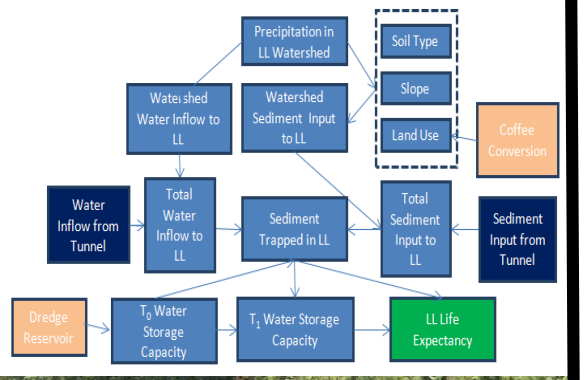
www.epa.gov



Decision Scenario Analysis for Addressing Sediment Accumulation in Lago Lucchetti, Puerto Rico

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National Health and Environmental Effects Research Laboratory
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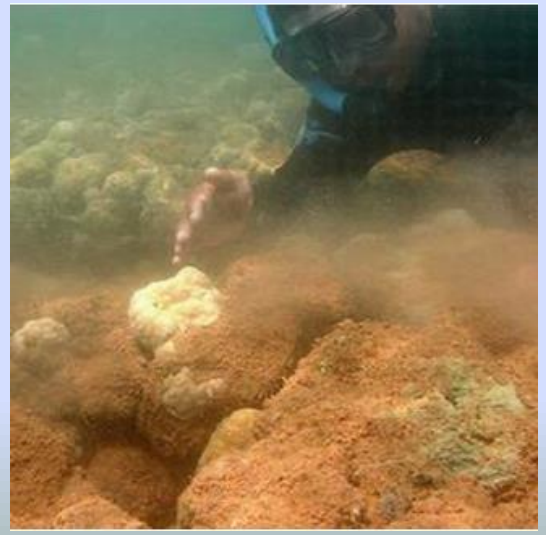
ACES Conference December 11, 2014

Coral Reef Protection

- The Guánica watershed has gone through many changes, including agricultural and municipal growth
- Landuse changes have altered the quantity and quality of water flowing into Guánica Bay
- Concern over effects on coastal corals led to a US Coral Reef Task Force initiative to reduce watershed pollution



Guánica Bay Watershed Management Plan: **Proposed Actions**

Shade-grown coffee

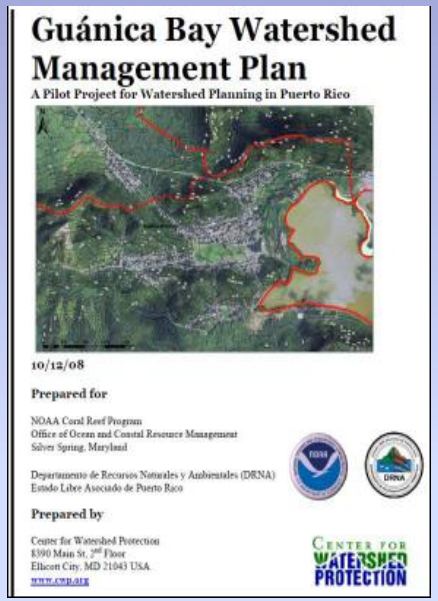
Dredging reservoirs

Lagoon restoration

Hydro-seeding

Riparian planting

Remove relic irrigation


Guánica Bay Watershed Management Plan

A Pilot Project for Watershed Planning in Puerto Rico

10/12/08

Prepared for

NOAA Coral Reef Program
Office of Ocean and Coastal Resource Management
Silver Spring, Maryland

Departamento de Recursos Naturales y Ambientales (DRNA)
Estado Libre Asociado de Puerto Rico

