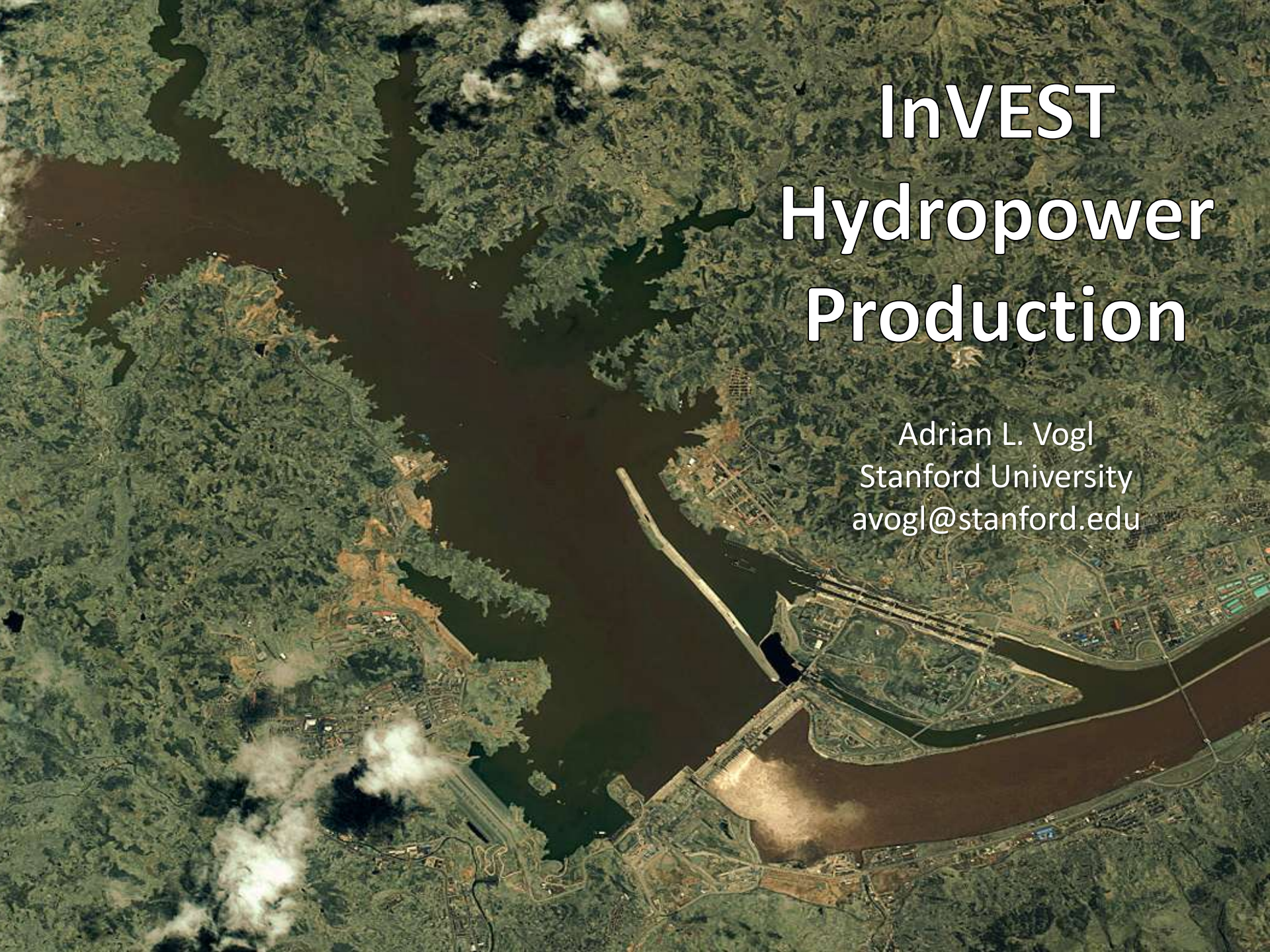

InVEST Hydropower Production

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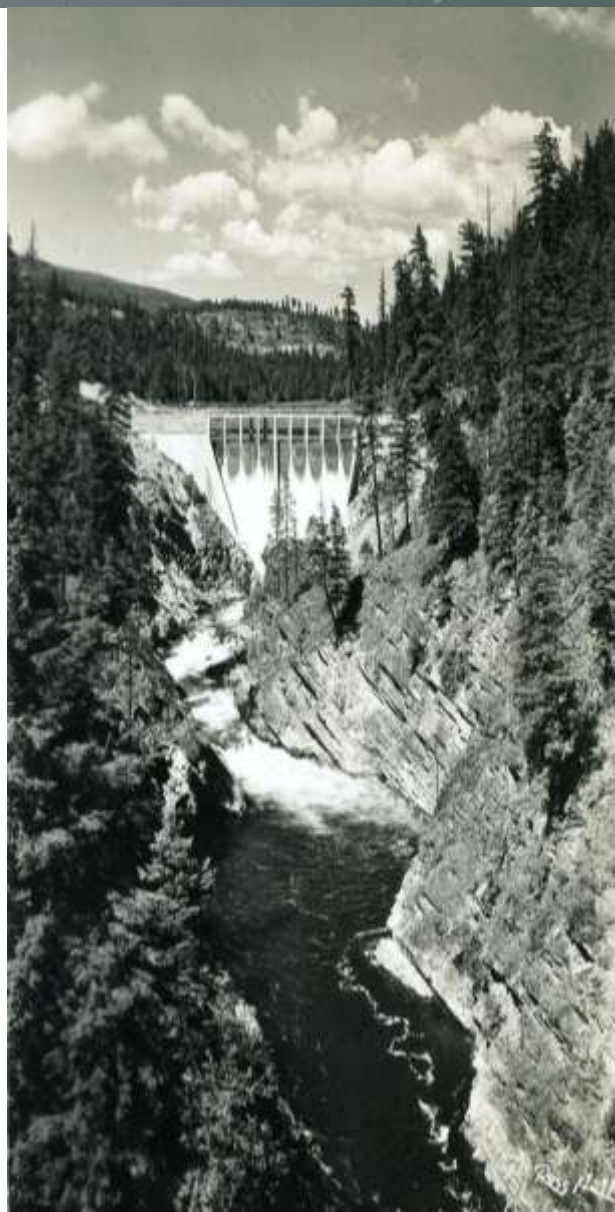
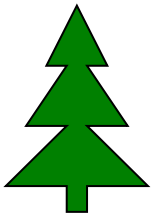
Questions InVEST can answer

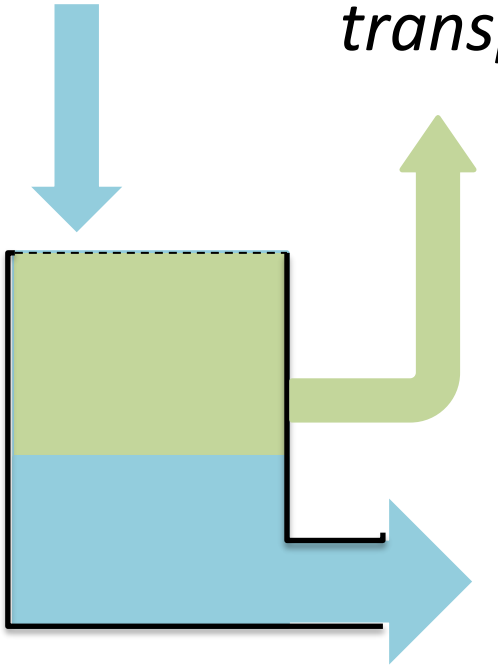
- How much water is available?
- Where does the water used for hydropower production come from?
- How much energy does it produce?
- How much is it worth?



