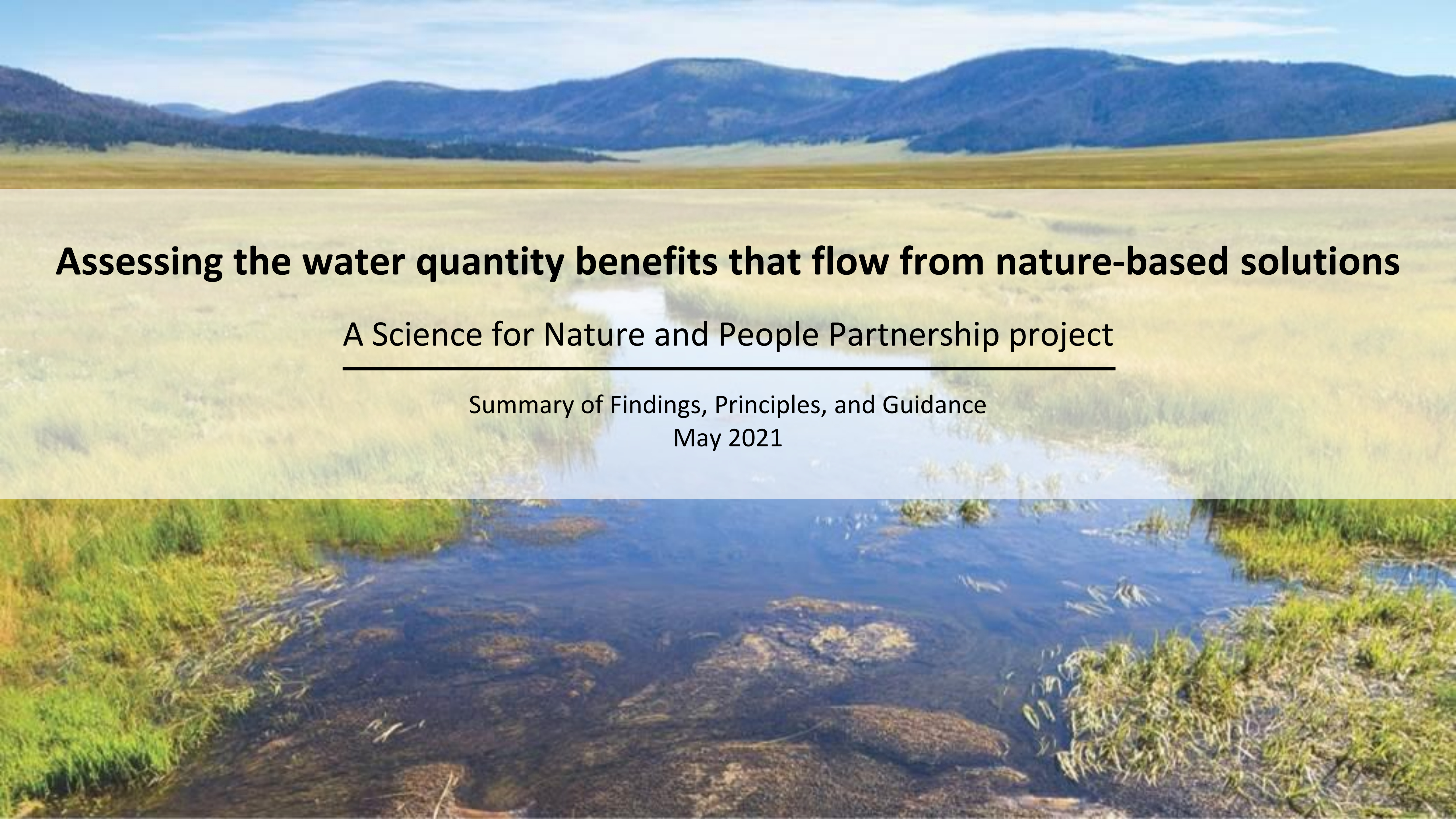


Assessing the water quantity benefits that flow from nature-based solutions

A Science for Nature and People Partnership project

Summary of Findings, Principles, and Guidance

May 2021

Project background

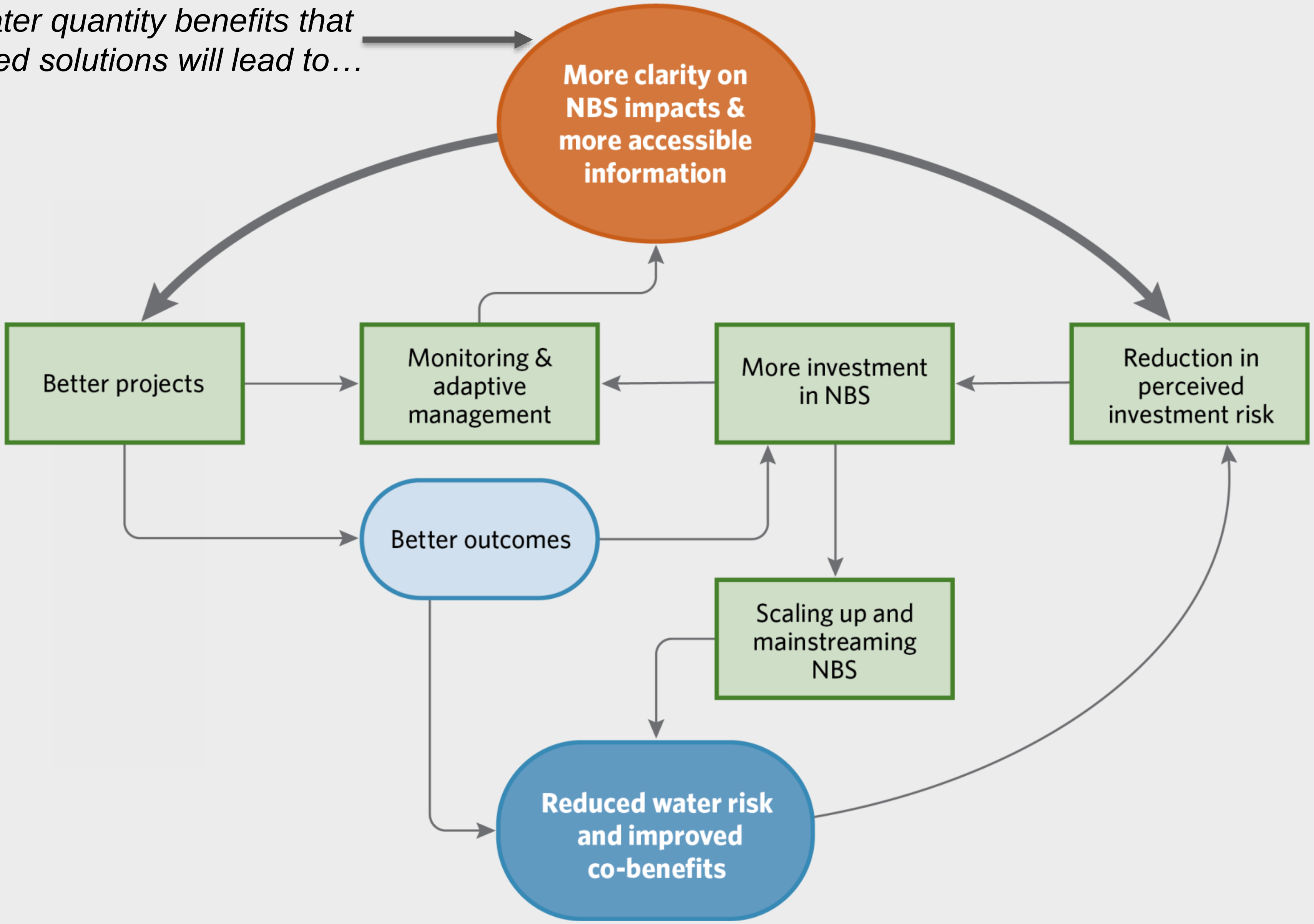
- Co-leads – Adrian Vogl (NatCap/Stanford), Kari Vigerstol (TNC), Robin Abell (CI)
- Researchers – James Dennedy-Frank (Stanford/LBNL), Stan Kang (TNC), Sydney Moss (NatCap/Stanford), Vivien Bonnesoeur, Diego Sotomayor, and Joshua Castro (Condesan)
- Implementation partners – John Matthews (AGWA), Jan Cassin (Forest Trends)
- Technical workshop (June 2018) – Kate Brauman (U of Minn), Wouter Buytaert (Imperial College), Tom Gleeson (U of Victoria), Neil McIntyre (U of Queensland), Robert Stallard (USGS/Smithsonian), Ted Grantham (UC Berkley)
- Practitioner/beneficiary workshop (Nov. 2018) – Newsha Ajami (Stanford), Daniela Giardina (Oxfam), Lissa Glasgo (GIIN), T. Grantham (UC Berkeley), Paul Hicks (CRS), Kate Moran (WaterNow Alliance), Suzanne Ozment (WRI), Rebecca Tharme (River Futures)
- Communication & messaging workshop (Apr. 2020) – Winston Yu (IWMI), Craig Beatty (WWF), Virginia Newton-Lewis (WaterAID), Robin Miller (Ceres), Gregg Brill (Pacific Institute), Carlos Aguilar (CRS), Wendy Larson (LimnoTech), Nick Wobbrock (Blue Forest Conservation), Raul Muñoz (IADB), Astrid Hillers (GEF)

