrier*) OR (non*cropped NEAR/1 barrier*) OR (grass* NEAR/1 margin*) OR (riparian NEAR/1 margin*) OR (un*cropped NEAR/1 margin*) OR (unmanaged NEAR/1 margin*) OR (veget* NEAR/1 margin*) OR (forest* NEAR/1 margin) OR "barrier strip*" OR "border strip*" OR "boundary buffer*" OR "boundary margin*" OR "boundary strip*" OR "boundary management*" OR "field border*" OR "field buffer*" OR "field margin*" OR "buffer strip*" OR "buffer zone*" OR "filter strip*" OR "filter zone*" OR "managed edge*" OR "buffer management*" OR bufferstrip* OR bufferzone* OR "cropland buffer*" OR "farmland buffer*" OR "farmland margin*" OR "ditch bank*" OR "farm buffer*" OR "farm edge*" OR "farm interface*" OR "field bank*" OR "field

boundary*" OR "field edge*" OR "field interface*" OR "filter margin*" OR "filter strip*" OR filterstrip* OR "filter zone*" OR filterzone* OR "margin strip*" OR beetlebank* OR "beetle bank*" OR "hedge row*" OR hedgerow* OR shelterbelt* OR "shelter belt*" OR "grassed waterway*" OR "grassed water way*" OR "grass waterway*" OR "grass water way*" OR "grassy waterway*" OR "grassy water way*" OR "vegetated waterway*" OR "vegetated water way*" OR "vegetative waterway*" OR "vegetative water way*" OR "wind buffer*" OR "agroforestry buffer*" OR "conservation buffer*")

AND

b) Impact/outcome terms

TS = ("water\$yield" OR "annual flow" OR "base\$flow*" OR "low flow*" OR "dry\$season flow" OR "overland flow" OR "peak flow" OR "time\$to?peak" OR "soil\$water ret*" OR "soil\$moisture ret*") OR TI=("flood*" OR "discharge*" OR "runoff" OR "recharge" OR hydrolog* OR "ground\$water" OR "aquifer*" OR "soil\$moisture" OR "soil\$water" OR "water\$stable" OR "flow regime" OR "water budget" OR "water\$storage" OR stream\$flow OR "water quantity" OR "discharge*" OR infiltration)

AND

c) Qualifier terms

TS = (((farm* OR agricultur* OR crop*) NEAR/1 land*) OR ((farm* OR agricultur* OR crop*) NEAR/1 catchment*) OR ((farm* OR agricultur* OR crop*) NEAR/1 watershed*) OR cultivat* OR (agro*eco*) OR agronom* OR arable* OR horticult*)

AND

d) Impact/outcome qualifier terms

TS = ("impact*" OR "effect*" OR "affect*" OR "linkage*" OR "evidence*" OR "response*" OR "change*")

Timespan:

All time, excluding 2019

Screening

All titles and abstracts will be reviewed by two reviewers against the inclusion and exclusion criteria below. If there's doubt about the relevance of an article, it should be retained for full text assessment. Time permitting, full texts of articles that meet inclusion criteria from screening the title and abstract also need to be further screened.

Applied a machine learning based tool to facilitate screening: Colandr (www.colandrapp.com). See [Cheng et al. 2018](#)

A third researcher to evaluate cases of disagreement.

Eligibility criteria:

Eligible interventions:

Ranching best management practices (BMPs), defined in the list of activities above

Eligible comparators:

- Before/after applying BMPs (temporal comparisons);
- Business-as-usual/no BMPs, different BMPs (spatial comparisons);
- Comparison with other land-use types

Eligible outcomes:

Outcomes (qualitative and quantitative) measured to indicate changes in annual water yield/streamflow, low flow, flooding, groundwater level/recharge, soil moisture, and infiltration.

Eligible types of study design:

Primary research studies involving field-based experimental manipulations and observations. Only direct evidence of impacts should be included. Modeling studies can be included if they provided primary data (or used empirical measurements for calibration). Laboratory studies will not be included. Relevant reviews and meta-analyses should be recorded in a separate dataset, and screen for their reference list for individual case studies.

Eligible languages:

All languages should be included where possible. Studies in languages not able to be translated should be included in a separate supplementary dataset.

Quality appraisal:

Since measurement methods and study designs are expected to vary substantially across outcomes/impacts, it would be difficult to undertake any quality assessment. We may consider assessing confidence/robustness of methods, based on type of data and type of comparators.

Secondary screening

Articles that pass the first screening will be screened based on a full-text review and the following additional criteria during data extraction and coding:

Additional inclusion criteria:

- infiltration ring measurements taken in the field
- simulated rainfall experiments

Exclusion criteria:

- Studies that do not report any hydrologic outcomes in the paper
- Studies that do not meet the eligibility criteria listed above
- Controlled lab studies with no measurements taken in situ in the field
- Studies only reporting differences in hydrologic outcomes for different species or eco-types of natural or managed grasslands (unless the latter are compared with natural species)

Ranching BMPs & flow impacts – literature search methodology

Scope

Objectives:

To identify, collate, and describe relevant published research relating to the impacts of ranching best management practices on water quantity, including annual water yield, low flow, flooding, groundwater level/recharge, soil moisture, and infiltration; To synthesize and produce a weighted evidence matrix to present the findings.

Primary question:

What evidence exists regarding the effects/impacts of ranching best management practices on water quantity?

Secondary question:

What gaps exist in current evidence base?

Population:

Empirical case/project-level evidence from rangelands, grasslands, pasture lands (defined as lands with grazing as main land use type) across the globe; specify grassland types as needed (prairie, paramo, puna, steppe, pampas, etc.);

Intervention:

Ranching best management practices (BMPs), defined in the list of activities below

Comparator:

Before applying BMPs, before turning into rangelands (temporal comparisons);
Business-as-usual/no BMPs, different BMPs (spatial comparisons);
Comparison with other land-use types

Outcome:

Any outcomes measured to indicate changes in annual water yield, low flow, flooding, groundwater level/recharge, soil moisture, and infiltration.

List of activities/interventions

List of ranching BMP activities, identified through a scoping process using literature on ranching practices collected through earlier projects. The following list is created by two reviewers, and is categorized broadly by managing vegetation, animal, or ecological processes.

1) **Vegetation-related management practices:**

- Brush management; brush removal; shrub control; controlling woody plant encroachment; woody encroachment
 - Note: These also linked to disturbance regimes (fire) management (see below)
- Invasive species control (Tamarix); non-native vegetation control
 - Note: linked to woody plant removal, but perhaps deserves its own category

- Buffer strips
- Riparian buffer (grass or trees)
- Silvopasture
- Pasture management
 - Haying; converting pasture to hay field; hay cut
 - Silage
 - Forage harvest efficiency
 - Pastoral improvement
 - Pasture composition management/manipulation/planting

2) Animal/livestock-related management practices:

- Grazing removal; no grazing; fencing/exclosure
- Stocking rate management
 - Including but not limited to: Season restricted grazing; rotational grazing; light continuous grazing; adaptive multi-paddock grazing; heavy continuous; extensive grazing; optimal grazing
 - Metrics to include in the search: Seasonality, intensity, duration (interval, period, cycles), density of animals (stocking density; animal density; stocking rate; animal units)
- Bedding site relocation
- Traditional pasture use

