Measuring and Valuing Ecosystem Services: InVEST and Modeling Approaches

Woods Institute for the Environment
Stanford University

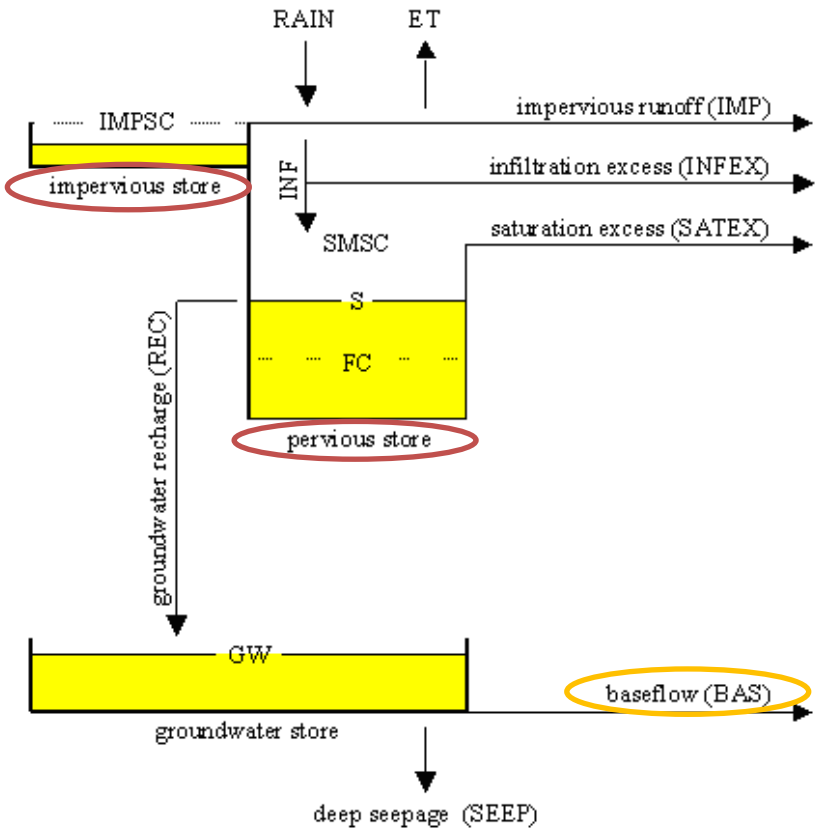
natural capital PROJECT

A Modeling Approach

Simple conceptual reservoir models (SWMM, Sacramento SMA,...)

