DATA SOURCES

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INVEST AND RIOS PARAMETER TABLES

description	lucode	LULC_veg	usle_c	sed_exp	sed_ret	sedret_eff	root_depth	Kc	rough_rank	cover_rank
Urban and paved roads	1	0	0.99	0.99	0.2	0.2	0	0.2	0.011	0.1
Bare soil and unpaved roads	2	0	1	1	0.26	0.26	500	0.15	0.02	0.16
Grass	3	1	0.034	0.034	0.845	0.845	2000	0.865	0.13	0.3
Shrub	4	1	0.128	0.128	0.505	0.505	2000	0.3	0.4	0.5
General agriculture	5	1	0.412	0.412	0.84	0.84	1000	1.1	0.09	0.39
Tea	6	1	0.08135	0.08135	0.84	0.84	1850	1.015	0.3535	0.883
Coffee	7	1	0.4393	0.4393	0.84	0.84	1600	1.055	0.276	0.45
Mixed forest	8	1	0.025	0.025	0.7375	0.7375	3500	1.008	0.6	0.91
Water	9	0	0	0	0.2	0.2	10	1.05	0.0001	0
Evergreen forest	10	1	0.025	0.025	0.7375	0.7375	3500	1.008	0.6	0.92
Forest plantation	11	1	0.121	0.121	0.7375	0.7375	3500	1.008	0.6	0.79
Pineapple	12	1	0.055	0.055	0.84	0.84	3500	0.4	0.12	0.26
Wetland	13	0	0.003	0.003	0.94	0.94	2200	1.2	0.6	0.31
Orchard	14	1	0.412	0.412	0.84	0.84	1000	1.1	0.09	0.39
Corn	15	1	0.412	0.412	0.84	0.84	1000	1.1	0.09	0.39
Native montane bunchgrass	16	1	0.03	0.03	0.845	0.845	2000	0.925	0.15	0.28
Bare rock	17	0	1	1	0.26	0.26	500	0.15	0.02	0.16
Unpaved road	18	0	1	1	0.26	0.26	500	0.15	0.02	0.16
Agroforestry	19	1	0.121	0.121	0.7375	0.7375	3500	1.008	0.6	0.79

WATER YIELD

Biophysical table	
LULC_veg	Contains the information on which AET equation to use (Eq. 1 or 2). Values should be 1 for vegetated land use except wetlands, and 0 for all other land uses, including wetlands, urban, water bodies, etc.
root_depth	The maximum root depth for vegetated land use classes, given in integer millimeters.
Kc	The plant evapotranspiration coefficient for each LULC class.
Seasonality factor (Z)	Floating point value on the order of 1 to 20 corresponding to the seasonal distribution of precipitation.
Demand table	
lucode	Integer value of land use/land cover class, must match LULC raster.
demand	The estimated average consumptive water use for each landuse / landcover type. (m^3/yr/pixel)

ROOT DEPTH

- Canadell, J., R. B. Jackson, and H. Mooney. 1996, Maximum rooting depth of vegetation types at the global scale. Oecologia 108: 583-595

  (summarizes 290 observations in the literature by biome & plant species)

- Must define effective max root depth for impermeable landuse/land classes, such as urban areas, or water bodies.
- A rule of thumb is to denote water and urban areas with minimal maximum rooting depths, but a zero value should not be used.

ROOT DEPTH

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Root Depth by Species	Root Depth by Biome
Trees 7.0 m	Cropland 2.1 m
Shrubs 5.1 m	Desert 9.5 m
Herbaceous Plants 2.6 m	Sclerophyllous Shrubland & Forest 5.2 m
	Tropical Deciduous Forest 3.7 m
	Tropical Evergreen Forest 7.3 m
	Grassland 2.6 m
	Tropical Grassland/Savanna 15 m
	Tundra 0.5 m

Kc

- FAO: http://www.fao.org/docrep/X0490E/x0490e0b.htm
  - Coefficients by crop growth stage (K_c ini, K_c mid, K_c end)
  - Must be converted to annual average K_c
  - Kc calculator: http://ncp-dev.stanford.edu/~dataportal/invest-data/Kc_calculator.xlsx
- Non-vegetated LULCs (wetlands, open water, impervious surface, etc.)
  - Values are only approximate, but unless the LULC represents a significant portion of the watershed, the impact of the approximation on model results should be minimal.
  - See InVEST documentation for recommended values based on Allen et al., 1998

Z (SEASONALITY FACTOR)

- Z is an empirical constant, typical values range from 1 to 20
- Some studies have estimated ω empirically, which can be used to estimate Z (e.g. Xu et al. 2013, Fig. 3; Liang and Liu 2014; Donohue et al. 2012)
- Estimate Z based on Donohue et al. (2012) study across a range of climatic conditions in Australia
  - Z = 0.2*N, where N is the number of rain events per year.
  - A "rain event" is characterized by a minimum period of 6 hours between two storms.
- Calibration of the Z coefficient may also be used by comparing modeled and observed data.

DEMAND

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- Average annual consumptive water use for each land use / land class type
- Agricultural areas: water used by cattle or agricultural processing that is not returned to the watershed
- Urban areas: may be estimated based on water use per person and multiplied by the approximate population area per raster cell.
- Industrial water use or water exports to other watersheds must also be considered where applicable.
- Important to account for pixel area!
- Can we use a negative demand to account for inter-basin transfers?