3) Restore historical disturbance regimes of rangelands/grasslands

- Prescribed fire
- Grazing by large herbivores; maintain a certain level of grazing, likely in the absence of native ungulates
- Grazing by small herbivores (e.g. prairie dogs)

4) Protection

- Native or natural rangeland/grassland protection
 - Note: Mostly paired catchment experiments, comparing with afforestation, cultivation, or high intensity grazing

Searches

Bibliographic database:

The following bibliographic database(s) (academic sources) will be searched for studies using English search terms (non-English articles, where present, are typically catalogued with English titles, abstracts and/or keywords):

1. Web of Science Core Collections (<http://wok.mimas.ac.uk/>)

Search string:

A search string comprising the following English search terms will be used as a basis for searches within each of the above databases (adapt to database-specific syntax as appropriate).

a) Ranching BMP terms

```
TS=((
(grass* NEAR/1 manage*) OR "range* manage*" OR "manage* range" OR "manage* of range"
OR (ranch* NEAR/1 manage*) OR (brush* NEAR/1 manage*) OR (shrub* NEAR/1 manage*) OR
("inva* species" NEAR/1 manage*) OR (Tamarix NEAR/1 manage*) OR (veget* NEAR/1
manage*) OR (riparian NEAR/1 manage*) OR (pasture* NEAR/1 manage*) OR (river* NEAR/1
manage*) OR (stream* NEAR/1 manage*) OR (grass* NEAR/1 BMP*) OR "range* BMP*" OR
"BMP* of range" OR (ranch* NEAR/1 BMP*) OR (brush* NEAR/1 BMP*) OR (shrub* NEAR/1
BMP*) OR ("inva* species" NEAR/1 BMP*) OR (Tamarix NEAR/1 BMP*) OR (veget* NEAR/1
BMP*) OR (riparian NEAR/1 BMP*) OR (pasture* NEAR/1 BMP*) OR (river* NEAR/1 BMP*) OR
(stream* NEAR/1 BMP*) OR (brush* NEAR/1 remov*) OR (shrub* NEAR/1 remov*) OR ((woody*
NEAR/1 encroach*) NEAR/1 remov*) OR ("inva* species" NEAR/1 remov*) OR (Tamarix NEAR/1
remov*) OR (veget* NEAR/1 remov*) OR (brush* NEAR/1 control*) OR (shrub* NEAR/1
control*) OR ((woody* NEAR/1 encroach*) NEAR/1 control*) OR ("inva* species" NEAR/1
control*) OR (Tamarix NEAR/1 control*) OR (veget* NEAR/1 control*) OR (grass* NEAR/1 strip*)
OR (veget* NEAR/1 strip*) OR (riparian NEAR/1 strip*) OR (grass* NEAR/1 buffer*) OR (veget*
NEAR/1 buffer*) OR (riparian NEAR/1 buffer*) OR (river* NEAR/1 buffer*) OR (stream* NEAR/1
buffer*) OR (grass* NEAR/1 barrier*) OR (brush* NEAR/1 barrier*) OR (shrub* NEAR/1 barrier*)
OR ("inva* species" NEAR/1 barrier*) OR (veget* NEAR/1 barrier*) OR (riparian NEAR/1
barrier*) OR (grass* NEAR/1 improv*) OR "range* improv*" OR "improv* range" OR "improv* of
range" OR (ranch* NEAR/1 improv*) OR (brush* NEAR/1 improv*) OR (shrub* NEAR/1 improv*)
OR (veget* NEAR/1 improv*) OR (riparian NEAR/1 improv*) OR (pasture* NEAR/1 improv*) OR
(pastor* NEAR/1 improv*) OR (river* NEAR/1 improv*) OR (stream* NEAR/1 improv*) OR
(grass* NEAR/1 manipul*) OR "range* manipul*" OR "manipulate* range" OR "manipulat*
of range" OR (ranch* NEAR/1 manipul*) OR (brush* NEAR/1 manipul*) OR (shrub* NEAR/1
manipulat*) OR (veget* NEAR/1 manipul*) OR (riparian NEAR/1 manipul*) OR (pasture*
NEAR/1 manipul*) OR (pastor* NEAR/1 manipul*) OR (grass* NEAR/1 plant*) OR "range*
plant*" OR "plant* range" OR "plant* of range" OR (brush* NEAR/1 plant*) OR (shrub* NEAR/1
plant*) OR (veget* NEAR/1 plant*) OR (riparian NEAR/1 plant*) OR (pasture* NEAR/1 plant*) OR
(pastor* NEAR/1 plant*) OR (grass* NEAR/1 exclos*) OR "range* exclos*" OR "exclos* range"
OR "exclos* of range" OR (ranch* NEAR/1 exclos*) OR (brush* NEAR/1 exclos*) OR (shrub*
NEAR/1 exclos*) OR (veget* NEAR/1 exclos*) OR (riparian NEAR/1 exclos*) OR (pasture* NEAR/1
exclos*) OR (pastor* NEAR/1 exclos*) OR (river* NEAR/1 exclos*) OR (stream* NEAR/1 exclos*)
OR (grass* NEAR/1 fenc*) OR "range* fenc*" OR "fenc* range*" OR "fenc* of range" OR (ranch*
NEAR/1 fenc*) OR (brush* NEAR/1 fenc*) OR (shrub* NEAR/1 fenc*) OR (veget* NEAR/1 fenc*)
OR (riparian NEAR/1 fenc*) OR (pasture* NEAR/1 fenc*) OR (pastor* NEAR/1 fenc*) OR (river*
NEAR/1 fenc*) OR (stream* NEAR/1 fenc*) OR (grass* NEAR/1 graz*) OR "range* graz*" OR
"graz* range*" OR "graz* of range*" OR (ranch* NEAR/1 graz*) OR (brush* NEAR/1 graz*) OR
(shrub* NEAR/1 graz*) OR (veget* NEAR/1 graz*) OR (riparian NEAR/1 graz*) OR (pasture*
NEAR/1 graz*) OR (pastor* NEAR/1 graz*) OR (river* NEAR/1 graz*) OR (stream* NEAR/1 graz*)
```