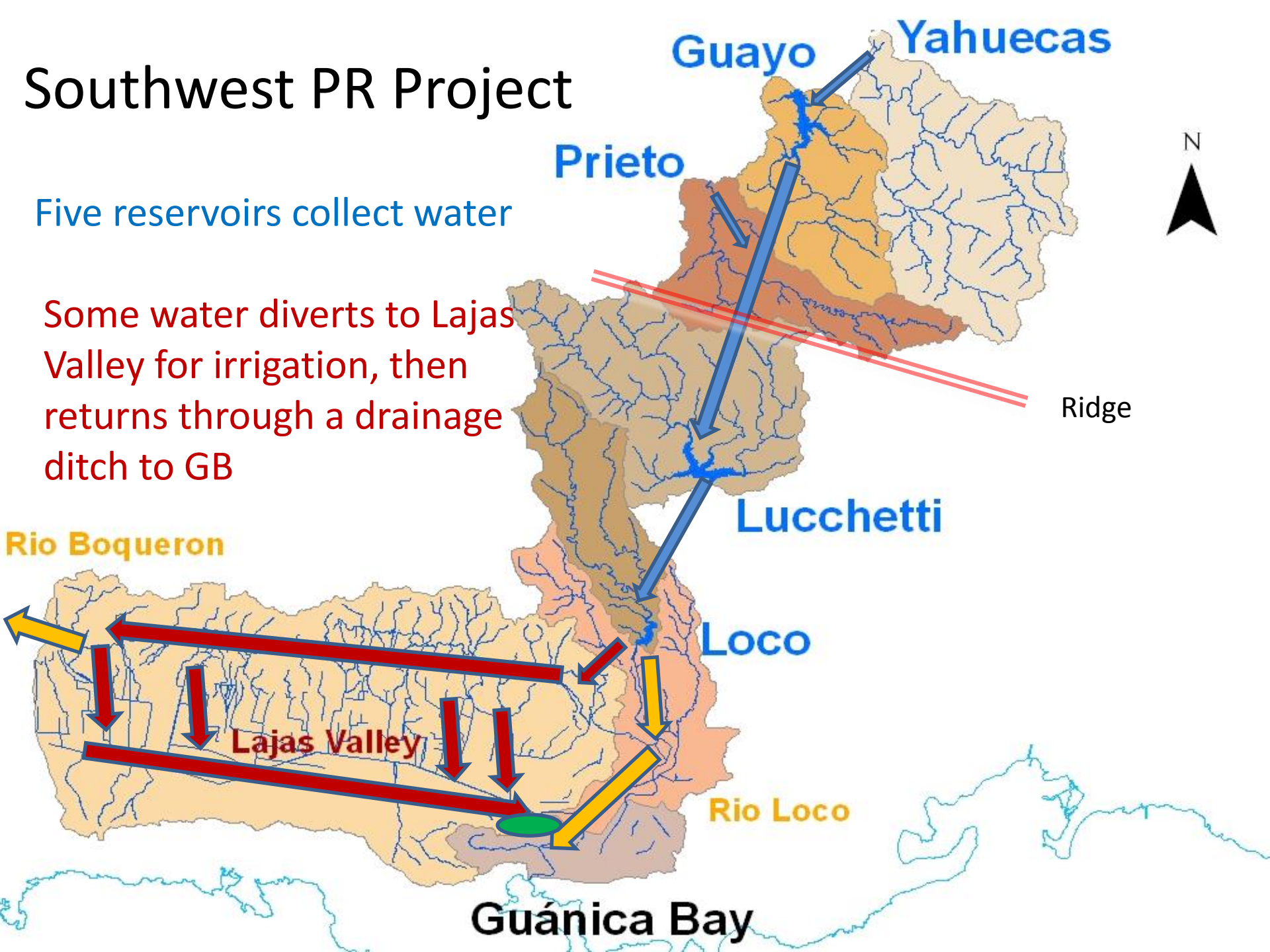
Prepared by

Center for Watershed Protection
8390 Main St. 2nd Floor
Ellicott City, MD 21043 USA
www.cwp.org

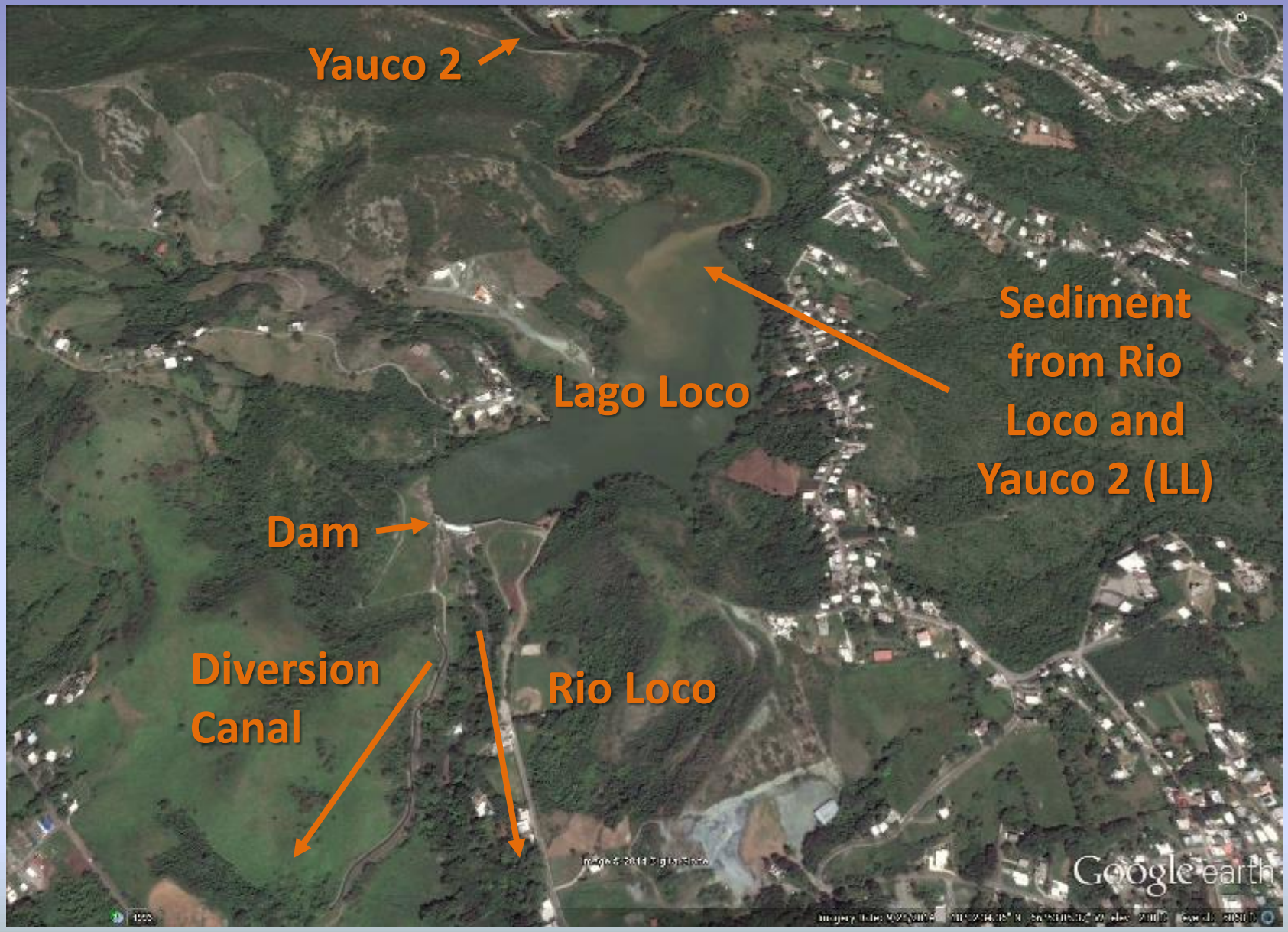
Southwest PR Project

Five reservoirs collect water

Some water diverts to Lajas Valley for irrigation, then returns through a drainage ditch to GB