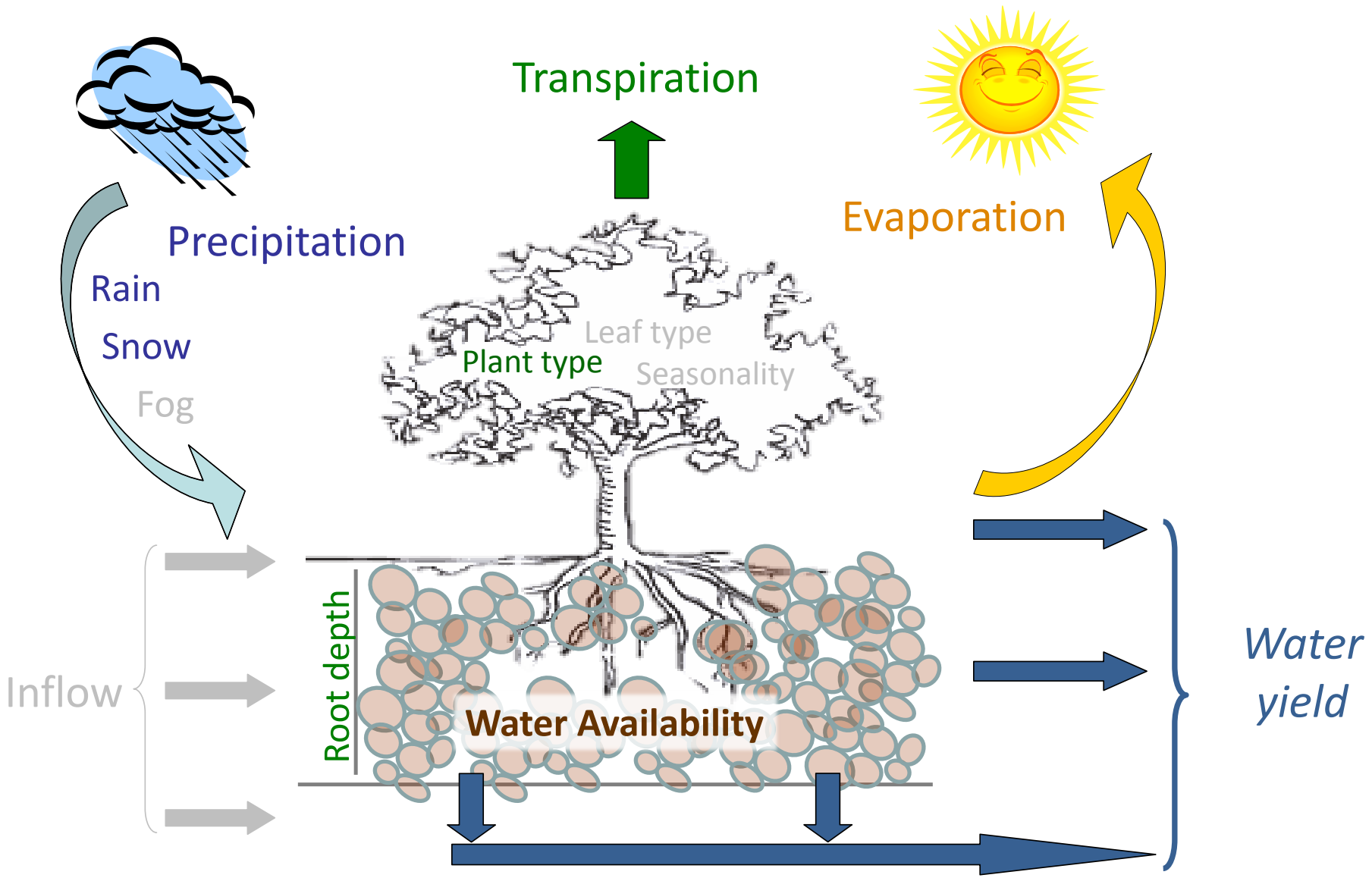
Advantages:
Simple to develop/calibrate

Limitations:
No physical representation of processes (limits predictive performance in a context of LU/climate change)