OR (grass* NEAR/1 protect*) OR "range* protect*" OR "protect* range*" OR "protect* of range*" OR (ranch* NEAR/1 protect*) OR (brush* NEAR/1 protect*) OR (shrub* NEAR/1 protect*) OR (veget* NEAR/1 protect*) OR (riparian NEAR/1 protect*) OR (pasture* NEAR/1 protect*) OR (pastor* NEAR/1 protect*) OR (river* NEAR/1 protect*) OR (stream* NEAR/1 protect*) OR (grass* NEAR/1 restor*) OR "range* restor*" OR "restor* range*" OR "restor* of range*" OR (ranch* NEAR/1 restor*) OR (brush* NEAR/1 restor*) OR (shrub* NEAR/1 restor*) OR (veget* NEAR/1 restor*) OR (riparian NEAR/1 restor*) OR (pasture* NEAR/1 restor*) OR (pastor* NEAR/1 restor*) OR (river* NEAR/1 restor*) OR (stream* NEAR/1 restor*) OR (manage* NEAR/1 non-native) OR (manage* NEAR/1 pastor*) OR (remov* NEAR/1 grass*) OR "remov* range*" OR "remov* of range*" OR "range* remov*" OR (remov* NEAR/1 ranch*) OR (remov* NEAR/1 non-native) OR (remov* NEAR/1 riparian) OR (remov* NEAR/1 pasture*) OR (remov* NEAR/1 pastor*) OR (control* NEAR/1 grass*) OR "control* range*" OR "control* of range*" OR "range* control*" OR (control* NEAR/1 ranch*) OR (control* NEAR/1 non-native) OR (control* NEAR/1 riparian) OR (control* NEAR/1 pasture*) OR (control* NEAR/1 pastor*) OR (buffer* NEAR/1 brush*) OR (buffer* NEAR/1 shrub*) OR (manipulat* NEAR/1 "inva* species") OR (manipulat* NEAR/1 Tamarix) OR (manipulat* NEAR/1 non-native) OR (manipulat* NEAR/1 river*) OR (manipulat* NEAR/1 stream*) OR (plant* NEAR/1 river*) OR (plant* NEAR/1 stream*) OR ((woody* NEAR/1 encroach*) NEAR/1 manage*) OR (non-native NEAR/1 manage*) OR (pastor* NEAR/1 manage*) OR (grass* NEAR/1 clear*) OR "range* clear*" OR "clear* range*" OR "clear* of range*" OR (ranch* NEAR/1 clear*) OR (brush* NEAR/1 clear*) OR (shrub* NEAR/1 clear*) OR ((woody* NEAR/1 encroach*) NEAR/1 clear*) OR ("inva* species" NEAR/1 clear*) OR (Tamarix NEAR/1 clear*) OR (non-native NEAR/1 clear*) OR (veget* NEAR/1 clear*) OR (riparian NEAR/1 clear*) OR (pasture* NEAR/1 clear*) OR (pastor* NEAR/1 clear*) OR (river* NEAR/1 clear*) OR (stream* NEAR/1 clear*))

OR

("buffer strip*" OR silvopasture* OR "hayng" OR "hay cut" OR "silage" OR "forage harvest efficiency" OR "grazing removal" OR "no grazing" OR "fencing" OR "animal unit*" OR "bedding site relocation" OR "traditional pasture use" OR "prescribed fire" OR "disturbance regime restoration" OR "farm pond*" OR impoundment* OR "pasture composition management" OR "pasture composition manipulation" OR "range* water manage*" OR "pasture* water manage*")

OR

((graz* NEAR/1 remov*) OR "no graz*" OR (graz* NEAR/1 duration) OR (graz* NEAR/1 intens*) OR (graz* NEAR/1 cycle) OR (graz* NEAR/1 interval) OR (graz* NEAR/1 period) OR (graz* NEAR/1 season*) OR (graz* NEAR/1 rotation*) OR (contin* NEAR/1 graz*) OR "multi-paddock" OR (adapt* NEAR/1 graz*) OR (optim* NEAR/1 graz*) OR (restrict* NEAR/1 graz*) OR (introduc* NEAR/1 graz*))

OR

((stock* NEAR/1 density) OR (stock* NEAR/1 rate*) OR (stock* NEAR/1 manage*) OR (stock* NEAR/1 BMP*) OR (stock* NEAR/1 exclos*))

AND

b) Impact/outcome terms

TS=("water\$yield" OR "annual flow" OR "base\$flow*" OR "low flow*" OR "dry\$season flow" OR "overland flow" OR "peak flow" OR "time\$to?peak" OR "soil\$water ret*" OR "soil\$moisture ret*") OR TI=("flood*" OR "discharge*" OR "runoff" OR "recharge" OR hydrolog* OR "ground\$water" OR "aquifer*" OR "soil\$moisture" OR "soil\$water" OR "water\$stable" OR "flow regime" OR "water budget" OR "water\$storage" OR stream\$flow OR "water quantity" OR "discharge*" OR "infiltration" OR "runoff")

AND

c) Qualifier terms

TS=("grass*" OR rangeland OR "pasture*" OR "prairie" OR "paramo" OR "puna" OR "steppe" OR "pampas" OR "graz*" OR "cattle*" OR "livestock" OR "extent bare ground" OR "percentage bare ground" OR "vegetation recovery period" OR "standing forage")

AND

d) Impact/outcome qualifier terms

TS=("impact*" OR "effect*" OR "affect*" OR "linkage*" OR "evidence*" OR "response*" OR "change*" OR "catchment")

Timespan:

All time, excluding 2019

Screening

All titles and abstracts will be reviewed by two reviewers against the inclusion and exclusion criteria below. If there's doubt about the relevance of an article, it should be retained for full text assessment. Time permitting, full texts of articles that meet inclusion criteria from screening the title and abstract also need to be further screened.

Applied a machine learning based tool to facilitate screening: Colandr (www.colandrapp.com). See [Cheng et al. 2018](#)

A third researcher to evaluate cases of disagreement.

Eligibility criteria:

Eligible interventions:

Ranching best management practices (BMPs), defined in the list of activities above

Eligible comparators:

Before applying BMPs, before turning into rangelands (temporal comparisons);

Business-as-usual/no BMPs, different BMPs (spatial comparisons);

Comparison with other land-use types

Eligible outcomes:

Outcomes (qualitative and quantitative) measured to indicate changes in annual water yield/streamflow, low flow, flooding, groundwater level/recharge, soil moisture, and infiltration.

Eligible types of study design:

Primary research studies involving field-based experimental manipulations and observations.

Only direct evidence of impacts should be included. Modeling studies can be included if they

provided primary data (or used empirical measurements for calibration). Laboratory studies will not be included. Relevant reviews and meta-analyses should be recorded in a separate dataset, and screen for their reference list for individual case studies.

Eligible languages:

All languages should be included where possible. Studies in languages not able to be translated should be included in a separate supplementary dataset.

Quality appraisal:

Since measurement methods and study designs are expected to vary substantially across outcomes/impacts, it would be difficult to undertake any quality assessment. We may consider assessing confidence/robustness of methods, based on type of data and type of comparators.

Secondary screening:

Articles that pass the first screening will be screened based on a full-text review and the following additional criteria during data extraction and coding:

Additional inclusion criteria:

Infiltration ring measurements taken in the field
Simulated rainfall experiments

Exclusion criteria:

Studies that do not report any hydrologic outcome data in the paper
Studies that do not meet the eligibility criteria listed above
Controlled lab studies with no measurements taken in situ in the field
Studies only reporting differences in hydrologic outcomes for different species or eco-types of natural or managed grasslands (unless the latter are compared with natural species)

Summary of quality control performed on the Agriculture & Rangeland BMP database

For ALL records, individual reviewers were asked to confirm the following:

1. Verify that all records had a value in the Control Direction field.
2. Verified that all change calculations were done as Control site minus Experiment site value.
3. Check that the entered values represent the difference between land cover changes, not other factors (for example, change through time or between different simulated rainfall rates).

Next, a Limited Quality Control was performed on some additional papers. Changes made in this round are noted by having a value in the "Edited by" field.

4. All papers coded as Broad Experiment Type = "Wetland" or "Forest" were re-checked for consistency with the study design. Some were re-coded as "Agriculture" or "Rangeland".
5. Verified consistency between Broad Experiment Type and Broad Treatment Class. For example, all Conservation tillage studies should be coded as Broad Treatment Class = "Agriculture" NOT "Forest".
6. Verified that all papers coded as Study Design = "Control/Impact" or "Before/after-control/impact" had a Control site linked in the Experiment Site entry.
7. Reviewed all studies where Study Design = "Gradient response"; wherever possible, these were re-coded to "Control/Impact" in order to reflect relevant impacts due to NBS-like interventions. Others were left as is.
8. Note that **no validation was done on how the flow measurements and change values were coded** as part of this limited quality control.