Water Yield

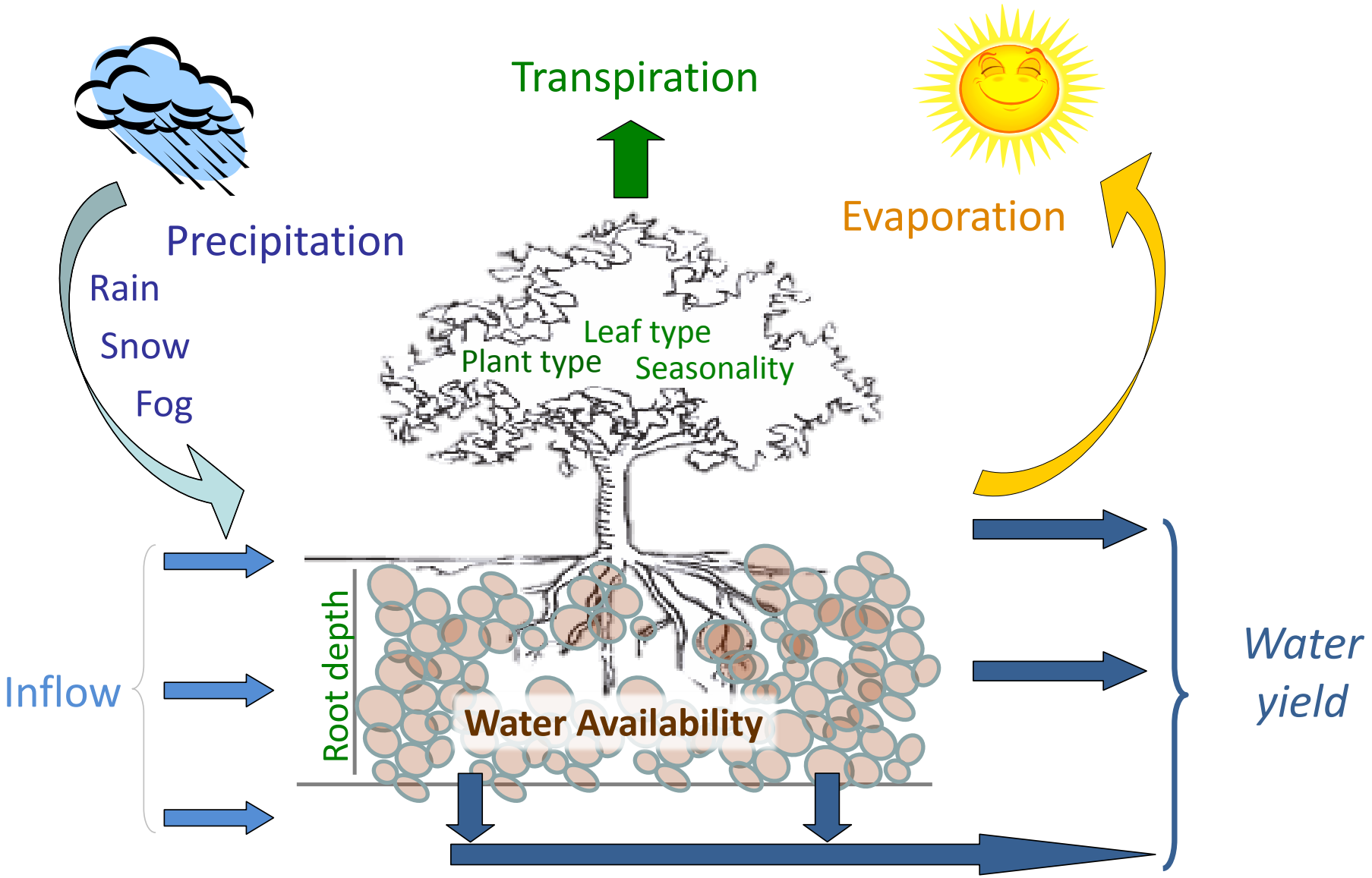


Precipitation – *Evapo-transpiration*

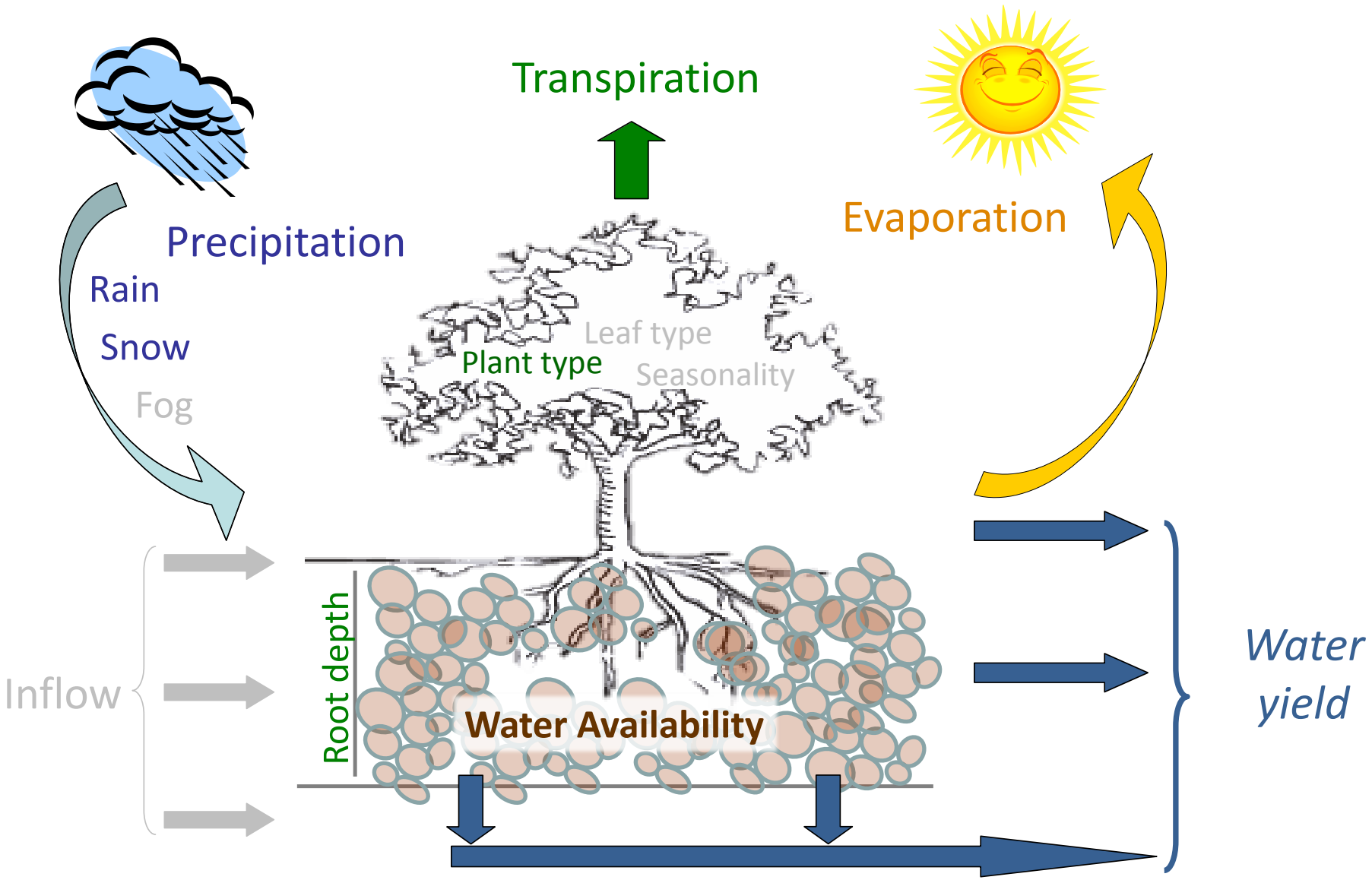


= Water yield

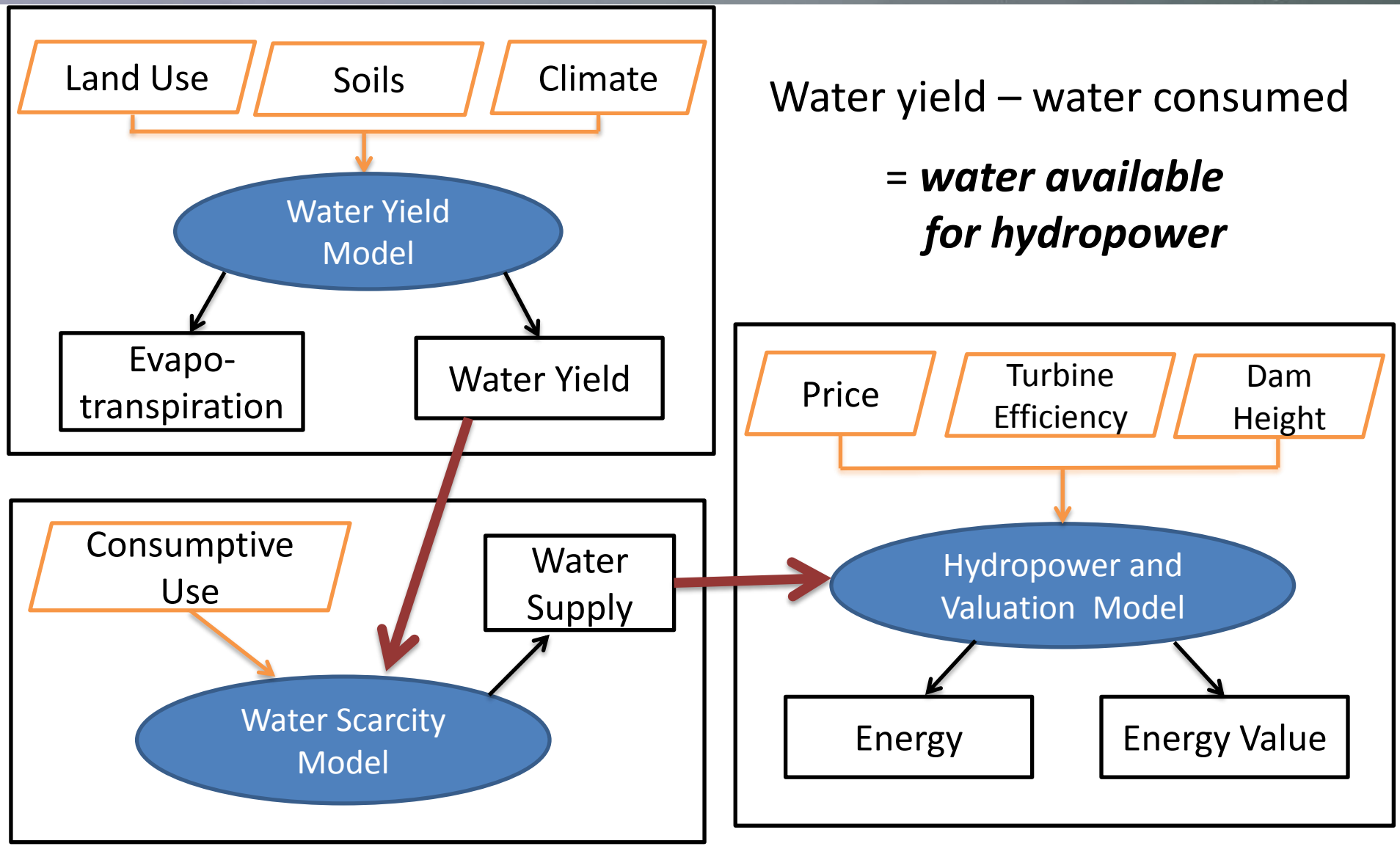
Water Yield


Transpiration
Evaporation
Precipitation
Rain
Snow
Fog
Leaf type
Plant type
Seasonality
Root depth
Water Availability
Inflow
Water yield

Water Yield


Transpiration
Evaporation
Precipitation
Rain
Snow
Fog
Leaf type
Plant type
Seasonality
Root depth
Water Availability
Inflow
Water yield