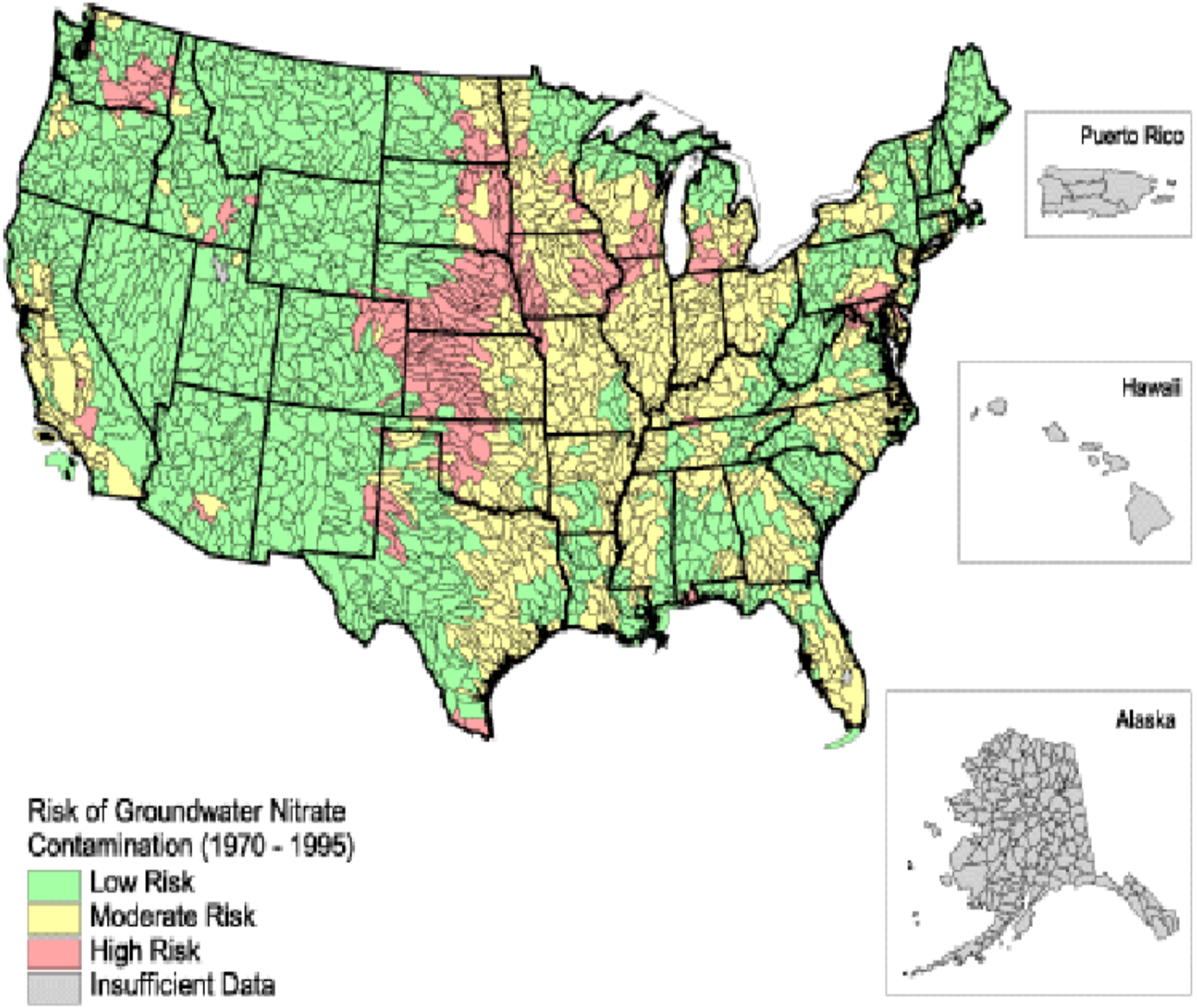


Source: (eWater 2012)