WATER YIELD

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Hydropower valuation table	
ws_id	Unique integer value for each watershed, which must correspond to values in the Watersheds layer.
station_desc	Name of hydropower station (optional)
efficiency	The turbine efficiency (floating point values generally 0.7 to 0.9).
fraction	The fraction of inflow water volume that is used to generate energy.
height	The head, measured as the average annual effective height of water behind each dam at the turbine intake in meters. Floating point value.
kw_price	The price of one kilowatt-hour of power produced by the station, in dollars or other currency. Floating point value.
cost	Annual cost of running the hydropower station (maintenance and operations costs). Floating point value.
time_span	An integer value of either the expected lifespan of the hydropower station or the period of time of the land use scenario of interest.
discount	The discount rate over the time span, used in net present value calculations. Floating point value.

- NREL
- National Renewable Energy Lab (US power facilities information)

SEDIMENT RETENTION

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Biophysical table	
usle_c	Cover-management factor for the USLE, a floating point value between 0 and 1.
usle_p	Support practice factor for the USLE, a floating point value between 0 and 1.
sedret_eff	The sediment retention value for each LULC class, as a floating point value between 0 and 1. This value is a percent per pixel area.
Valuation table	
ws_id	(watershed ID): Unique integer value for each reservoir, which must correspond to values in the Watersheds layer.
dr_cost	Cost of sediment dredging in $ (Currency) / m3 removed. Floating point value.
dr_time	Integer time period to be used in calculating Present Value (PV) of removal costs.
dr_disc	The rate of discount over the time span, used in net present value calculations.
wq_cost	Cost of removing sediment for water quality in $ (Currency) / m3 removed. Floating point value.
wq_time	Integer time period to be used in calculating Present Value (PV) of removal costs.
wq_disc	The rate of discount over the time span, used in net present value calculations.

USLE C & P

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- Literature review in local area (search for studies that estimate USLE parameters for different land cover types)
- U.S. Department of Agriculture soil erosion handbook http://topsoil.nserl.purdue.edu/usle/AH_537.pdf
- USLE Fact Sheet http://www.omafra.gov.on.ca/english/engineer/facts/12-051.pdf
- U.N. Food and Agriculture Organization http://www.fao.org/docrep/T1765E/t1765e0c.htm
- NOAA's N-SPECT (non-point source erosion control tool, also loading coefficients)
- InVEST parameter value literature database http://naturalcapitalproject.org/database.html

RETENTION EFFICIENCIES

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- Literature review in local area (search for studies that estimate retention for different land cover types)
  - Observational studies (e.g. measuring above and below a vegetated strip)
  - Modeling studies (reporting calibrated results attributing retention to a particular land cover type, or watershed with one dominant land cover)

- Adjust for cell size

- InVEST parameter value literature database http://naturalcapitalproject.org/database.html

SEDIMENT RETENTION

Sediment threshold table	
ws_id	(watershed ID): Unique integer value for each reservoir, which must correspond to values in the Watersheds layer.
dr_time	Integer time period corresponding to the remaining designed lifetime of the reservoir (if assessing avoided sedimentation) or the expected time period over which the land use will remain relatively constant.
dr_deadvol	The volume of water below the turbine (dead volume of reservoir)
wq_annload	Allowed annual sediment loading, used for valuing sediment retention for water quality.

NUTRIENT RETENTION

Biophysical table	
root_depth/ Kc	(Same as for water yield model)
load_n/ load_p	The nutrient loading for each land use. If nitrogen is being evaluated, supply values in load_n, for phosphorus, supply values in load_p.
eff_n/ eff_p	The vegetation filtering value per pixel size for each LULC class, as an integer percent between zero and 100. If nitrogen is being evaluated, supply values in eff_n, for phosphorus, supply values in eff_p.
Valuation table	
ws_id	Unique integer value for each watershed, which must correspond to values in the Watersheds layer.
cost	Annual cost of nutrient removal treatment in $ / kg removed. Floating point value.
time_span	Number of years for which net present value will be calculated. Integer value.
discount	The rate of discount over the time span, used in net present value calculations. Floating point value.
Threshold table	
ws_id	(watershed ID): Unique integer value for each reservoir, which must correspond to values in the Watersheds layer.
thresh_n/ thresh_p	The total critical annual nutrient loading allowed for the nutrient of interest at the point of interest. Floating point value. It has units of Kg.yr-1.

NUTRIENT LOADS & EFFICIENCIES

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- Literature review in local area (similar approach as sediment model)
  - Observational studies (e.g. measuring above and below a vegetated strip)
  - Modeling studies (reporting calibrated results attributing retention to a particular land cover type, or watershed with one dominant land cover)

- Adjust for cell size

- InVEST parameter value literature database http://naturalcapitalproject.org/database.html

ONLINE DATA RESOURCES

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http://naturalcapitalproject.org/database.html

CALIBRATION DATA
WATER MODELS

- Annual average runoff
  - For hydropower valuation, use inflow measured at facility
  - Multi-year average (>10 years) preferable
- Annual average sediment load
  - Can convert concentration to load based on flow rate and catchment area
- Annual average nutrient load (nitrogen/phosphorus)
  - Match units with InVEST outputs
- Common calibration parameters: Z, Kc, C, sedret_eff, load_n, load_p, eff_n, eff_p, threshold flow accumulation

Q&A