Model Architecture



Water yield – water consumed

= ***water available for hydropower***

Model Inputs

Climate

Precipitation, Potential Evapotranspiration, Zhang

Watersheds

Main and sub-watersheds for point of interest

Soils

Soil depth, Plant Available Water Content

Water demand

Land Use/Land Cover

Root depth, Evapotranspiration coefficient

Economic

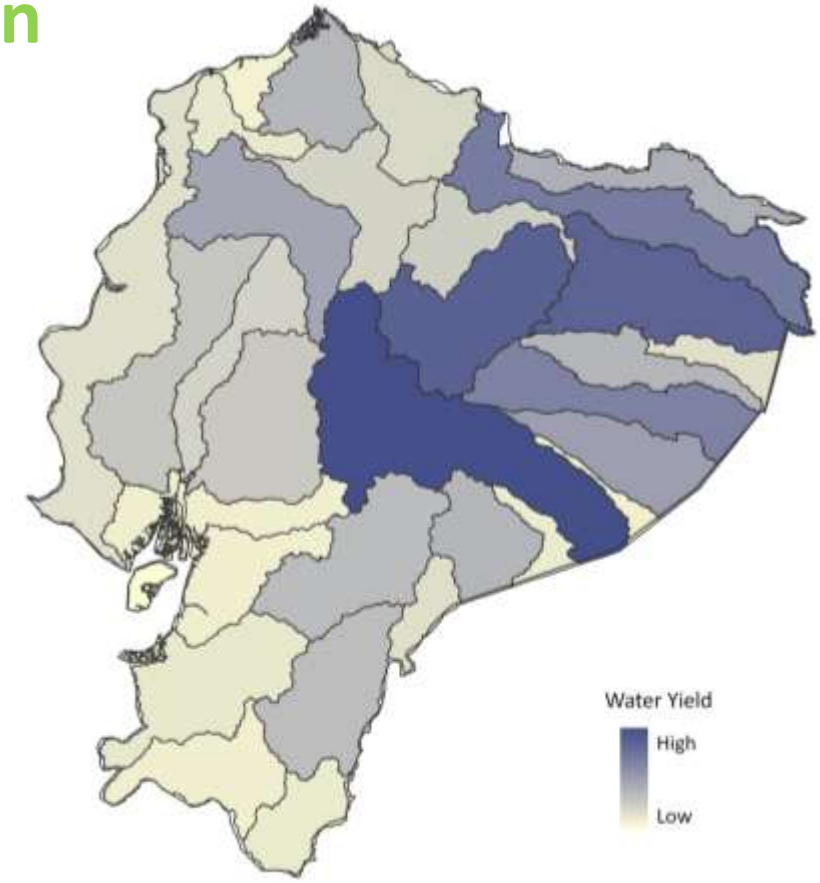
Hydropower plant data, price of energy

Obtaining Input Data

- Local: Field work, rain gauges, hydropower plant data
- Regional: National data
- Similar ecotypes: climate, elevation, vegetation
- Global: Climactic Research Unit precipitation, FAO soils, GLCF landcover
- Root depth/etk: Literature search

Model Outputs

- **Actual Evapotranspiration**
  mm/year
- **Water yield**
  mm/year
- **Water supply**
  m^3/year
  Used in valuation
- **Energy/value for hydropower**
  Kw/currency over timespan



Limitations

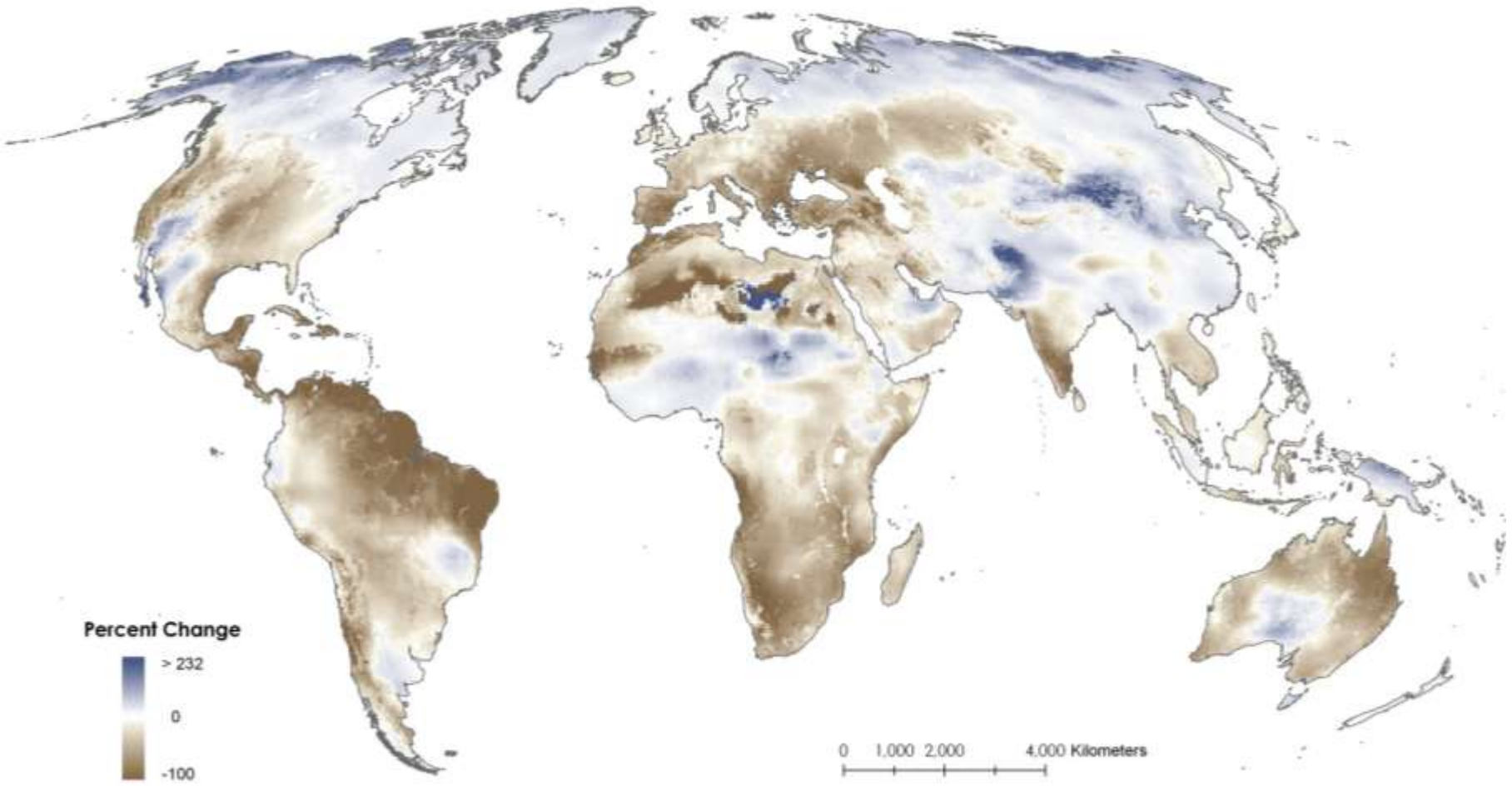
- Neglects extremes and seasonal variation of water yield
- Neglects surface-deep groundwater interactions
- Assumes hydropower production and pricing remain constant

Outlook

- Groundwater recharge index
- Automate calibration
- Monthly time step
- Regionalize the Zhang constant
- Tier 2 water yield model