Full quality control was then performed on a subset of papers. Changes made in this round are noted by having a value in the "Quality Control" field.

9. All papers where Broad Treatment Class = "Rangeland management", "Vegetative buffer strips/vegetative buffer management", or "Fire" were checked for accuracy and completeness. Further, a search was done for any records that included the keywords "fire" or "buffer" in any fields, and those were also reviewed to determine if the Broad Treatment Class was coded correctly. Here we paid special attention to the selection and coding of the study's control and experiment sites, along with the following fields for each record:
 - a. Broad Experiment Type
 - b. Study design
 - c. Broad Treatment Class
 - d. Treatment Class Details
 - e. Vegetation before and after treatment
 - f. Treatment details
 - g. Control site
 - h. Control direction
 - i. Flow measurements and change fields: verified that metrics were reported in the proper fields, the values are correct, and changes are calculated correctly.
 - j. Reasoning for measure selection
10. A random selection of 30 papers across all treatment types was included in the above quality control procedure and corrections were made to those entries. That review revealed additional problems with papers that were not captured in the process above. **Users are therefore cautioned against drawing any conclusions from the database based on records that have not undergone full verification.** These include any entries where the "Quality Control" field is blank.

SNAPP Flow Impacts Literature Review Dataset: Field Definitions

SNAPPFlowImpacts_agRangeDB_20210701.zip

Study site

SITE NAME [TEXT]^{*,†}

Short descriptive name of site where experiment was conducted.

VEGETATION/ECOSYSTEM CLASS [CLASS]^{*}

IGBP land cover classifications; see map at <http://glcf.umd.edu/data/lc/>

Class entries: Evergreen needleleaf forests; Evergreen broadleaf forests; Deciduous needleleaf forests; Deciduous broadleaf forests; Mixed forests; Closed shrublands; Open shrublands; Woody savannas; Savannas; Grasslands; Permanent wetlands; Croplands; Urban and built-up lands; Cropland/natural vegetation mosaics; Snow and ice; Barren; Water bodies

SITE LATITUDE [NUMERIC, DECIMAL DEGREE]^{*}

Conversion tool at: <https://www.fcc.gov/media/radio/dms-decimal>

Forest: Location of catchment—less detailed than Experiment Latitude

Wetland: Location of catchment—less detailed than Experiment Latitude

Rangeland: Location of rangeland

Agriculture: Location of agricultural fields

SITE LONGITUDE [NUMERIC, DECIMAL DEGREE]^{*}

Conversion tool at: <https://www.fcc.gov/media/radio/dms-decimal>

Forest: Location of catchment—less detailed than Experiment Latitude

Wetland: Location of catchment—less detailed than Experiment Latitude

Rangeland: Location of rangeland

Agriculture: Location of agricultural fields

STUDY SITE DESCRIPTION [TEXT]

Long description of site where study was conducted.

CLIMATE REGION CLASSIFICATION [CLASS]

Koppen-Geiger climate zones, level 2; see Peel et al., 2007 at <https://www.hydrol-earth-syst-sci.net/11/1633/2007/>

High-res map and raster data in supplement

Class entries: Tropical rainforest; Tropical monsoon; Tropical savannah; Arid desert; Arid steppe; Temperate dry summer; Temperate dry winter; Temperate without dry season; Cold dry summer; Cold dry winter; Cold without dry season; Polar tundra; Polar frost

(typically not entered; can be inferred from Lat/Long entries in previous fields)

CITATION [CITATION ID FOREIGN KEY]^{*,‡}

10 citation fields that reference this study site, with links to Zotero literature database

Experiment site

EXPERIMENT NAME [TEXT]^{*,†}

Short descriptive name of experimental treatment

SITE NAME [SITE ID FOREIGN KEY]^{*,‡}

Short descriptive name of site; linked to same field in Study Site table

BROAD EXPERIMENT TYPE [CLASS]^{*}

Classes: Forest; Wetland; Rangeland; Agriculture

STUDY DESIGN [CLASS]^{*}

Classes from *Eco Evidence Analysis Methods Manual: A Systematic Approach to evaluate Causality in Environmental Science*, available at

https://www.researchgate.net/publication/263273816_Eco_Evidence_Analysis_Methods_Manual_A_Systematic_Approach_to_Evaluate_Causality_in_Environmental_Science

Classes: After impact; Control/impact; Before/after; Gradient response; Before/after-control/impact; Before/after-control/impact paired; Multiple before/after control/impact

STUDY SCALE [CLASS]^{*}

Classes: Landscape; Plot

EXPERIMENT AREA [NUMERIC, M²]^{*}

Meaning of number depends on Broad Experiment Type and Study Scale

Forest: Watershed area, intervention area for plot-scale

Wetland: Watershed area, wetland area for plot-scale

Rangeland: Watershed area for natural experiments, total of plot area(s) for plot-scale

Agriculture: Watershed area for natural experiments, total of plot area(s) for plot-scale

PERCENT BEFORE TREATMENT [NUMERIC]

Meaning of number depends on Study Design, and Study Scale

Forest: Fraction forest before treatment

Wetland: Fraction of watershed that is wetland before treatment

Rangeland: Fraction of watershed that is relevant rangeland before treatment; 1.0 for plot-scale experiments

Agriculture: Fraction of watershed that is relevant agriculture before treatment; 1.0 for plot-scale experiments

EXPERIMENT LATITUDE [NUMERIC, DECIMAL DEGREE]

Conversion tool at: <https://www.fcc.gov/media/radio/dms-decimal>

Measurement point for streamflow (bottom of catchment), if available for Landscape scale studies; otherwise general experiment location as reported in study. If study does not report lat/long then a google search was performed on the experiment site name and the lat/long inferred from the results.

EXPERIMENT LONGITUDE [NUMERIC, DECIMAL DEGREE]

Conversion tool at: <https://www.fcc.gov/media/radio/dms-decimal>

Measurement point for streamflow (bottom of catchment), if available for Landscape scale studies; otherwise general experiment location as reported in study. If study does not report lat/long then a google search was performed on the experiment site name and the lat/long inferred from the results.