Objectives

- Assess the opportunity for nature-based solutions to reduce the water availability and flooding risks associated with land use change and climate change
- Develop principles and guidance for decision support

Assessing the the water quantity benefits that flow from nature-based solutions will lead to…

Theory of Change



Outputs

- A rigorous **synthesis of evidence** from peer-review for nature-based solutions and their links to hydrologic changes under a variety of contexts
- A **manuscript** submitted to a high impact peer-review journal detailing the project findings
- **Principles and guidance** for helping decision-makers evaluate the potential for land-based adaptation to hydrologically-mediated impacts from land use change and climate change.
    - Target audiences
        - conservation and sustainable agriculture practitioners
        - investors

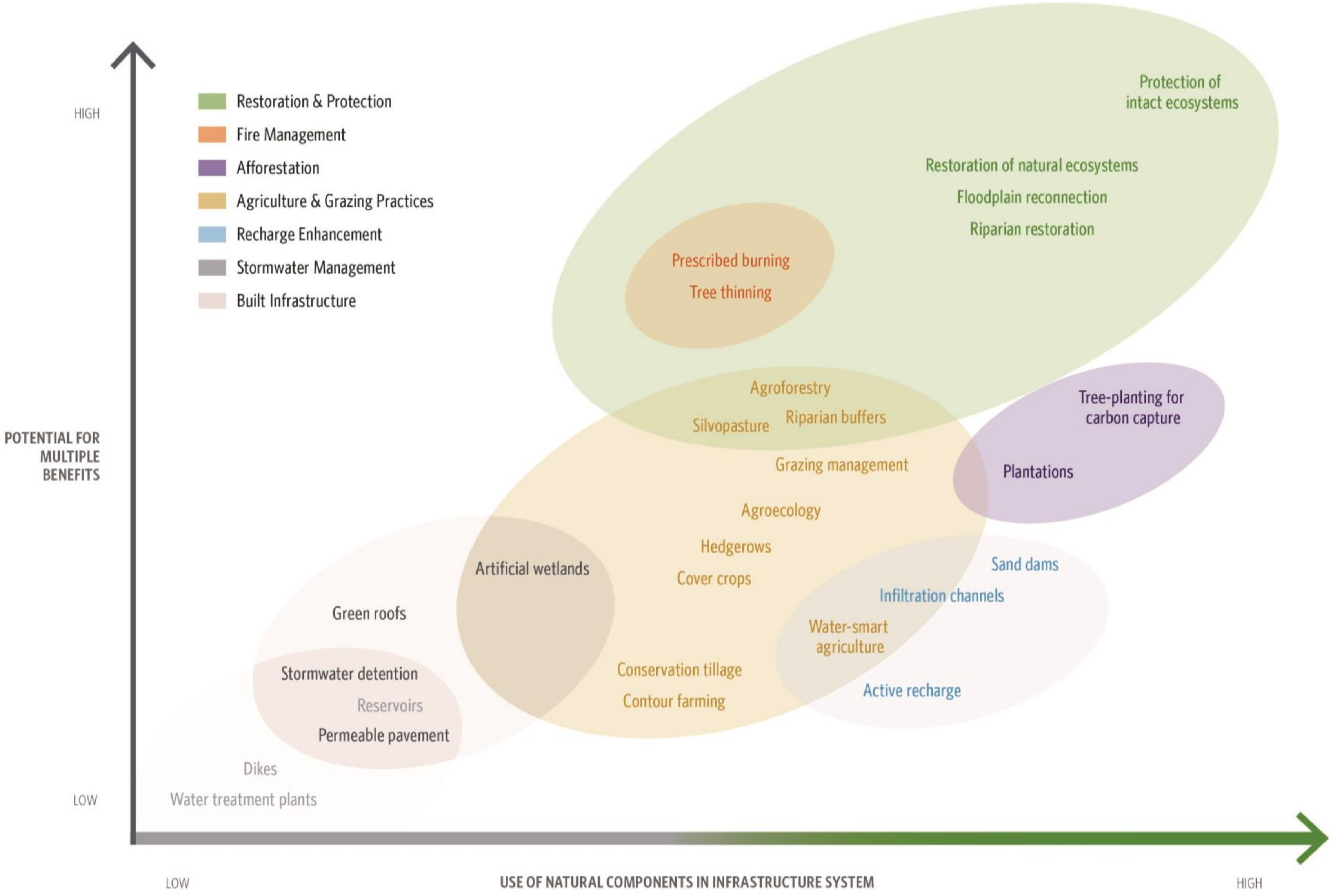
Definitions and scope

- Definitions: we adopt definitions for nature-based solutions, nature-based water infrastructure, etc. from Climate Bonds Initiative's water infrastructure criteria
- Scope (solutions):
  - forest protection and restoration
  - wetland conservation and restoration
  - fire management
  - rangeland best management practices
  - agricultural best management practices
- Scope (systems): landscapes (watersheds) but not river channels and floodplains