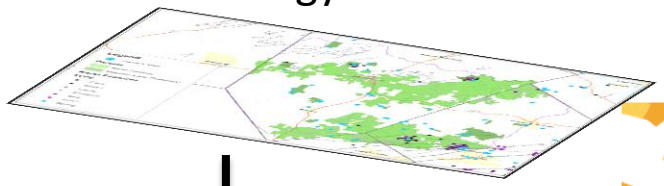
InVEST Annual Water Yield Model



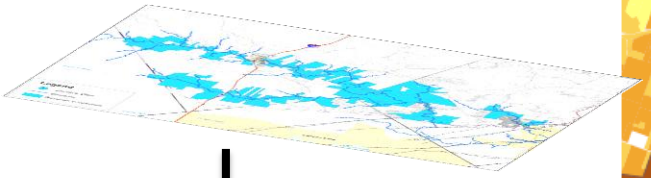
Diagnostic Screening Approaches



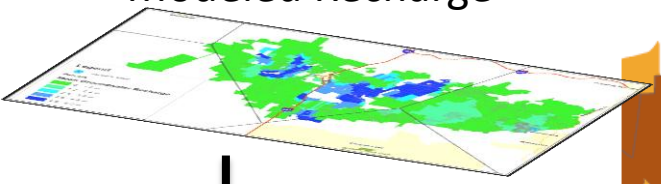
Geology



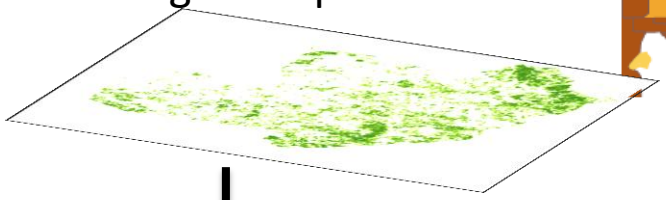
Riparian Areas



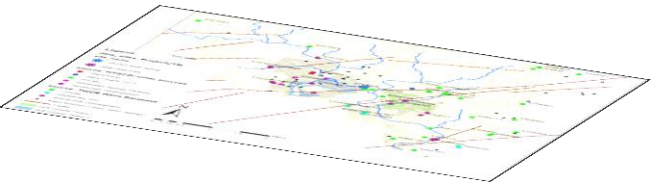
Modeled Recharge



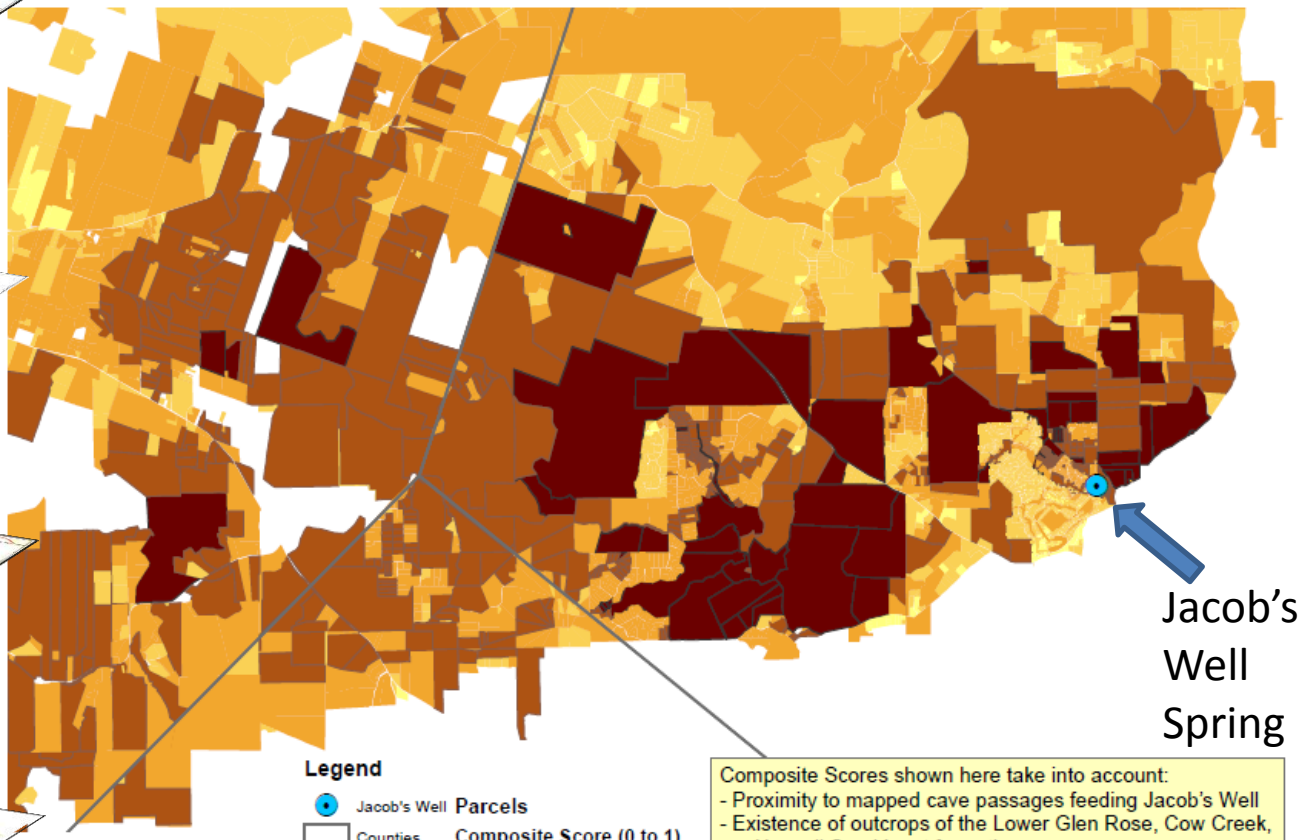
Endangered Species Habitat



Infrastructure/Threats



Composite Ecosystem Service Scores