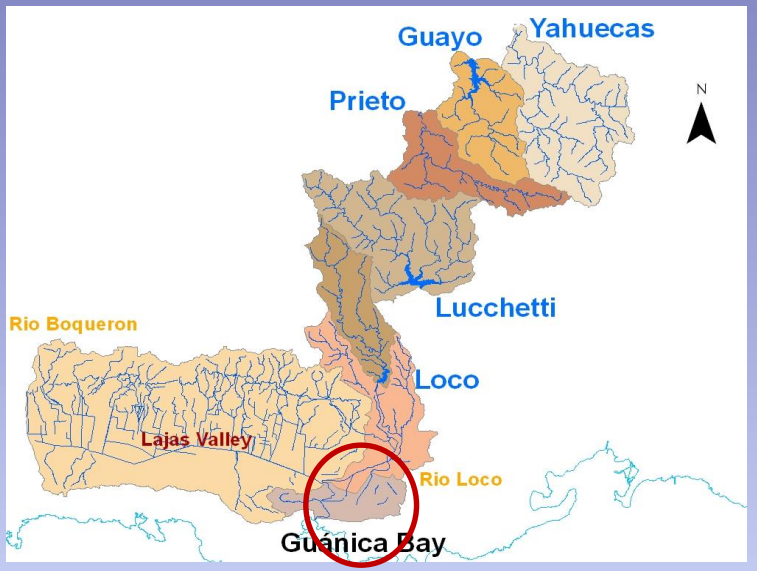


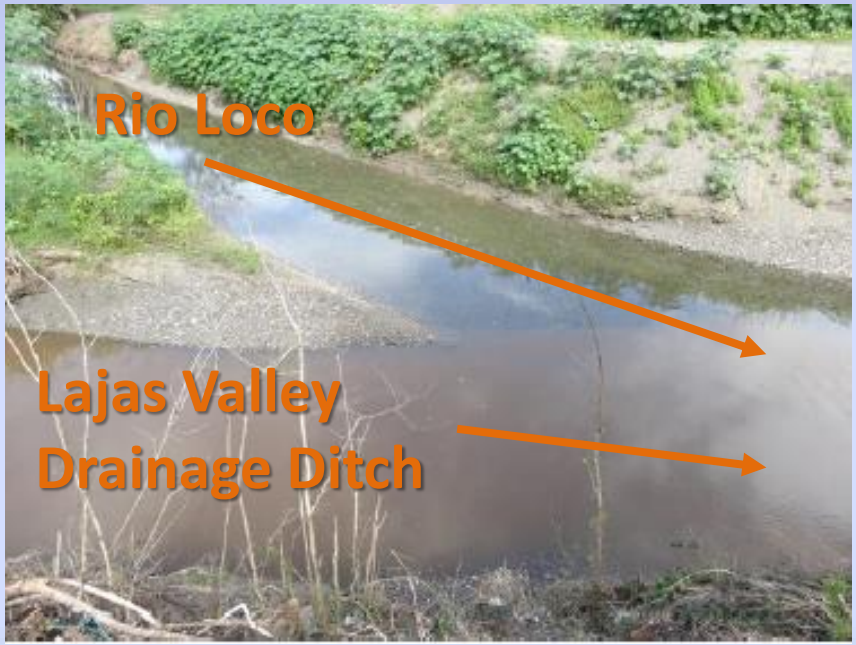

From Lago Lucchetti
Yauco 2
Rio Loco
To Lago Loco

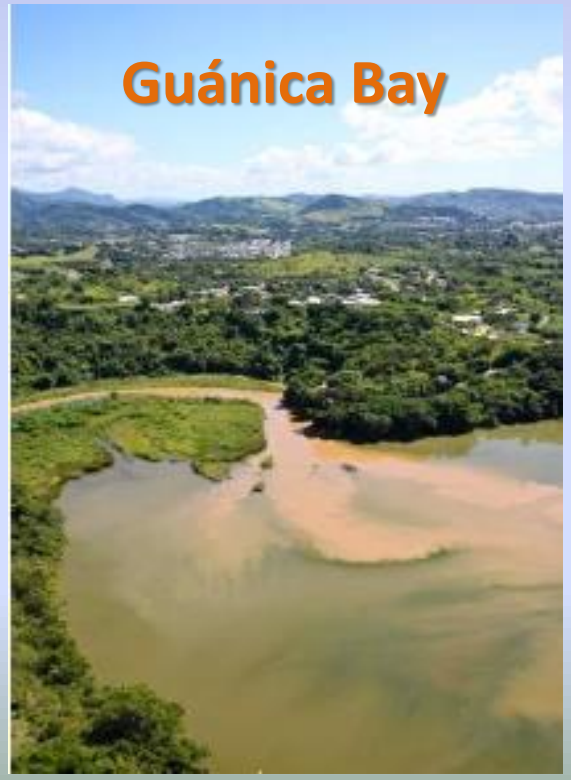

Yauco 2
Lago Loco
Sediment from Rio Loco and Yauco 2 (LL)
Dam
Diversion Canal
Rio Loco
Google earth

Coral Reef Protection

Should management decisions be focused on sediment from the Rio Loco or from the Lajas Valley Drainage (Return) Ditch?



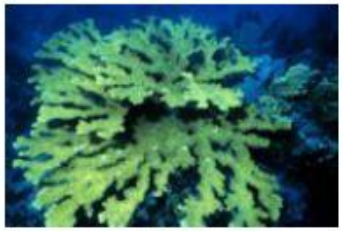




Water Quality and Quantity (Ecosystem Services)