VEGETATION CLASS BEFORE TREATMENT [CLASS]

Forest: Native tropical forest; Secondary tropical forest; Tropical plantation; Native temperate forest; Secondary temperate forest; Temperate plantation; Native boreal forest; Secondary boreal forest; Boreal plantation; General/not specified forest

Wetland: Surface water depression wetland, surface water slope wetland, groundwater depression wetland, groundwater slope wetland; temperate wetland; tropical wetland; General/not specified wetland

Rangeland: Closed shrubland; Open shrubland; Woody savannah; Savannah; Grassland; pastureland; agriculture

Agriculture: Intensive agriculture row crops; Intensive agriculture orchard; Low-intensity agricultural row crops; Low-intensity agricultural orchards; General/not specified agriculture

DESCRIPTION OF SITE VEGETATION BEFORE TREATMENT [TEXT]

Free text entry including all relevant details

VEGETATION CLASS AFTER TREATMENT [CLASS]

Forest: Native tropical forest; Secondary tropical forest; Tropical plantation; Native temperate forest; Secondary temperate forest; Temperate plantation; Native boreal forest; Secondary boreal forest; Boreal plantation; General/not specified forest

Wetland: Surface water depression wetland, surface water slope wetland, groundwater depression wetland, groundwater slope wetland; temperate wetland; tropical wetland; General/not specified

Rangeland: Closed shrubland; Open shrubland; Woody savannah; Savannah; Grassland; Pasture; General/not specified rangeland

Agriculture: Intensive agriculture row crops; Intensive agriculture orchard; Low-intensity agricultural row crops; Low-intensity agricultural orchards; General/not specified agriculture

DESCRIPTION OF SITE VEGETATION AFTER TREATMENT [TEXT]

Free text entry including all relevant details

BROAD TREATMENT CLASS [CLASS]

Forest: Reforestation with native vegetation; Afforestation with non-native species; Afforestation with plantation; Deforestation to plantation; Deforestation to brush; Deforestation to grassland; Deforestation to degraded land

Wetland: Wetland drained; Wetland restored; Wetland constructed/created; wetland enhanced

Rangeland: Brush/shrub management; Grassland management; Rangeland/pasture management; Invasive species management; Woody encroachment management; Silvopasture; Hay management; Fire; Water management; Grazing management; Stock management

Agriculture: Conservation tillage/tillage management; vegetative buffer strips/vegetative buffer management

TREATMENT CLASS DETAILS 1, 2 [CLASS]

Forest: Clearcut; Selective logging; Burning; Herbicide; Cabling; Overstory removal; Strip shelterwood cut; Tractor logging; Skyline logging; Unplanned deforestation (e.g., for ag. development)

Wetland: Wetland hydrological restoration; Wetland filled; Wetland fully drained; Wetland partially drained; Wetland channelized, subsurface drainage added; Wetland permanently flooded; Wetland diked; Wetland impounded; Wetland farmed/grazed; Wetland constructed for wastewater management; Wetland constructed for agricultural runoff management; Pond created

Rangeland: Brush/shrub protection; Brush/shrub restoration; Brush/shrub BMPs; Brush/shrub removal or clearing; Grassland protection; Grassland restoration; Grassland BMPs; Grassland clearing; Rangeland/pasture protection; Rangeland/pasture restoration; Rangeland/pasture BMPs; Invasive species removal; Other invasive species control measures; Removal of woody encroachment; Control of woody encroachment; Riparian buffer introduction/planting; Riparian buffer restoration; Riparian buffer protection; Riparian buffer BMPs; Riparian vegetation removal; Hay introduction; Hay cut; Prescribed fire; Restored fire regime; Farm pond; Water impoundment;

Grazing introduction; Grazing enclosure or fencing; Grazing management-duration; Grazing management-continuous; Grazing management-seasonal; Grazing management-light intensity; Grazing management-heavy intensity; Grazing management-rotational; Grazing removal; Stock density management; Stock rate management

Agriculture: Conservation tillage; Minimum tillage; Reduced tillage; Zero tillage/no tillage; Ridge tillage; Strip tillage; Mulch tillage; Zone tillage; Vegetative buffer introduction/planting; Vegetative buffer restoration; Vegetative buffer protection; Vegetative buffer BMPs;

PERCENT TREATED [NUMERIC]

Percent of experiment area (plot or watershed) treated

TREATMENT DETAILS [TEXT]

Free text entry including all relevant details.

CONTROL SITE [CONTROL ID FOREIGN KEY][‡]

Short descriptive name of control site; linked to Control Site:Control Name

CONTROL DIRECTION [CLASS]^{*}

Used to indicate whether the control site as entered in the database represents the nature-based solution or “more natural” treatment or the more impacted or “business as usual” treatment.

Classes: Control is more impacted, Control is more natural, Control is unclear

CALIBRATION START YEAR [INTEGER, YEAR]

Starting year for collection of calibration data, when applicable

CALIBRATION DURATION [NUMERIC, YEARS]

Period of collection of calibration data, when applicable

INTERVENTION START YEAR [INTEGER, YEAR]

Year of intervention or experiment, or when intervention began

INTERVENTION DURATION [NUMERIC, YEARS]^{*}

Time since intervention was implemented (if a long-term study), or time over which experiment was conducted (if short-term)

ELEVATION MEDIAN [NUMERIC, M]

Median elevation of watershed or experiment area, in meters

ELEVATION MEAN [NUMERIC, M]

Mean elevation of watershed or experiment area, in meters

ELEVATION MINIMUM [NUMERIC, M]

Minimum elevation of watershed or experiment area, in meters

ELEVATION MAXIMUM [NUMERIC, M]

Maximum elevation of watershed or experiment area, in meters

ASPECT [CLASS]

Aspect of watershed or experiment area

Classes: N; NE; E; SE; S; SW; W; NW

SLOPE [NUMERIC, %]

Slope of watershed or experiment area, in percentage

SOIL [CLASS]

Soils classified according to USDA soil taxonomy at first level:

https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_051232.pdf, with global map at https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/use/?cid=nrcs142p2_054013

Classes: Alfisol; Andisol; Aridisol; Entisol; Gelisol; Histisol; Inceptisol; Mollisol; Oxisol; Spodosol; Ultisol; Vertisol

SOIL DESCRIPTION [TEXT]

Description of soil beyond USDA class when available, or when some other classification is used

MEAN ANNUAL RAINFALL [NUMERIC, MM]

Mean annual rainfall in watershed or at experiment site

MEAN ANNUAL STREAMFLOW [NUMERIC, MM]

Mean annual streamflow in watershed, wetland, or experimental area, normalized to the watershed area or relevant experimental area. Meaning of number depends on Study Design:

After impact; Control/impact; Gradient response: Mean annual streamflow measured at the experiment site.

Before/after: Mean annual streamflow measured at the experiment site, after experimental treatment.

Before/after-control/impact; Before/after-control/impact paired; Multiple before/after control/impact: The fractional change in mean annual streamflow measured after the treatment relative to streamflow measured before the treatment, at the experiment site: $(A_t - B_t)/B_t$

CHANGE IN ANNUAL STREAMFLOW [NUMERIC, MM]

Change in annual streamflow in watershed, wetland, or experimental area, normalized to watershed area or relevant experimental area. Meaning of number depends on Study Design:

After impact; Control/impact; Gradient response: calculated as control site value minus experiment site value.

Before/after: calculated as the value measured after the experimental treatment minus before the treatment.

Before/after-control/impact; Before/after-control/impact paired; Multiple before/after control/impact: calculated as the difference between fractional change in streamflow values

measured at the control site (c) and the fractional change in streamflow values measured at the experiment site (t), as follows

$$(A_c - B_c)/B_c - (A_t - B_t)/B_t$$

SIGNIFICANCE OF CHANGE IN ANNUAL STREAMFLOW [BINARY]

Indicator of whether change in annual streamflow is statistically significant, per the assessment of study authors

LOW FLOW MEASURE [TEXT]

Description of measure used to describe low flow, with units

If there are multiple low flow measures, one was selected that best reflected the purpose of this review: to understand the water quantity effects of nature-based solutions.

LOW FLOW [NUMERIC]

Low flow; in units from Low Flow Measure field. Meaning of number depends on Study Design:

After impact; Control/impact; Gradient response: Low flow measured at the experiment site.