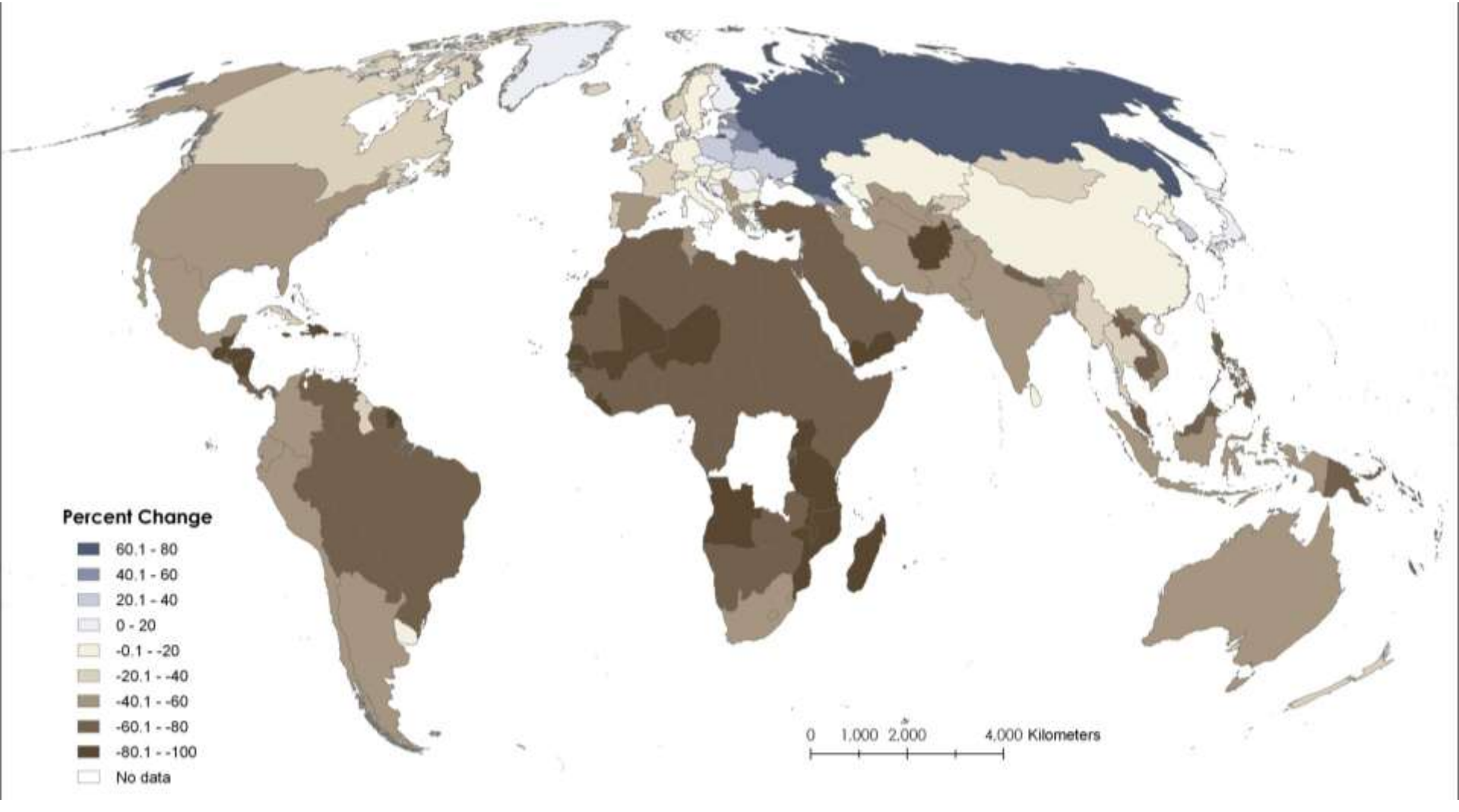
Application

Predicted water yield change 1990-2060, HADCM climate change model

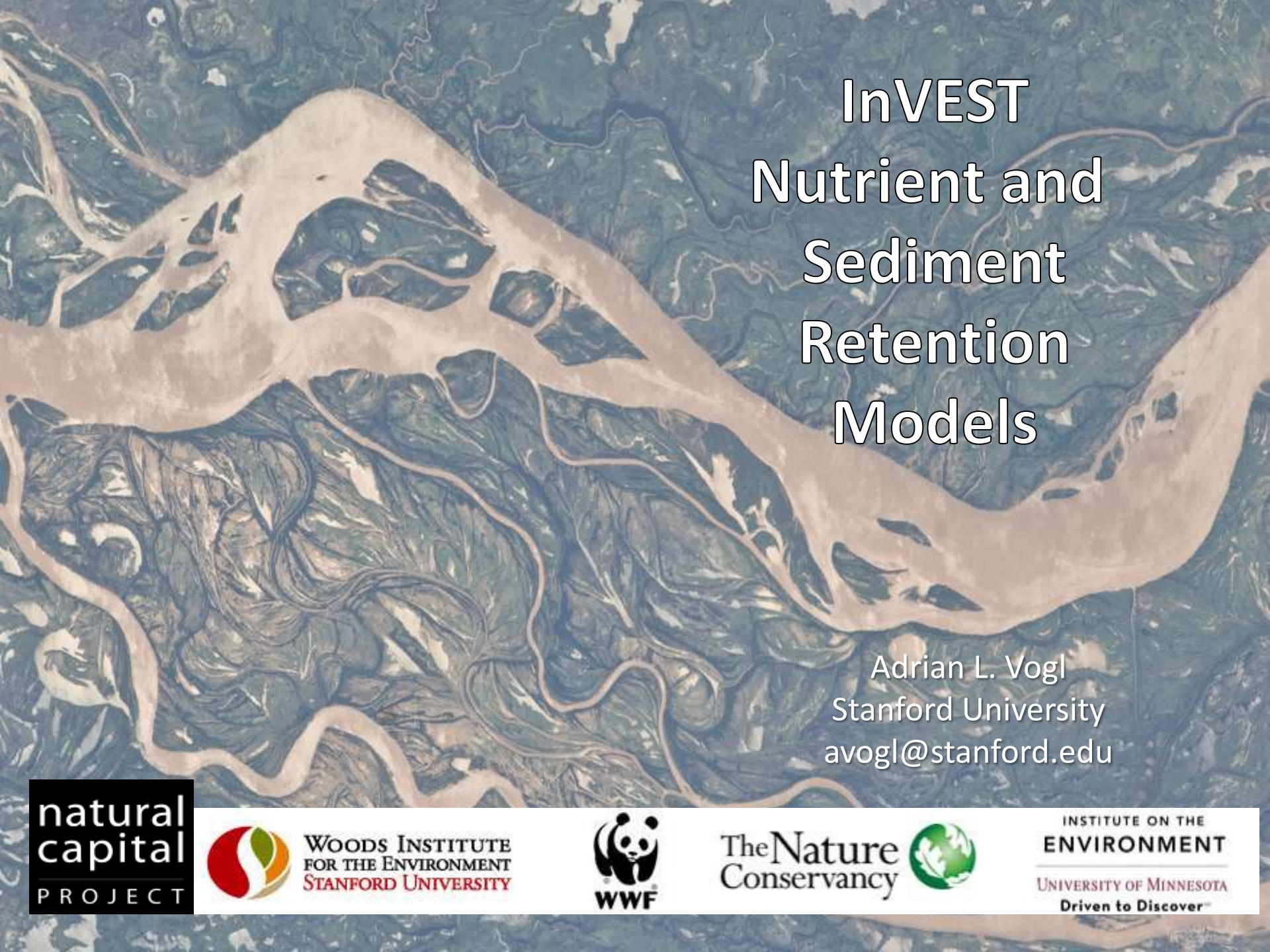


Application

Predicted per capita water yield change 1990-2060, HADCM climate change model




Questions?