Freshwater Habitat

Coral Reefs



Bird and Reptile Biodiversity

Agricultural Irrigation

Drinking Water

Flood Control

Waste Water Dilution

Hydroelectric

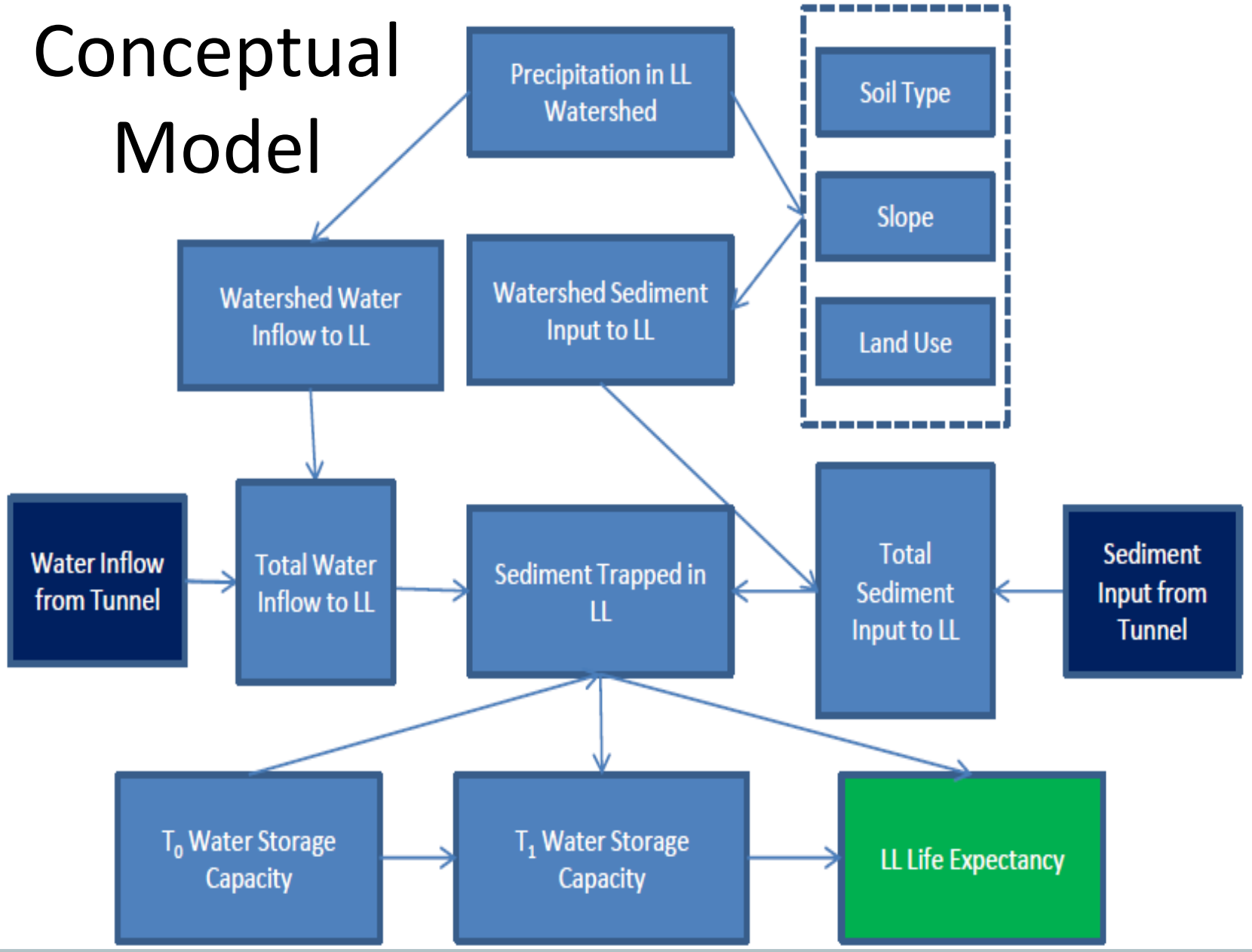
What is the Life Expectancy of Lago Lucchetti?

Most Reservoirs in Puerto Rico are ½ filled with sediment, placing at risk the many ecosystem services they provide

How long can LL provide current and future services?

How will management options affect LL life expectancy?

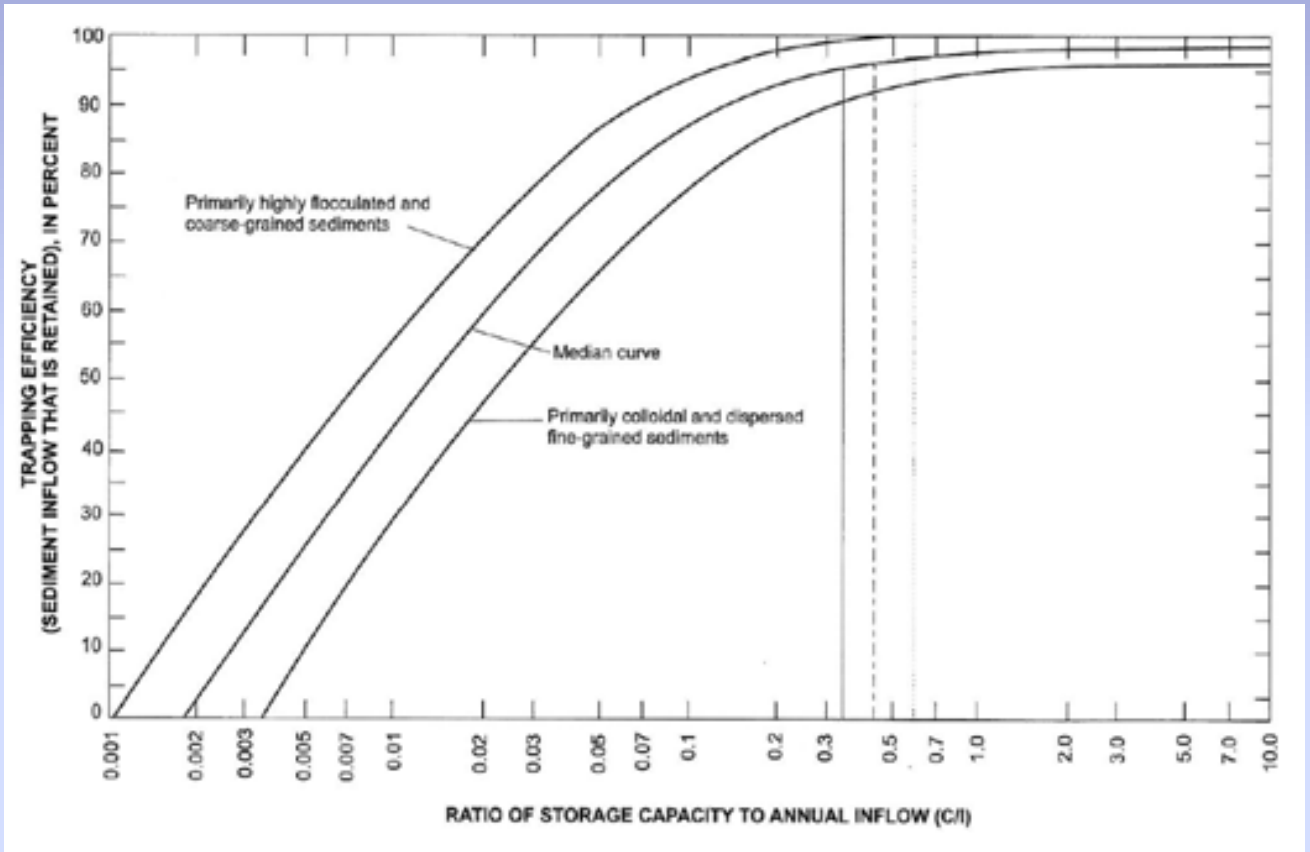
Conceptual Model



Trapping Efficiency: Capacity to Trap Sediment

Ratio of reservoir capacity to inflow [Brunes Curve]