Jacob's Well Probable Contributing Area



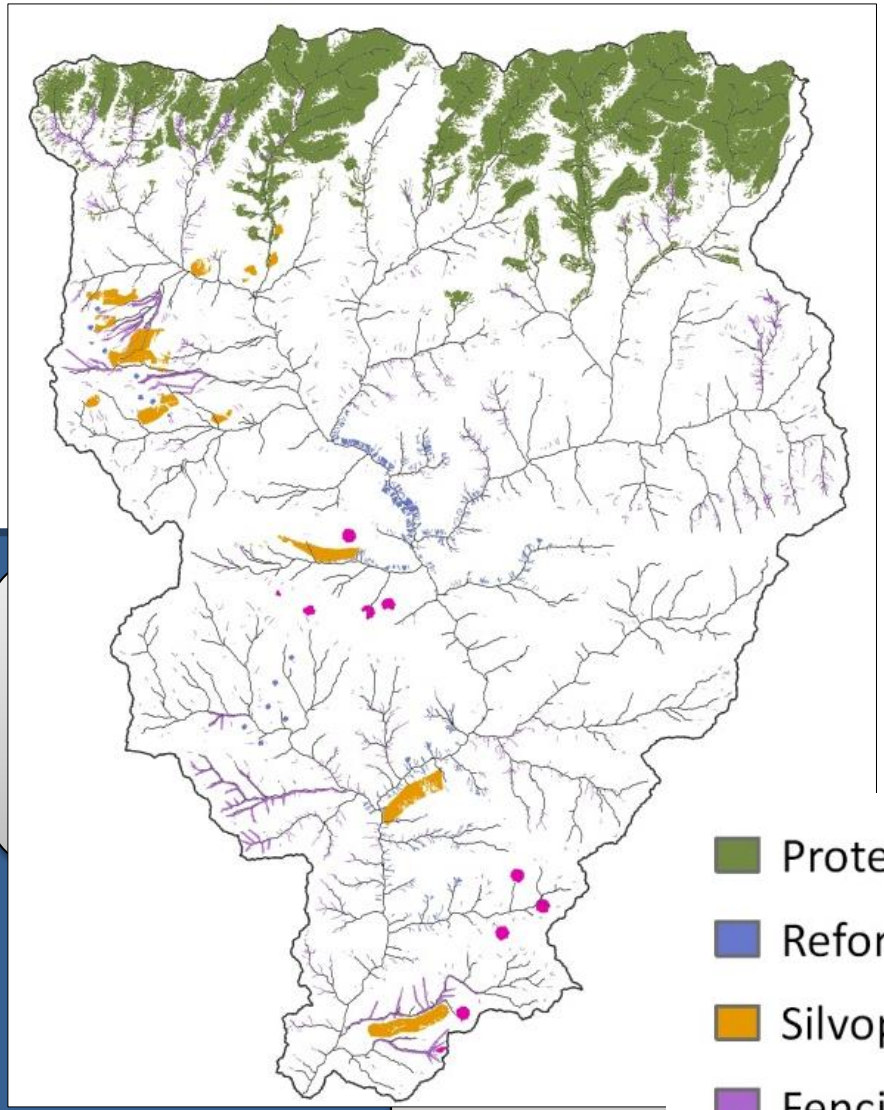
Composite Scores shown here take into account:
- Proximity to mapped cave passages feeding Jacob's Well
- Existence of outcrops of the Lower Glen Rose, Cow Creek, or Hensell Sand karst formations
- Mapped karst feature or fault present
- Average annual groundwater recharge
- Proximity to riparian areas
- Potential golden-cheeked warbler habitat
- Location outside a utility CCN