InVEST Nutrient and Sediment Retention Models

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natural capital PROJECT

Woods Institute for the Environment Stanford University

WWF

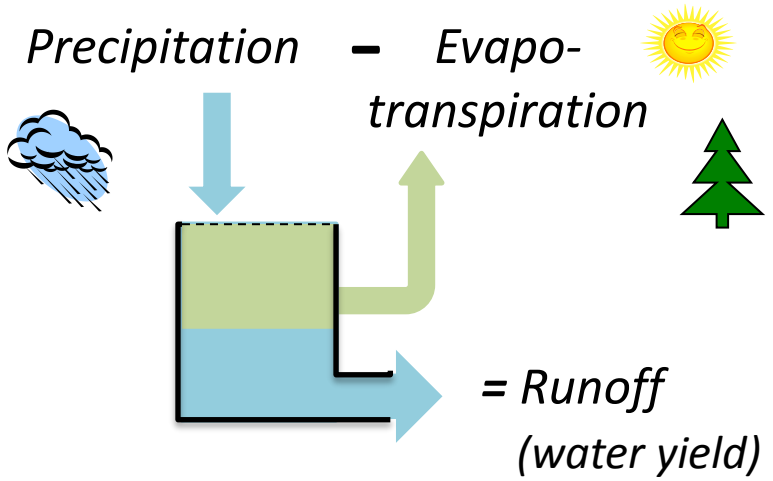
The Nature Conservancy

Institute on the Environment
University of Minnesota
Driven to Discover℠

Nutrient Retention Model

Based on runoff and export coefficients*

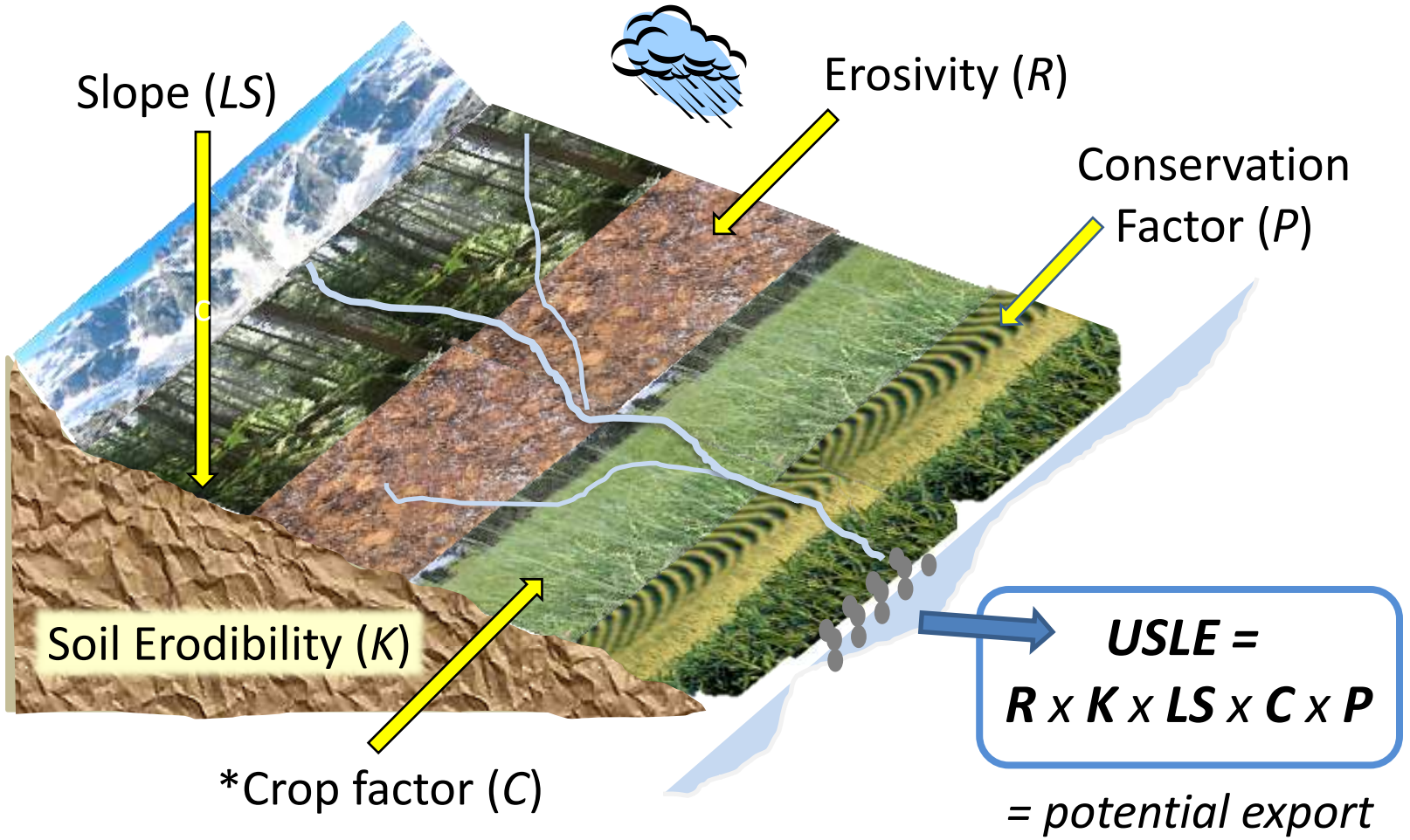
- Nitrogen and phosphorus
- Includes climate and geomorphology
- Potential export from a parcel/pixel