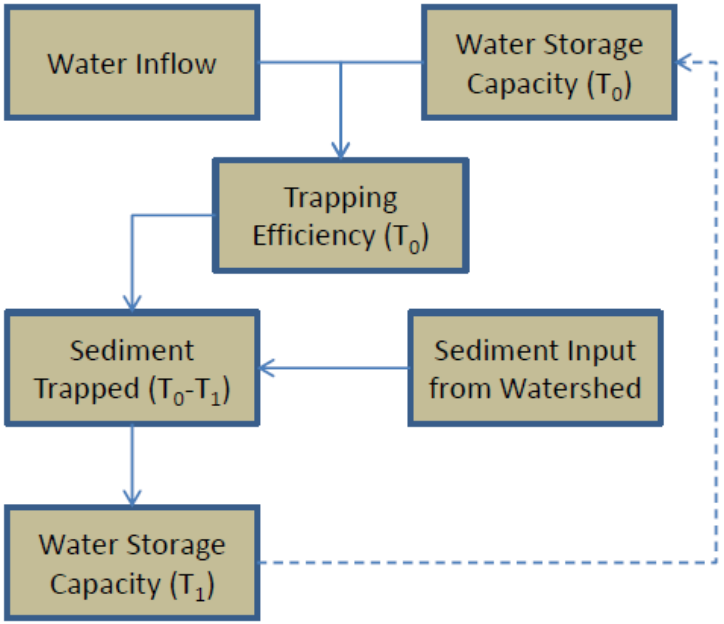
Trapping Efficiency



Storage Capacity/Water Inflow

TrapEff (Inflow, K) = ((0.97)^((0.19)^ (log10(K/Inflow))))*100

Sediment Balance Model



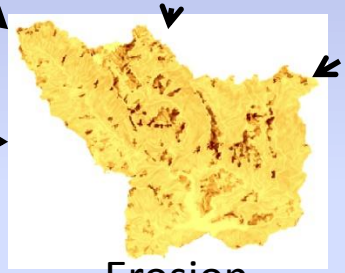
To estimate the amount of water and sediment delivered through tunnels into successive reservoirs