Before/after: Low flow measured at the experiment site, after experimental treatment.

Before/after-control/impact; Before/after-control/impact paired; Multiple before/after control/impact: The fractional change in low flow measured after the treatment relative to low flow measured before the treatment, at the experiment site: $(A_t - B_t)/B_t$

CHANGE IN LOW FLOW [NUMERIC]

Change in low flow calculated as control site minus experiment site; in units from Low Flow Measure field. Meaning of number depends on Study Design:

After impact; Control/impact; Gradient response: calculated as control site value minus experiment site value.

Before/after: calculated as the value measured after the experimental treatment minus before the treatment.

Before/after-control/impact; Before/after-control/impact paired; Multiple before/after control/impact: calculated as the difference between fractional change in low flow values measured at the control site (c) and the fractional change in low flow values measured at the experiment site (t), as follows

$$(A_c - B_c)/B_c - (A_t - B_t)/B_t$$

SIGNIFICANCE OF CHANGE IN LOW FLOW [BINARY]

Indicator of whether change in low flow is statistically significant, per the assessment of study authors

PEAK FLOW MEASURE [TEXT]

Description of measure used to describe peak flow, with units

If there are multiple peak flow measures, one was selected that best reflected the purpose of this review: to understand the water quantity effects of nature-based solutions.

PEAK FLOW [NUMERIC]

Peak flow; in units from Peak Flow Measure field. Meaning of number depends on Study Design:

After impact; Control/impact; Gradient response: Peak flow measured at the experiment site.

Before/after: Peak flow measured at the experiment site, after experimental treatment.

Before/after-control/impact; Before/after-control/impact paired; Multiple before/after control/impact: The fractional change in peak flow measured after the treatment relative to peak flow measured before the treatment, at the experiment site: $(A_t - B_t)/B_t$

CHANGE IN PEAK FLOW [NUMERIC]

Change in peak flow; in units from Peak Flow Measure field. Meaning of number depends on Study Design:

After impact; Control/impact; Gradient response: calculated as control site value minus experiment site value.

Before/after: calculated as the value measured after the experimental treatment minus before the treatment.

Before/after-control/impact; Before/after-control/impact paired; Multiple before/after control/impact: calculated as the fractional change in peak flow values measured at the control site (c) and the fractional change in peak flow values measured at the experiment site (t), as follows

$$(A_c - B_c)/B_c - (A_t - B_t)/B_t$$

SIGNIFICANCE OF CHANGE IN PEAK FLOW [BINARY]

Indicator of whether change in peak flow is statistically significant, per the assessment of study authors

GROUNDWATER RECHARGE MEASURE [TEXT]

Description of measure used to describe groundwater recharge, with units

If there are multiple groundwater recharge measures, one was selected that best reflected the purpose of this review: to understand the water quantity effects of nature-based solutions.

GROUNDWATER RECHARGE [NUMERIC]

Groundwater recharge; in units from Groundwater Recharge Measure field. Meaning of number depends on Study Design:

After impact; Control/impact; Gradient response: Groundwater recharge measured at the experiment site.

Before/after: Groundwater recharge measured at the experiment site, after experimental treatment.

Before/after-control/impact; Before/after-control/impact paired; Multiple before/after control/impact: The fractional change in groundwater recharge measured after the treatment relative to groundwater recharge measured before the treatment, at the experiment site: $(A_t - B_t)/B_t$

CHANGE IN GROUNDWATER RECHARGE [NUMERIC]

Change in groundwater recharge; in units from Groundwater Recharge Measure field. Meaning of number depends on Study Design:

After impact; Control/impact; Gradient response: calculated as control site value minus experiment site value.

Before/after: calculated as the value measured after the experimental treatment minus before the treatment.

Before/after-control/impact; Before/after-control/impact paired; Multiple before/after control/impact: calculated as the fractional change in groundwater recharge values measured at the control site (c) and the fractional change in groundwater recharge values measured at the experiment site (t), as follows

$$(A_c - B_c)/B_c - (A_t - B_t)/B_t$$

SIGNIFICANCE OF CHANGE IN GROUNDWATER RECHARGE [BINARY]

Indicator of whether change in groundwater recharge is statistically significant, per the assessment of study authors

SOIL MOISTURE MEASURE [TEXT]

Description of measure used to describe soil moisture, with units

If there are multiple soil moisture measures, one was selected that best reflected the purpose of this review: to understand the water quantity effects of nature-based solutions.

SOIL MOISTURE [NUMERIC]

Soil moisture; in units from Soil Moisture Measure field. Meaning of number depends on Study Design:

After impact; Control/impact; Gradient response: Soil moisture measured at the experiment site.

Before/after: Soil moisture measured at the experiment site, after experimental treatment.

Before/after-control/impact; Before/after-control/impact paired; Multiple before/after control/impact: The fractional change in soil moisture measured after the treatment relative to soil moisture measured before the treatment, at the experiment site: $(A_t - B_t)/B_t$

CHANGE IN SOIL MOISTURE [NUMERIC]

Change in soil moisture; in units from Soil Moisture Measure field. Meaning of number depends on Study Design:

After impact; Control/impact; Gradient response: calculated as control site value minus experiment site value.

Before/after: calculated as the value measured after the experimental treatment minus before the treatment.

Before/after-control/impact; Before/after-control/impact paired; Multiple before/after control/impact: calculated as the fractional change in soil moisture values measured at the control site (c) and the fractional change in soil moisture values measured at the experiment site (t), as follows

$$(A_c - B_c)/B_c - (A_t - B_t)/B_t$$

SIGNIFICANCE OF CHANGE IN SOIL MOISTURE [BINARY]

Indicator of whether change in soil moisture is statistically significant, per the assessment of study authors

SHORT-TIMESCALE FLOW MEASURE [TEXT]

Description of measure used to describe short-timescale flow, either overland flow or short-term discharge, with units

Short-timescale flow measures are meant to address the response to particular precipitation events, whether natural or created by a precipitation simulator. These may focus on either the overland flow response or the total discharge in the short time period after precipitation. This category includes any flows measured at sub-annual time scales, even if the reported results include more than one event.

If there are multiple short-timescale flow measures, one was selected that best reflected the purpose of this review: to understand the water quantity effects of nature-based solutions.

SHORT-TIMESCALE FLOW [NUMERIC]

Overland flow; in units from Overland Flow Measure field. Meaning of number depends on Study Design:

After impact; Control/impact; Gradient response: Overland flow measured at the experiment site.

Before/after: Overland flow measured at the experiment site, after experimental treatment.

Before/after-control/impact; Before/after-control/impact paired; Multiple before/after control/impact: The fractional change in overland flow measured after the treatment relative to overland flow measured before the treatment, at the experiment site: $(A_t - B_t)/B_t$

CHANGE IN SHORT-TIMESCALE FLOW [NUMERIC]

Change in overland flow; in units from Overland Flow Measure field. Meaning of number depends on Study Design:

After impact; Control/impact; Gradient response: calculated as control site value minus experiment site value.

Before/after: calculated as the value measured after the experimental treatment minus before the treatment.