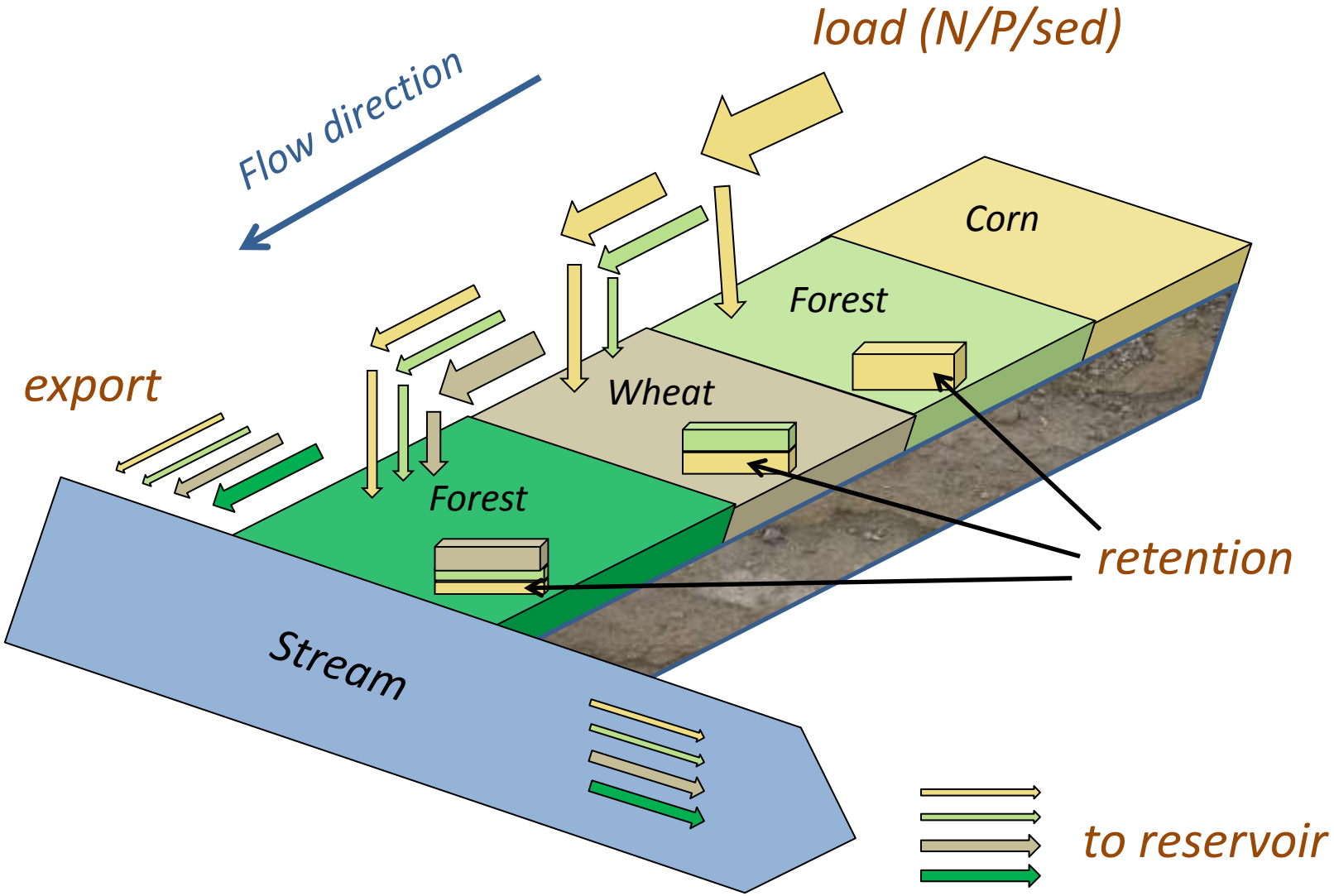
Landuse	Nitrogen Export Values (kg/ha/yr)	Phosphorus Export values (kg/ha/yr)
Forest	1.8	0.011
Corn	11.1	2
Cotton	10	4.3
Soybeans	12.5	4.6
Small Grain	5.3	1.5
Pasture	3.1	0.1
Feedlot or Dairy	2900	220
Idle	3.4	0.1
Residential	7.5	1.2
Business	13.8	3
Industrial	4.4	3.8

Sediment Retention Model

Based on the Universal Soil Loss Equation (USLE)