USLE Sediment Model

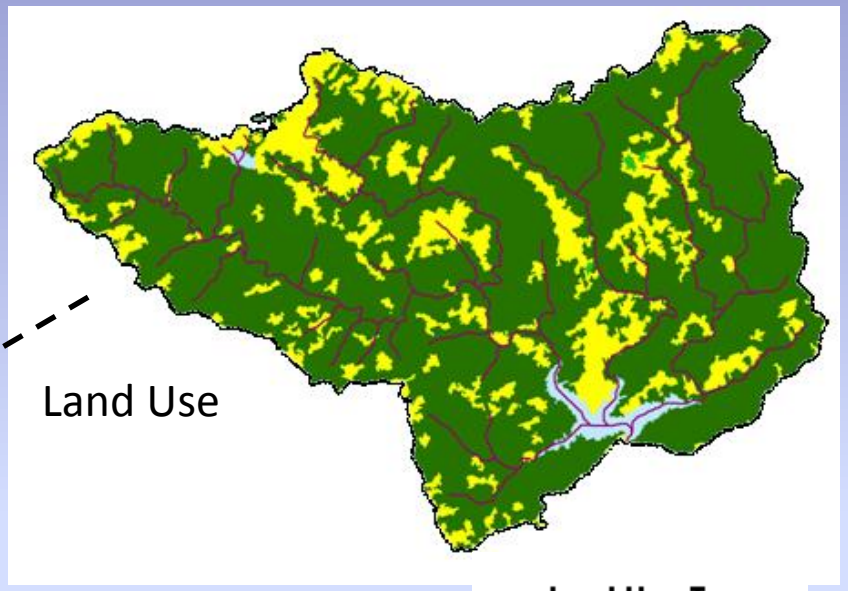
Slope

Precipitation

Soil



Erosion

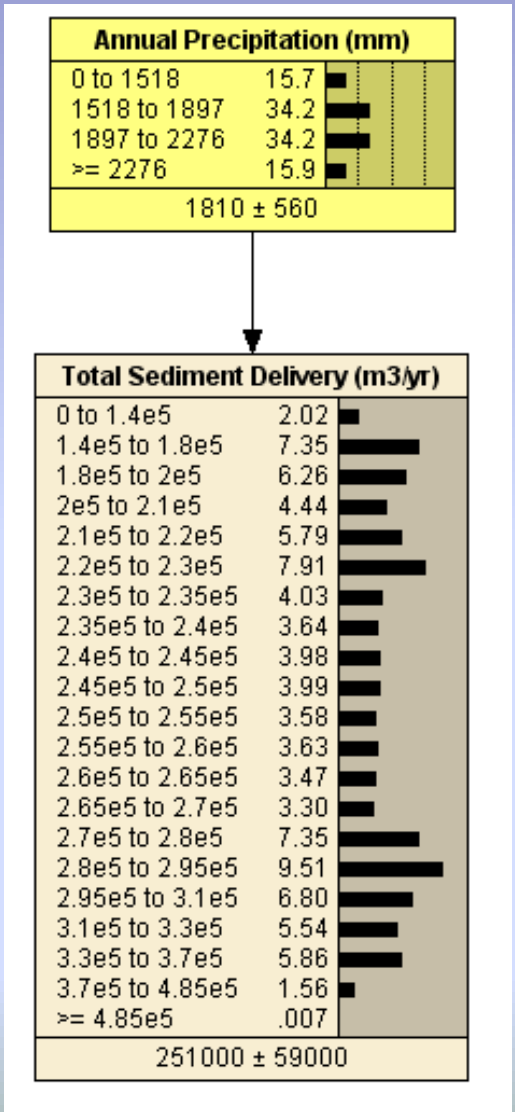


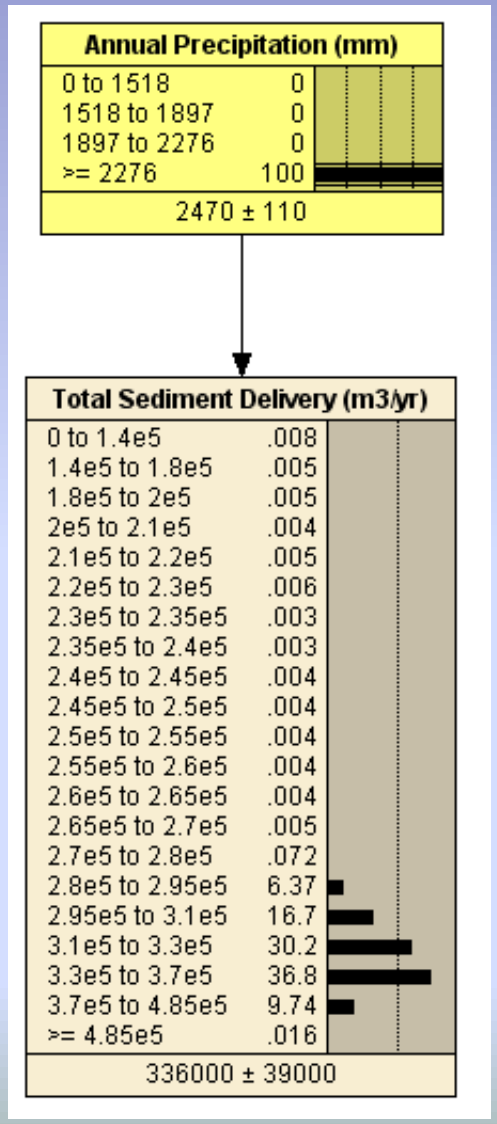
Land Use

Sediment Delivery Ratio

Sediment Delivery (m^3/yr)