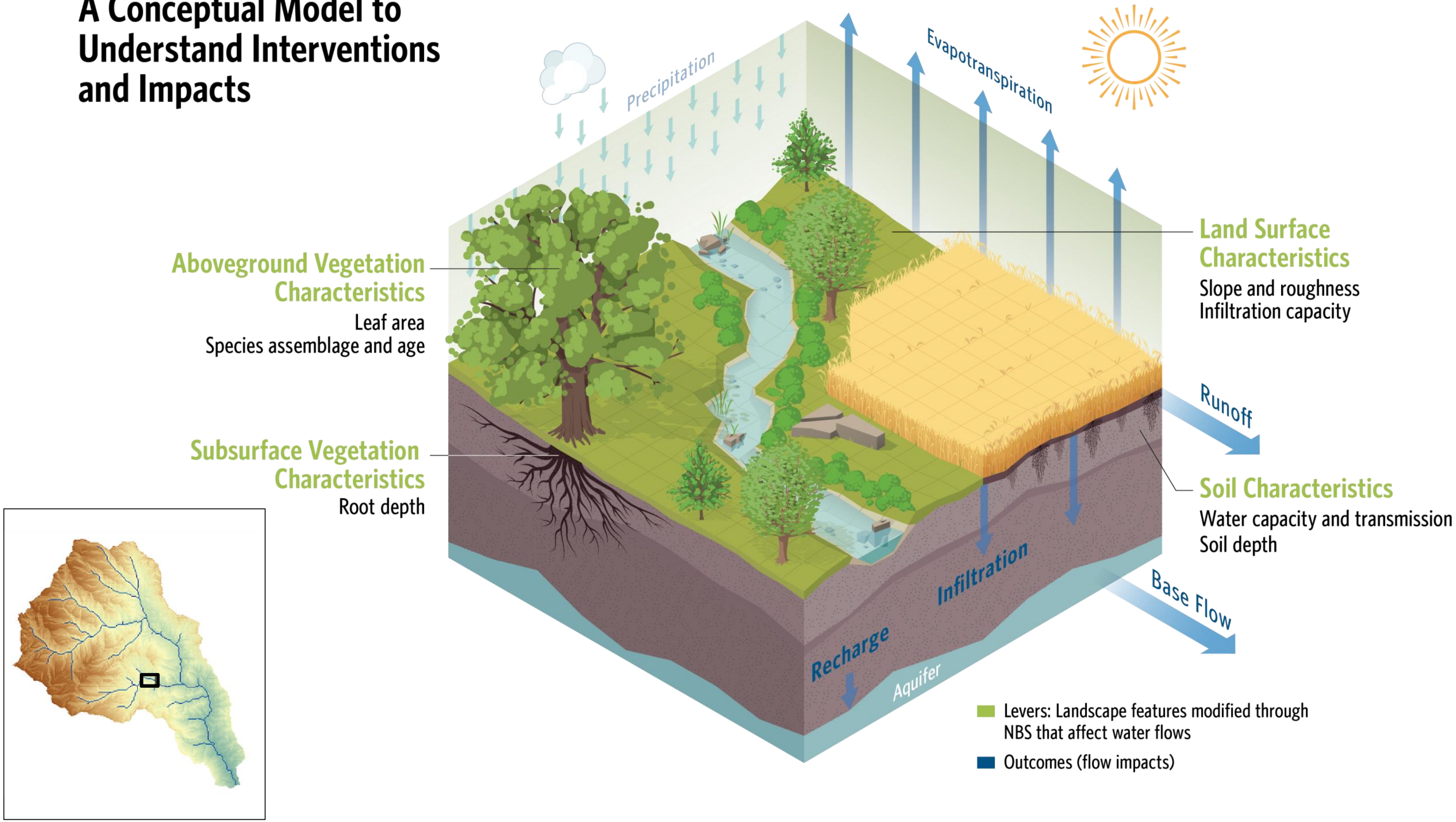
Figures

- Nature-based intervention spectrum
  - Communicates the green to gray spectrum and highlight trade-offs
- Conceptual diagram
  - Shows the hydrologic fluxes likely to be affected by nature-based interventions, as well as characteristics that may mediate impacts.
  - Helps explain why the type of intervention and context will change the hydrologic impacts at different scales.
- Weight of evidence matrix (forthcoming)
  - Provides a snapshot of the literature review results