Before/after-control/impact; Before/after-control/impact paired; Multiple before/after control/impact: calculated as the fractional change in overland flow values measured at the control site (c) and the fractional change in overland flow values measured at the experiment site (t), as follows

$$(A_c - B_c)/B_c - (A_t - B_t)/B_t$$

SIGNIFICANCE OF CHANGE IN SHORT-TIMESCALE FLOW [BINARY]

Indicator of whether change in overland flow is statistically significant, per the assessment of study authors

INFILTRATION MEASURE [TEXT]

Description of measure used to describe infiltration, with units

If there are multiple infiltration measures, one was selected that best reflected the purpose of this review: to understand the water quantity effects of nature-based solutions.

INFILTRATION [NUMERIC]

Infiltration; in units from Infiltration Measure field. Meaning of number depends on Study Design:

After impact; Control/impact; Gradient response: Infiltration measured at the experiment site.

Before/after: Infiltration measured at the experiment site, after experimental treatment.

Before/after-control/impact; Before/after-control/impact paired; Multiple before/after control/impact: The fractional change in infiltration measured after the treatment relative to infiltration measured before the treatment, at the experiment site: $(A_t - B_t)/B_t$

CHANGE IN INFILTRATION [NUMERIC]

Change in infiltration; in units from Infiltration Measure field. Meaning of number depends on Study Design:

After impact; Control/impact; Gradient response: calculated as control site value minus experiment site value.

Before/after: calculated as the value measured after the experimental treatment minus before the treatment.

Before/after-control/impact; Before/after-control/impact paired; Multiple before/after control/impact: calculated as the fractional change in infiltration values measured at the control site (c) and the fractional change in infiltration values measured at the experiment site (t), as follows

$$(A_c - B_c)/B_c - (A_t - B_t)/B_t$$

SIGNIFICANCE OF CHANGE IN INFILTRATION [BINARY]

Indicator of whether change in infiltration is statistically significant, per the assessment of study authors

REASONING FOR MEASURE SELECTION [TEXT]

This field is used to provide reasons for the particular measures selected in the fields above, when multiple measures are available, as well as the source of the specific measurement data selected (Figures, Tables, etc. within the manuscript).

STATISTICAL APPROACH [TEXT]

Statistical approach used to check for significant change in any of the flow measures above, if any

MEASURE CHANGE RANGES OR STANDARD DEVIATION [TEXT]

Text entry to put in standard deviation, range, or other distributional information about any of the measures listed above.

QUALITY OF RESULT [CLASS]

Reviewer's assessment of quality of result; separate calculation will be done for result quality using modified version of *Eco Evidence Analysis Methods Manual: A Systematic Approach to evaluate Causality in Environmental Science*, available at

[https://www.researchgate.net/publication/263273816 Eco Evidence Analysis Methods Manual A Systematic Approach to Evaluate Causality in Environmental Science](https://www.researchgate.net/publication/263273816_Eco_Evidence_Analysis_Methods_Manual_A_Systematic_Approach_to_Evaluate_Causality_in_Environmental_Science)

Classes: High, Medium, Low

REASON FOR QUALITY OF RESULT [TEXT]

Reviewer's explanation for rating the quality of result

CRITICAL FLAWS [CLASS]

Yes or no. Used if the study design or measurements contained critical flaws that seriously cast doubt on the quality of the results.

DETAILS OF CRITICAL FLAWS [TEXT]

Text description, noting critical flaws in the study.

CITATION [CITATION ID FOREIGN KEY]*,‡

7 citation fields with links to Zotero literature database

REVIEWER [CLASS]*

Reviewer who coded the manuscript

EDITED BY [CLASS]

Name of the reviewer who edited the record. A value in this field indicates that limited quality control was performed and some fields edited. Limited quality control included checking consistency between Broad Experiment Type and Broad Treatment Class, Experiment and Control site matching, and checking that measurement descriptions match the category in which they were coded. **With limited QC, the values entered for flow measures and changes were not verified.**

If this field is blank, then no quality control was performed and this and all associated records for this study should be checked thoroughly before using in any analysis.

QUALITY CONTROL [CLASS]

Name of the reviewer who performed final quality control on the record. A value in this field indicates that a full quality control was performed on the record. A full quality control included verifying that the values entered for flow measures and changes were coded correctly, and that other relevant fields (treatment type, descriptions of vegetation before and after treatment, treatment details, etc.) are complete and correct.

If this field is blank, then no quality control was performed and this and all associated records for this study should be checked thoroughly before using in any analysis.

Control site

When the study does not specify a control site, the control site was selected as the site that represents the most impacted or conventional practices, or baseline behavior without nature-based solution. For example, high-input agriculture or conventional grazing practices would be selected as the control site and agriculture with vegetated buffers or rotational grazing would be selected as the experiment site.

In some cases, the control site may represent the more natural site--in such cases, the field Experiment Site:Control Direction is set to "Control is more natural".

No control site is specified for gradient response nor for before/after studies (Experiment Site: Study Design).

CONTROL NAME [TEXT]*,†

Short descriptive name of control site, linked to Control Site field in Experiment Site table.

SITE NAME [SITE ID FOREIGN KEY]*,‡

Short descriptive name of site; linked to same field in Study Site table

BROAD EXPERIMENT TYPE [CLASS]*

Classes: Forest; Wetland; Rangeland; Agriculture

CONTROL AREA [NUMERIC, M²]*

Meaning of number depends on Experiment Site: Broad Experiment Type and Experiment Site: Study Scale

Forest: Watershed area, intervention area for plot-scale

Wetland: Watershed area, wetland area for plot-scale

Rangeland: Watershed area for natural experiments, total of plot area(s) for plot-scale

Agriculture: Watershed area for natural experiments, total of plot area(s) for plot-scale

PERCENT IN CONTROL [NUMERIC]

Percent of experiment area (plot or watershed) in control

CALIBRATION START YEAR [INTEGER, YEAR]

Starting year for collection of calibration data in control area, when applicable

CALIBRATION DURATION [NUMERIC, YEARS]

Period of collection of calibration data in control area, when applicable

CONTROL LATITUDE [NUMERIC, DECIMAL DEGREE]

Conversion tool at: <https://www.fcc.gov/media/radio/dms-decimal>

Measurement point for streamflow (bottom of catchment), if available for Landscape scale studies; otherwise general experiment location as reported in study. If study does not report lat/long then a google search was performed on the experiment site name and the lat/long inferred from the results.

CONTROL LONGITUDE [NUMERIC, DECIMAL DEGREE]

Conversion tool at: <https://www.fcc.gov/media/radio/dms-decimal>

Measurement point for streamflow (bottom of catchment), if available for Landscape scale studies; otherwise general experiment location as reported in study. If study does not report lat/long then a google search was performed on the experiment site name and the lat/long inferred from the results.