RIOS

RIOS MODULES

Portfolio Builder

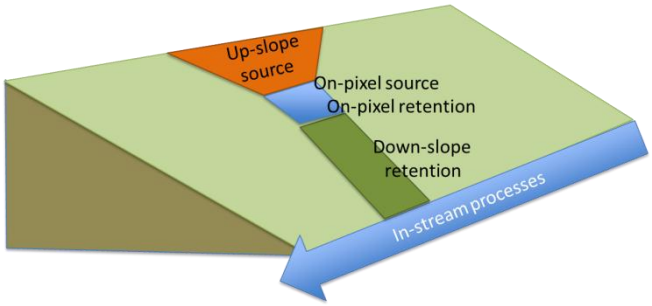
- Erosion Control (Hydro, Drinking Water)
- Nitrogen Regulation
- Phosphorus Regulation
- Groundwater Recharge
- Flood Mitigation
- Dry Season Baseflow
- Biodiversity
- "Other"



RIOS Ranking Models

- Rank where land management changes will have the ***greatest impact*** on the selected service
- Factors determined through literature review
- Compromise between process representation and data availability
- Diagnostic screening, not process representation

Groundwater Recharge Enhancement



Up-slope Source

- Slope
- Retention + Source Factors
- Source area

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Source:

- Rainfall depth
- Vegetative cover
- Soil texture
- Slope
- Actual evapo-transpiration

Retention:

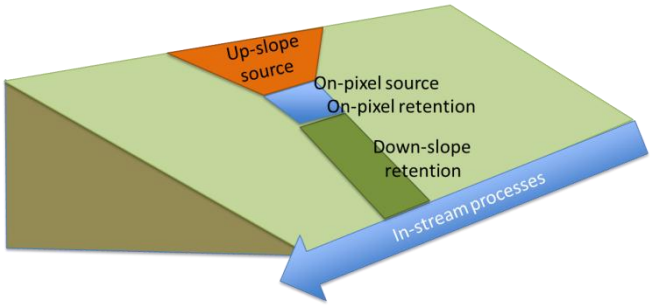
- Vegetation Roughness (n)
- Extent of karst
- Soil depth

Downslope Retention

- Slope
- Vegetation Roughness (n)
- Karst
- Soil depth
- Flow length to stream

Beneficiaries

Groundwater Recharge Enhancement



Runoff Index

Up-slope Source

- Slope
- Retention + Source Factors
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- Rainfall depth
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- Vegetation Roughness (n)
- Karst
- Soil depth
- Flow length to stream

Beneficiaries

Challenges/opportunities

- Need to clearly define the **desired outputs of the model** (i.e. the inputs to the **ES valuation** modules):
  - Complete representation of the groundwater flow in a watershed is challenging (getting the ***supply*** right)
  - Clearly define and delineate deep groundwater versus subsurface flow, relate to services

- Model **validation**/uncertainty analyses
  - Informs **data collection** (e.g. need for soil moisture/gw level monitoring?)
  - Develop a simple **testing framework** to understand what the model is able to represent

Challenges/opportunities

- Need to target the **processes of interest** and develop **conceptual models** for these processes/services:
  - **Maintaining groundwater-dependent ecosystems**
    - Improve representation of groundwater from the unsaturated zone versus deep groundwater
    - Improve linkages between groundwater and ecosystems
  - **Maintenance of baseflow**
    - Improve representation of shallow interflow
  - **Water supply for groundwater pumping**
    - Represent aquifer as a lumped reservoir
  - **Maintaining groundwater quality**
    - Link models of groundwater contamination to land management/ natural capital

Challenges/opportunities

- Making the link from **processes** of interest to **services & value**
  - Improve trade-off dynamics between surface- and ground-water
  - New valuation models, i.e. supply from groundwater pumping

- Different approaches required for modeling biophysical system, linking to beneficiaries, and economic valuation

References

eWater, 2012. Model for urban stormwater improvement conceptualisation (MUSIC) Version 5.1, eWater Cooperative Research Centre, Canberra, Australia.

Gupta, H.V., 2008. Reconciling Theory With Observations: Elements of A Diagnostic Approach To Model Evaluation. *Hydrological Processes*, 22: 3802-3813.

Winter, T.C., Harvey, J.W., Franke, O.L., Alley, W.M., 1998. Ground Water and Surface Water A Single Resource. USGS.