Watershed Sediment Delivery to Lago Lucchetti

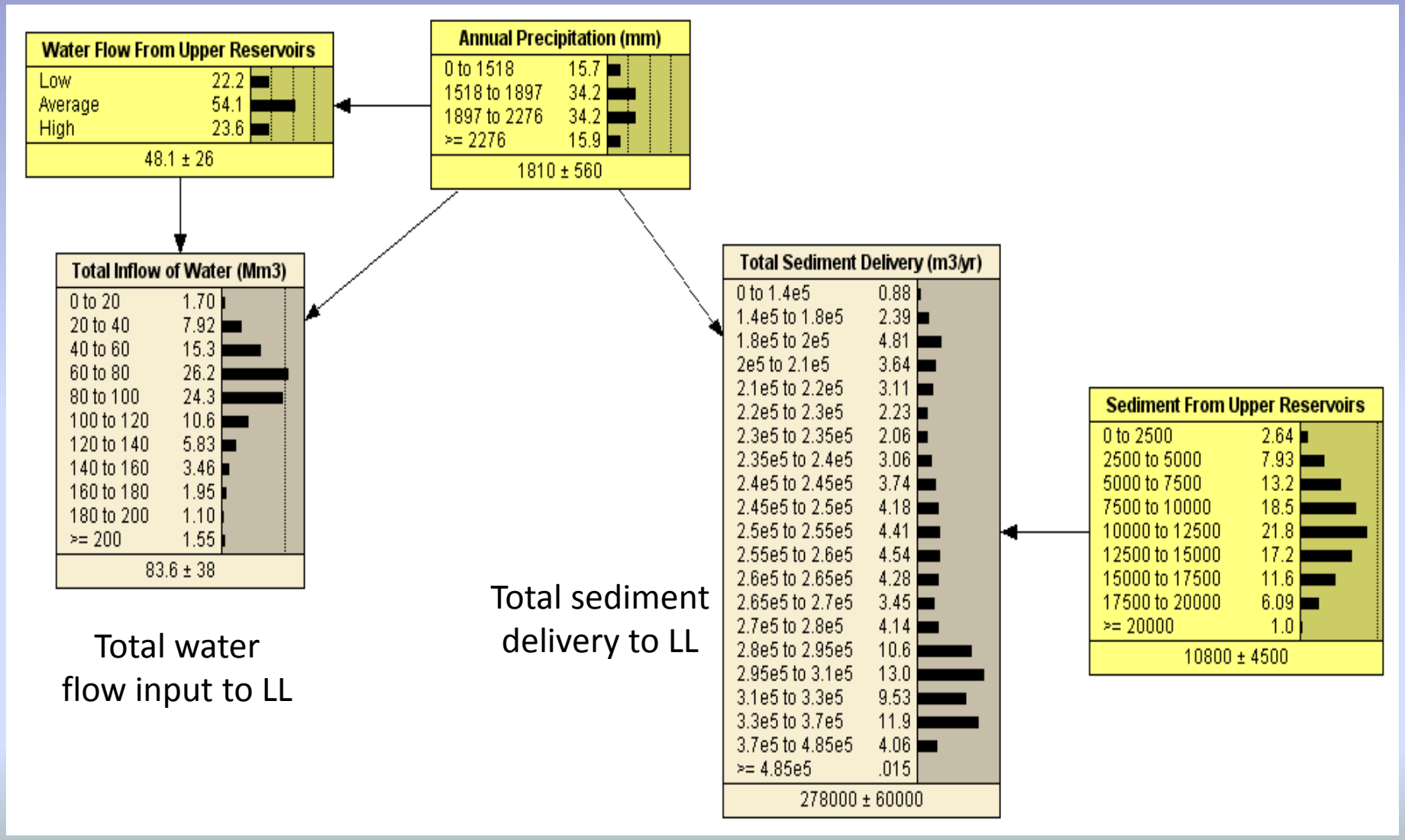




Bayesian Belief Network

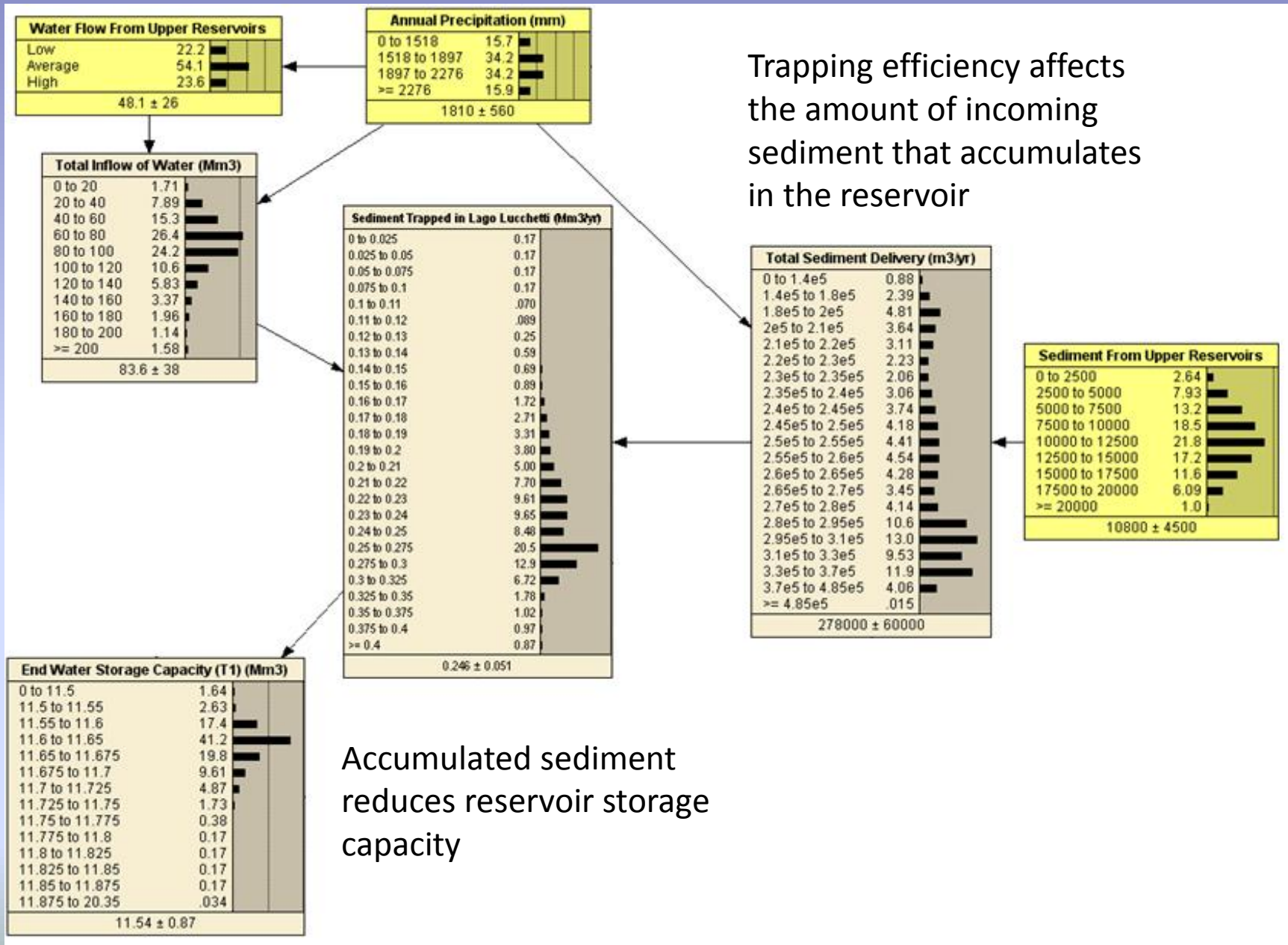
- Limited data
- High uncertainty
- Expert opinion
- Multiple objectives and decisions
- Project scaling