Nature-based Intervention Spectrum

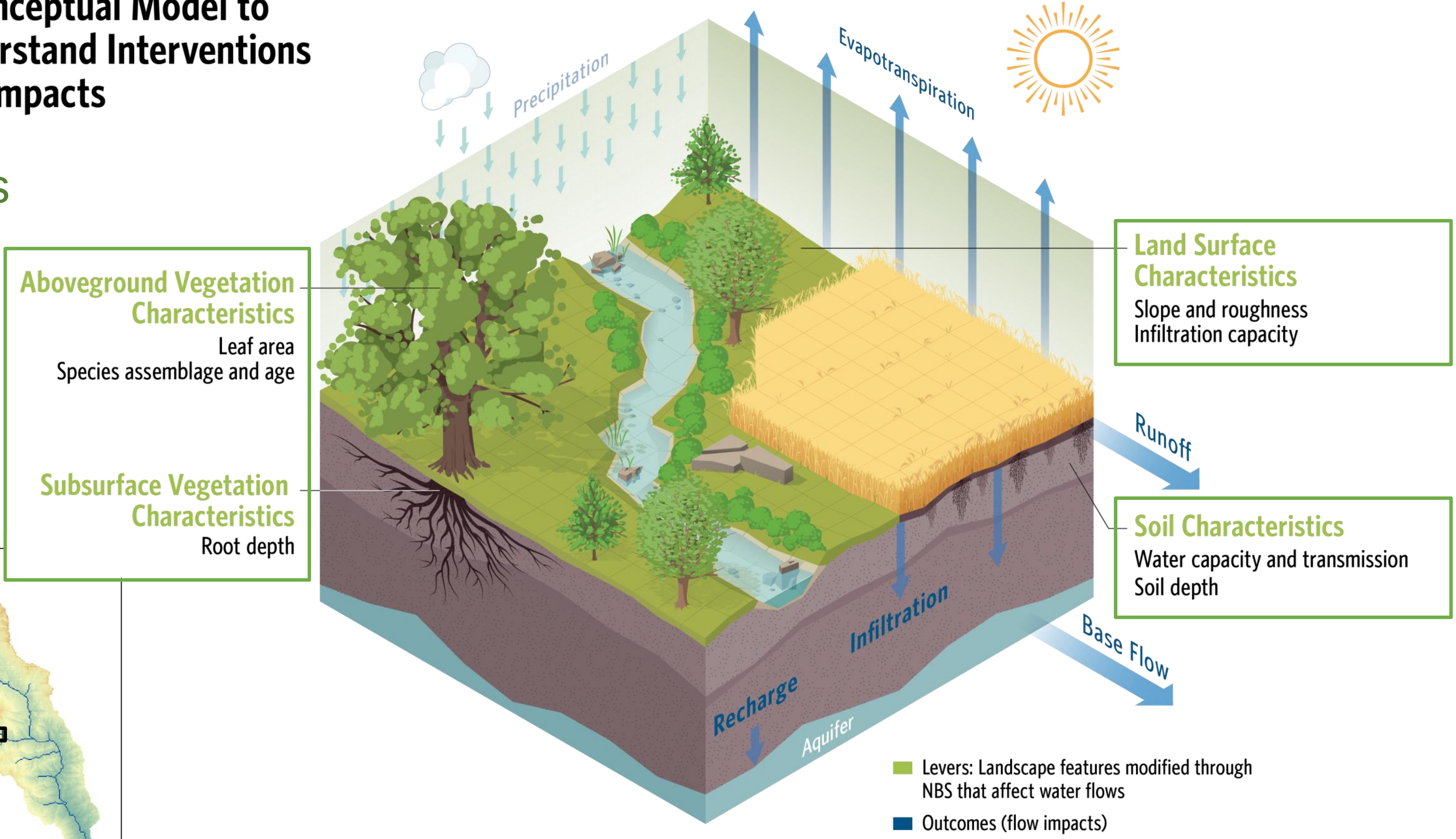


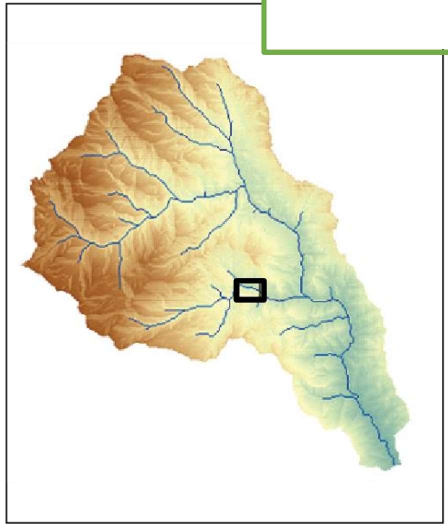
A Conceptual Model to Understand Interventions and Impacts