VEGETATION CLASS IN CONTROL [CLASS]

Forest: Native tropical forest; Secondary tropical forest; Tropical plantation; Native temperate forest; Secondary temperate forest; Temperate plantation; Native boreal forest; Secondary boreal forest; Boreal plantation; General/not specified forest

Wetland: Surface water depression wetland, surface water slope wetland, groundwater depression wetland, groundwater slope wetland; temperate wetland; tropical wetland; General/not specified wetland

Rangeland: Closed shrubland; Open shrubland; Woody savannah; Savannah; Grassland; Pasture; General/not specified rangeland

Agriculture: Intensive agriculture row crops; Intensive agriculture orchard; Low-intensity agricultural row crops; Low-intensity agricultural orchards; General/not specified agricultural

DESCRIPTION OF CONTROL SITE VEGETATION [TEXT]

Free text entry including all relevant details

ELEVATION MINIMUM [NUMERIC, M]

Minimum elevation of control watershed or area, in meters

ELEVATION MEDIAN [NUMERIC, M]

Median elevation of control watershed or area, in meters

ELEVATION MEAN [NUMERIC, M]

Mean elevation of control watershed or area, in meters

ELEVATION MAXIMUM [NUMERIC, M]

Maximum elevation of control watershed or area, in meters

ASPECT [CLASS]

Aspect of control watershed or plot area

Classes: N; NE; E; SE; S; SW; W; NW

SLOPE [NUMERIC, %]

Slope of control watershed or plot area, in percentage

SOIL [CLASS]

Soils classified according to USDA soil taxonomy at first level:

https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_051232.pdf, with global map at https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/use/?cid=nrcs142p2_054013

Classes: Alfisol; Andisol; Aridisol; Entisol; Gelisol; Histisol; Inceptisol; Mollisol; Oxisol; Spodosol; Ultisol; Vertisol

SOIL DESCRIPTION [TEXT]

Description of soil beyond USDA class when available, or when some other classification is used

MEAN ANNUAL RAINFALL [NUMERIC, MM]

Mean annual rainfall in control watershed or site

MEAN ANNUAL STREAMFLOW [NUMERIC, MM]

Mean annual streamflow in watershed, wetland, or experimental area measured at the control site; normalized to watershed area or relevant control area. Meaning of number depends on Study Design:

After impact; Control/impact; Gradient response: Mean annual streamflow measured at the control site.

Before/after-control/impact; Before/after-control/impact paired; Multiple before/after control/impact: The fractional change in mean annual streamflow measured after the treatment relative to streamflow measured before the treatment, at the control site: $(A_c - B_c)/B_c$

LOW FLOW MEASURE [TEXT]

Description of measure used to describe low flow, with units

If there are multiple low flow measures, one was selected that best reflected the purpose of this review: to understand the water quantity effects of nature-based solutions.

LOW FLOW [NUMERIC]

Low flow; in units from Low Flow Measure field. Meaning of number depends on Study Design:

After impact; Control/impact; Gradient response: Low flow measured at the control site.

Before/after-control/impact; Before/after-control/impact paired; Multiple before/after control/impact: The fractional change in low flow measured after the treatment relative to low flow measured before the treatment, at the control site: $(A_c - B_c)/B_c$

PEAK FLOW MEASURE [TEXT]

Description of measure used to describe peak flow, with units

If there are multiple peak flow measures, one was selected that best reflected the purpose of this review: to understand the water quantity effects of nature-based solutions.

PEAK FLOW [NUMERIC]

Peak flow; in units from Peak Flow Measure field. Meaning of number depends on Study Design:

After impact; Control/impact; Gradient response: Peak flow measured at the control site.

Before/after-control/impact; Before/after-control/impact paired; Multiple before/after control/impact: The fractional change in peak flow measured after the treatment relative to peak flow measured before the treatment, at the control site: $(A_c - B_c)/B_c$

GROUNDWATER RECHARGE MEASURE [TEXT]

Description of measure used to describe groundwater recharge, with units

If there are multiple groundwater recharge measures, one was selected that best reflected the purpose of this review: to understand the water quantity effects of nature-based solutions.

GROUNDWATER RECHARGE [NUMERIC]

Groundwater recharge; in units from Groundwater Recharge Measure field. Meaning of number depends on Study Design:

After impact; Control/impact; Gradient response: Groundwater recharge measured at the control site.

Before/after-control/impact; Before/after-control/impact paired; Multiple before/after control/impact: The fractional change in groundwater recharge measured after the treatment relative to groundwater recharge measured before the treatment, at the control site: $(A_c - B_c)/B_c$

SOIL MOISTURE MEASURE [TEXT]

Description of measure used to describe soil moisture, with units

If there are multiple soil moisture measures, one was selected that best reflected the purpose of this review: to understand the water quantity effects of nature-based solutions.

SOIL MOISTURE [NUMERIC]

Soil moisture; in units from Soil Moisture Measure field. Meaning of number depends on Study Design:

After impact; Control/impact; Gradient response: Soil moisture measured at the control site.

Before/after-control/impact; Before/after-control/impact paired; Multiple before/after control/impact: The fractional change in soil moisture measured after the treatment relative to soil moisture measured before the treatment, at the control site: $(A_c - B_c)/B_c$

SHORT-TIMESCALE FLOW MEASURE [TEXT]

Description of measure used to describe short-timescale flow, either overland flow or short-term discharge, with units

Short-timescale flow measures are meant to address the response to particular precipitation events, whether natural or created by a precipitation simulator. These may focus on either the overland flow response or the total discharge in the short time period after precipitation. This category includes any flows measured at sub-annual time scales, even if the reported results include more than one event.

If there are multiple short-timescale flow measures, one was selected that best reflected the purpose of this review: to understand the water quantity effects of nature-based solutions.

SHORT-TIMESCALE FLOW [NUMERIC]

Overland flow; in units from Overland Flow Measure field. Meaning of number depends on Study Design:

After impact; Control/impact; Gradient response: Overland flow measured at the control site.

Before/after-control/impact; Before/after-control/impact paired; Multiple before/after control/impact: The fractional change in overland flow measured after the treatment relative to overland flow measured before the treatment, at the control site: $(A_c - B_c)/B_c$

INFILTRATION MEASURE [TEXT]

Description of measure used to describe infiltration, with units

If there are multiple infiltration measures, one was selected that best reflected the purpose of this review: to understand the water quantity effects of nature-based solutions.

INFILTRATION [NUMERIC]

Infiltration; in units from Infiltration Measure field. Meaning of number depends on Study Design:

After impact; Control/impact; Gradient response: Infiltration measured at the control site.

Before/after-control/impact; Before/after-control/impact paired; Multiple before/after control/impact: The fractional change in infiltration measured after the treatment relative to infiltration measured before the treatment, at the control site: $(A_c - B_c)/B_c$

REASONING FOR MEASURE SELECTION [TEXT]

This field is used to provide reasons for the particular measures selected in the fields above, when multiple measures are available, as well as the source of the specific measurement data selected (Figures, Tables, etc. within the manuscript).

CITATION [CITATION ID FOREIGN KEY]*,‡

7 citation fields with links to Zotero literature database

Citation

CITATION ID [TEXT]*,‡

Unique citation identifier, using the format: First author last name, et al or second author last name, year of publication, a or b or c if this already exists.

For example: Dennedy-Frank & Gorelick 2019 -> dennedyfrankgorelick2019

Dennedy-Frank et al., 2019 -> dennedyfranketal2019

Dennedy-Frank 2019 -> dennedyfrank2019

ZOTERO LINK

Link to DOI record; if not DOI exists, an attempt was made to connect the paper to a webpage link

Excluded study

CITATION [CITATION ID FOREIGN KEY]*,‡

Citation, linked to Citation ID field in Citation table.

REASON FOR EXCLUSION*

Text description of why this study was excluded from the database

REVIEWER [CLASS]*

Reviewer who approved exclusion of the study.

Notes

†Primary key is a unique field within the table

‡Foreign key needs to match the value in another table