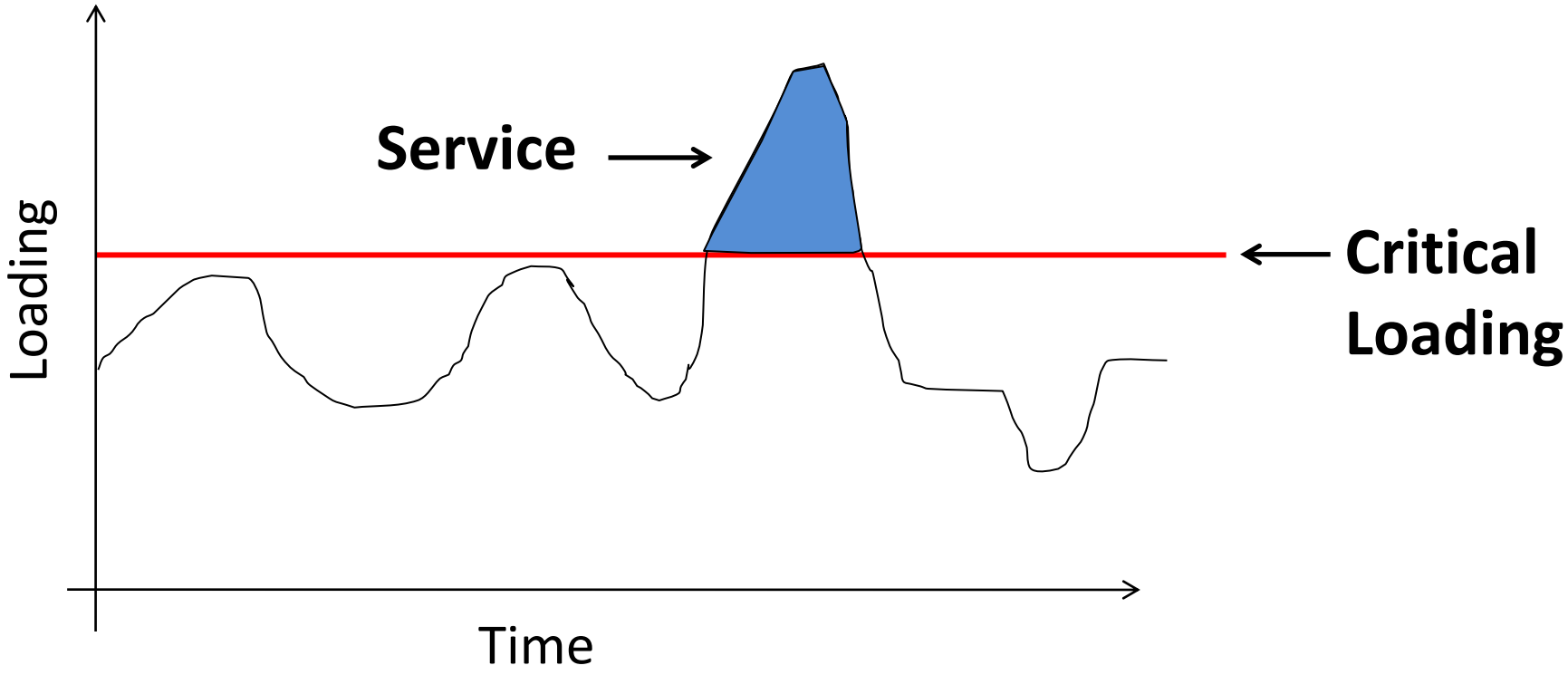


Hydraulic Connectivity



Valuation

- *Net Present Value* of retention
- Based on *avoided treatment costs*



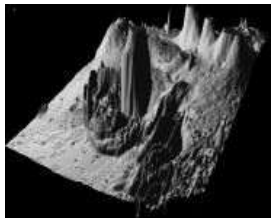
Inputs - Nutrient

Climate

Precipitation, Potential evapotranspiration, Zhang

Soils

Soil depth,
Available water content



Topography

Digital elevation model,
Threshold flow acc

Watersheds

Catchments flowing into points of interest

Land use/Land cover

Export coefficients, retention capacity, root depth, etk

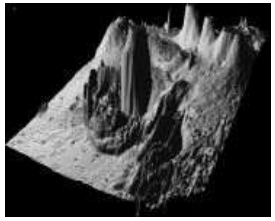
Economic

Critical loading, treatment cost, time, discount rate

Inputs - Sediment

Land use/Land cover

Vegetation retention, land practice and management



Topography

Digital elevation model, slope threshold, threshold flow acc

Erosivity

Based on intensity and kinetic energy of rainfall

Erodibility

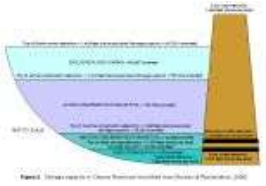
Soil detachment and transport potential due to rainfall

Streams

Used to determine where sediment flows to

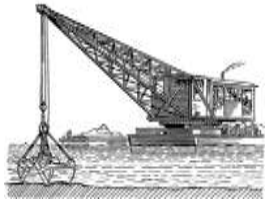
Watershed Areas

Catchments flowing into reservoirs



Reservoir Features

Dead volume, lifetime of reservoir, allowed load



Economic

Reservoir dredging costs
Or water quality filtering costs

Outputs - Nutrient

Nutrient Exported

Kg/year

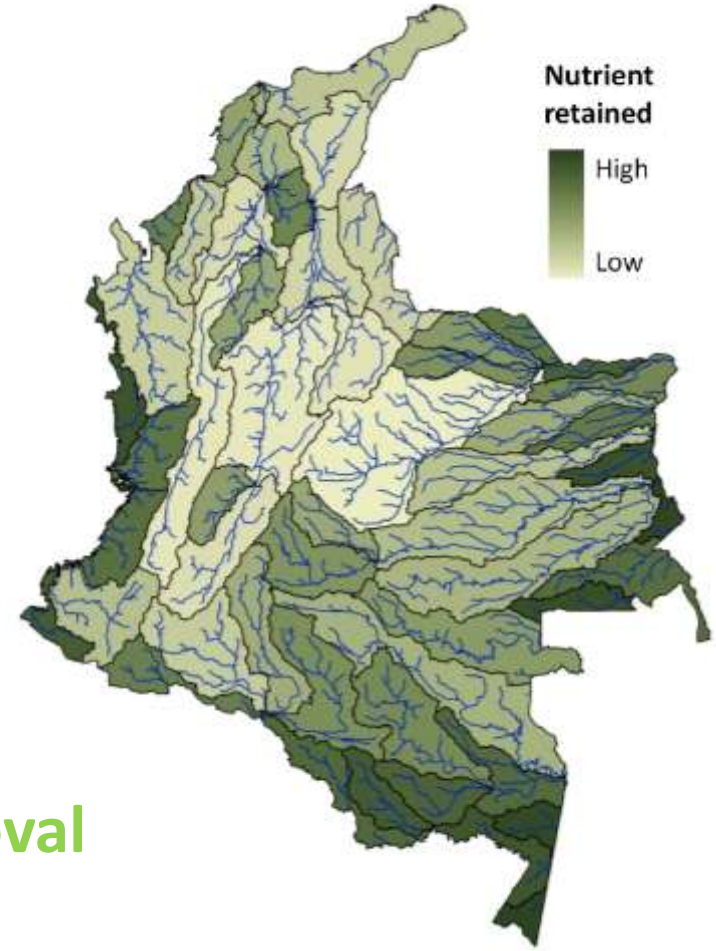
Nutrient Retained

Kg/year

Used in valuation

Value of Nutrient Removal for Water Quality

Currency over time period



Outputs - Sediment

Potential Soil loss

Calculated from USLE

Tons/year

Sediment Retained

Tons/year

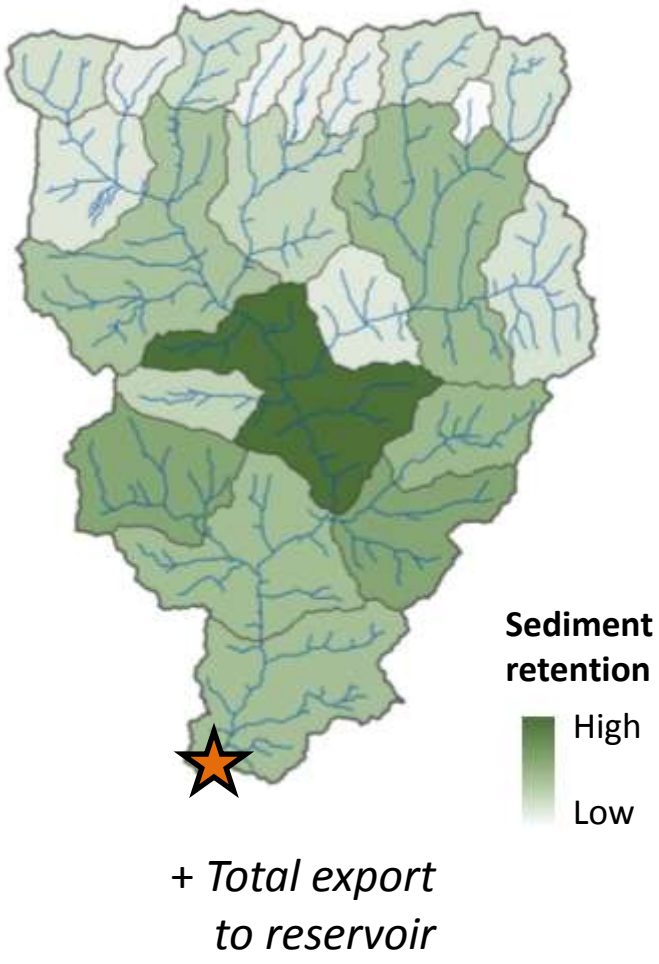
Used in valuation

Sediment Exported

Tons/year

Value of Sediment Removal for Water Quality/Dredging

Currency over time period



+ Total export to reservoir

Limitations - Nutrient

- All bio-physio-chemical processes are lumped in one export coefficient
- Annual basis, no seasonality
- No in-stream processes or point sources
- Assess one pollutant per run
- No saturation in uptake

Limitations - Sediment

- Predicts erosion from sheet wash alone
- Sediment gets to outlet within a year
- No limit to retention
- Neglects the role of topography, soil, climate in the retention processes
- Accuracy limited in mountainous areas


Questions?