A Conceptual Model to Understand Interventions and Impacts

Levers





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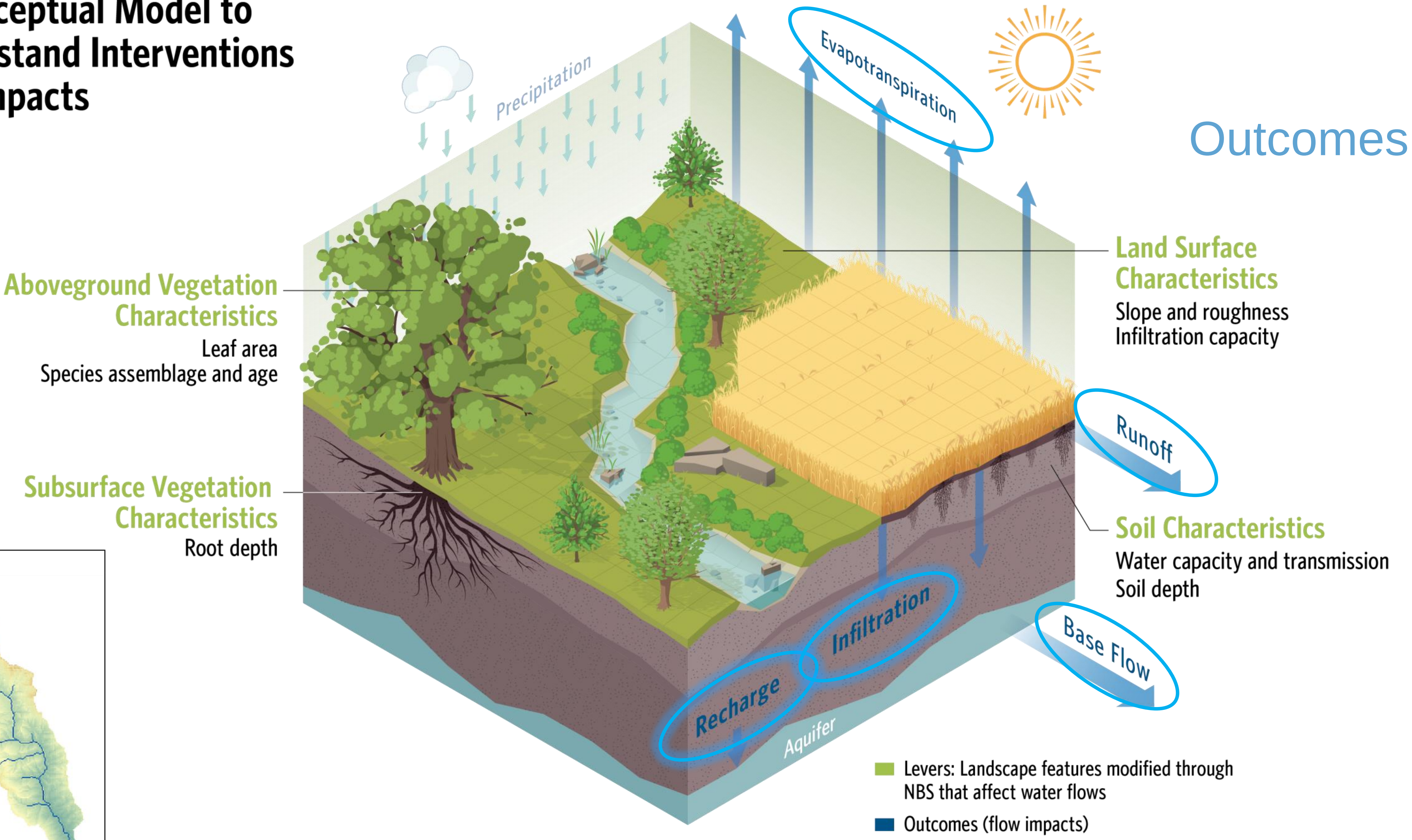

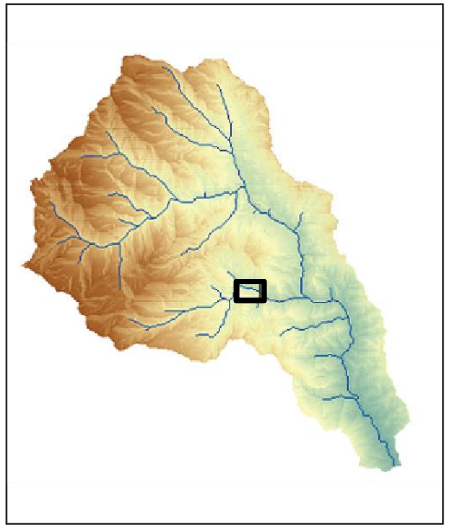

Summary of Findings

Findings: Long-term water availability

- Most NBS *reduce* total annual water yield with significant certainty.
- ↓ Conservation tillage, forest restoration and forest protection, wetland restoration.
- ↓ ↑ Other practices mixed
- Remember, ↓ flow can mean ↓ flood peaks, too

Take-home: you are likely not going to get more water, and you will probably get less.

Findings: Seasonal water availability

- NBS effects on groundwater recharge and dry season flow are highly variable.
- Forest protection, reforestation: sometimes ↑ ; sometimes ↓
- Wetlands also complicated:
  - Base flow sometimes ↑ (1/4) ; sometimes ↓ (1/3)
  - Groundwater recharge: ↑ in water table depth/groundwater level but highly variable

Take-home: It's complicated. Don't count on it.

Findings: Flood risk

- Many NBS reduce quickflow, though wetlands can cause both increases and decreases.
- Forest restoration, vegetative buffers and conservation tillage: mostly ↓
- Wetlands mixed: evenly distributed b/t ↓ ↑ and no change
- Fire prevention in rangelands, grazing management and grassland protection also mixed: large ↓, no change or small ↑

Take-home: NBS can help reduce some flooding, but don't expect them to reduce catastrophic flooding.

Findings: Infiltration & soil moisture

- The impacts of NBS - particularly in agricultural lands - on infiltration and soil moisture are still uncertain.
- Conservation tillage: often large ↑ ; sometimes small ↓
- Managing rangelands and preventing fires: ↑ or ↓

Take-home: Good news if you are a farmer of non-irrigated crops. In other cases, context is key.

Principles for NBS Design

Principles: Think locally

- We can improve the water security of local communities (people whose livelihoods and water sources depend on local soil moisture, local springs, flows, etc.) through implementing locally appropriate and carefully designed NBS in working landscapes.
- These practices can increase resiliency by improving soil moisture retention, reducing soil loss from excess surface runoff, and maintaining soil health.

Principles: Go big for big impact

- Differences in the size of effects is strongly related to the area over which NBS are applied.
- Local effects are in some cases strong, but when averaged over a whole watershed the overall results are small unless a large area of the watershed is affected.
- NBS can have large effects on water quantity in two main cases:
  1. When they are applied over very large areas of the watershed
  2. When making massive changes in the local evapotranspiration due to either the particular vegetation or when applied in very specific locations

Principles: Protect invisible infrastructure

- Maintain and manage large areas of existing natural vegetation and/or wetlands to:
  - <u>Reduce quickflow/flooding</u>: by maintaining the natural ability to store and retain water, avoid exacerbating flood risk downstream
  - <u>Maintain groundwater levels:</u> by avoiding loss of infiltration and large increases in pumping associated with land use change
  - <u>Maintain baseflow</u>: by avoiding soil compaction and consequent reduction in permeability and subsequent infiltration
  - <u>Maintain regional/continental climate patterns & rainfall</u> tied to large intact forests

Principles: Understand levers

- The total input of water to a system is primarily a function of that system's climate regime. The timing and amount of rainfall, and the amount of water in long-term deep aquifer storage, are not levers that can be addressed with NBS.
- NBS will not create more water in an absolute sense, but they facilitate the retention, movement, timing, and/or reallocation of water around the landscape.
- Understanding levers has important implications for how we use NBS to distribute water benefits among different stakeholders.

Principles: Match actions to objectives

- To effectively design and manage NBS for water outcomes, first clearly define objectives and the timing and scale of water issues to be addressed.
- Scale the intervention appropriately for the desired impact.
  - If downstream water availability is a primary goal of the program, activities should be implemented over large enough areas to ensure a significant impact at scale.
- Location matters. Target activities for greatest impact.

Principles: Manage for changing conditions

- The establishment and persistence of NBS are dynamic processes that require adaptive management.
- Impacts may change over time as vegetation responds to interannual variation in precipitation and temperature and the occurrence of extreme events, such as floods, drought, and wildfire.
- Performance will vary due to natural dynamics through the stages of project implementation, stabilization and long-term management.
- Climate factors outside the control of in-watershed actors will affect both the inter-annual performance variability and present opportunities for adaptive management.

Principles: Design for the future

- Changes in the timing, intensity, duration, and amount of rainfall will result in complex interactions with any changes in vegetation, surface and soil properties that occur as a result of NBS.
- Designing interventions with both current and likely future conditions in mind will enhance the sustainability of interventions.
- NBS can improve the resilience of local communities to future climate changes, e.g. by introducing drought-resistant species, protecting the soil surface from more intense rainfall events, preserving soil health and long-term productive capacity.

Principles: Track performance and adapt

- Invest in ongoing monitoring of desired impacts in a way that such impacts can be directly attributed back to NBS, allowing for learning and adaptation.
- Monitor components with high uncertainties to help with adaptive management.
- Monitor at multiple scales where possible to track local impacts on a shorter time scale and ultimate impacts on a longer time scale.

Guidance

Guidance: Project design & implementation

- Evaluate water quantity impacts for all NBS investments, even when water quantity is not an intended aspect of the project.
- Monitoring and adaptive management systems should be included in project budgets.
- Projects should be designed for flexible, adaptive management for uncertain future economic and climatic conditions.

Guidance: Financing and funding

- NBS defined as “water” projects may face project qualification obstacles, such as establishing usufruct or meeting procurement guidelines. Early discussion between funding qualification and project development teams will be important to ensure that potential administrative barriers are identified early.
- Cost-benefit analyses should include co-benefits when possible.
- Traditional economic evaluation metrics such as net present value (NPV) may not capture project qualities critical for decision makers and/or stakeholders.

Guidance: Research

- The role of climate shifts in creating major changes in water quantity through ecosystem impacts remains an important outstanding issue. The practice of designing/managing NBS under non-stationary conditions has been largely ignored.
- Applied research that evaluates the effects of before and after studies on NBS through a quantitative lens is an enormous gap, as is the need for direct comparisons between the relative efficacy of a spectrum of gray to green water quantity interventions for specific application categories.

Guidance: Interactions Part 1

- Require that projects consider both green and gray components at project inception.
- Improve early-stage problem definition processes to reflect multi-purpose applications over single-purpose investments; multi-purpose projects may be more likely to include ecological co-benefits.
- Increase the scale of project evaluation, both temporally and spatially, to include catchment and basin scale impacts on other stakeholders, as well as evaluate over the operational lifetime rather than over the finance period.
- Increase early-stage stakeholder engagement processes, which is more likely to increase support for co-benefits.

Guidance: Interactions Part 2

- Integrate environmental impact assessment and project development as parallel rather than sequential processes.
- Increase the importance and weight of climate change-related uncertainty early in the development process, which will support the use of NBS approaches as a tool for maintaining flexibility.
- Create/encourage higher demand with potential agencies, decision makers, finance groups, so that more projects can be initiated and demand is more visible.
- Recognize special financing, data, management/operations needs that relate to NBS, such as managing for dynamic systems over long operational lifetimes.

Acknowledgements

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