Water & Sediment from Upper Reservoirs



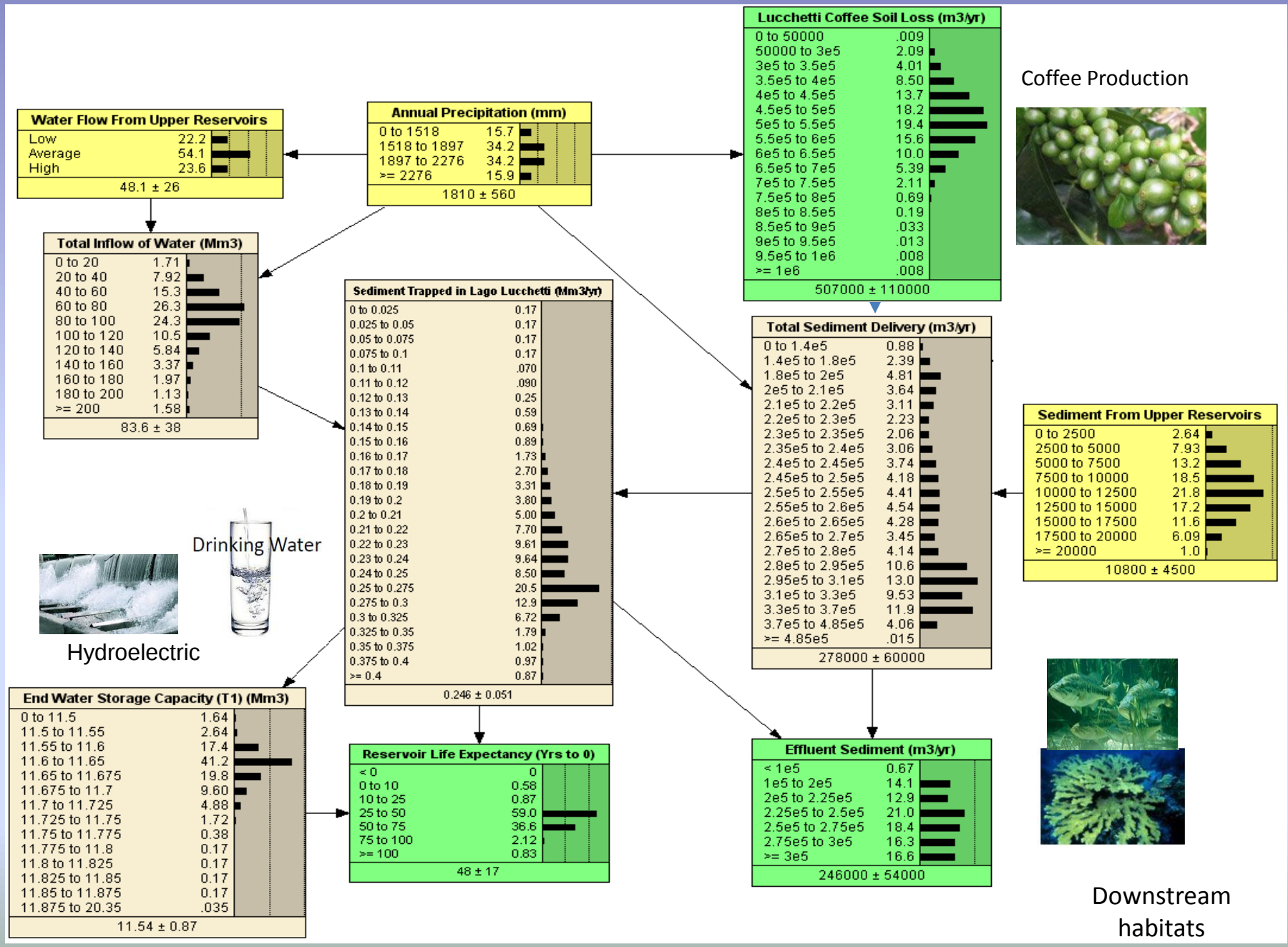
Total water flow input to LL

Total sediment delivery to LL

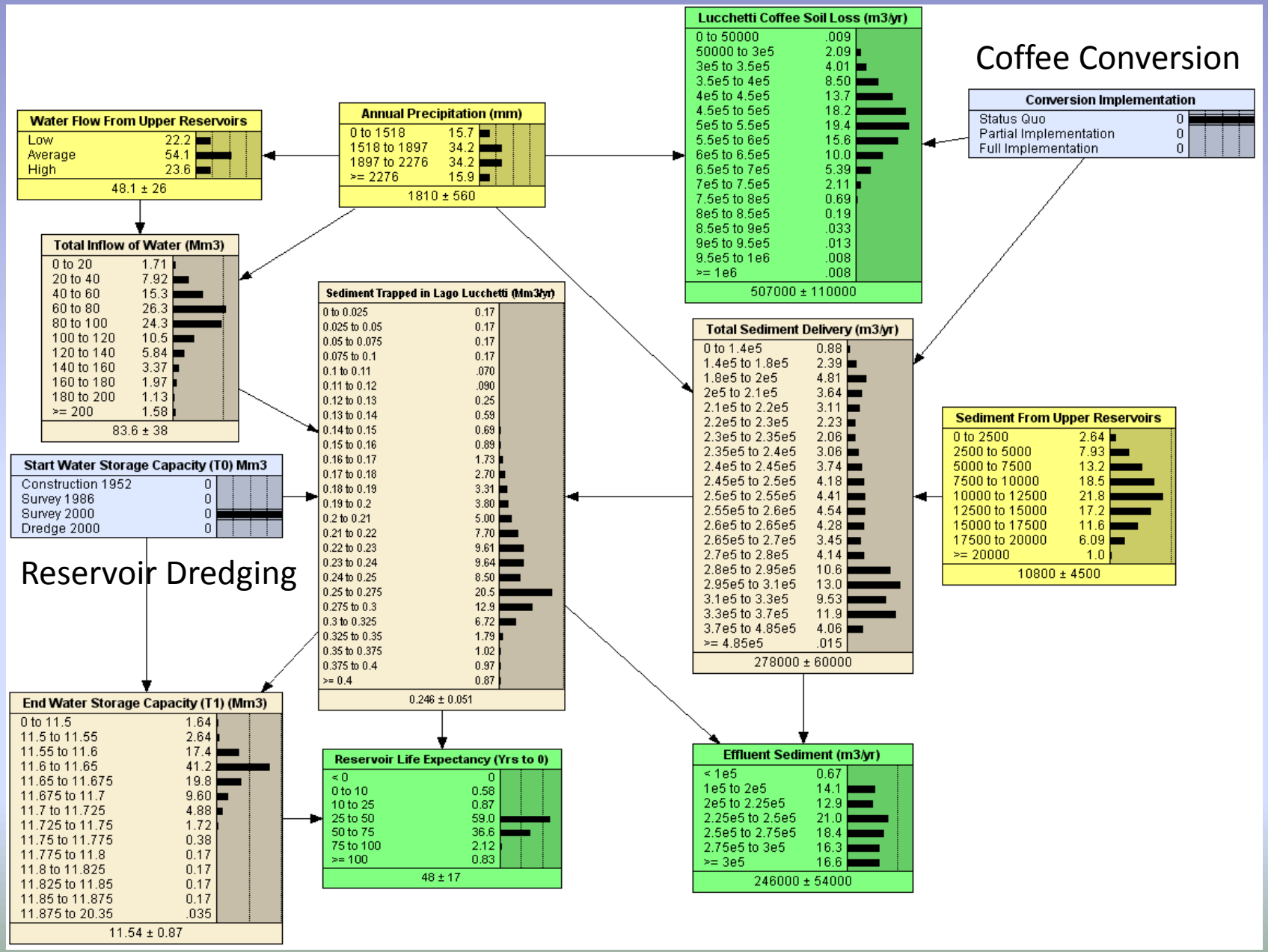


Trapping efficiency affects the amount of incoming sediment that accumulates in the reservoir

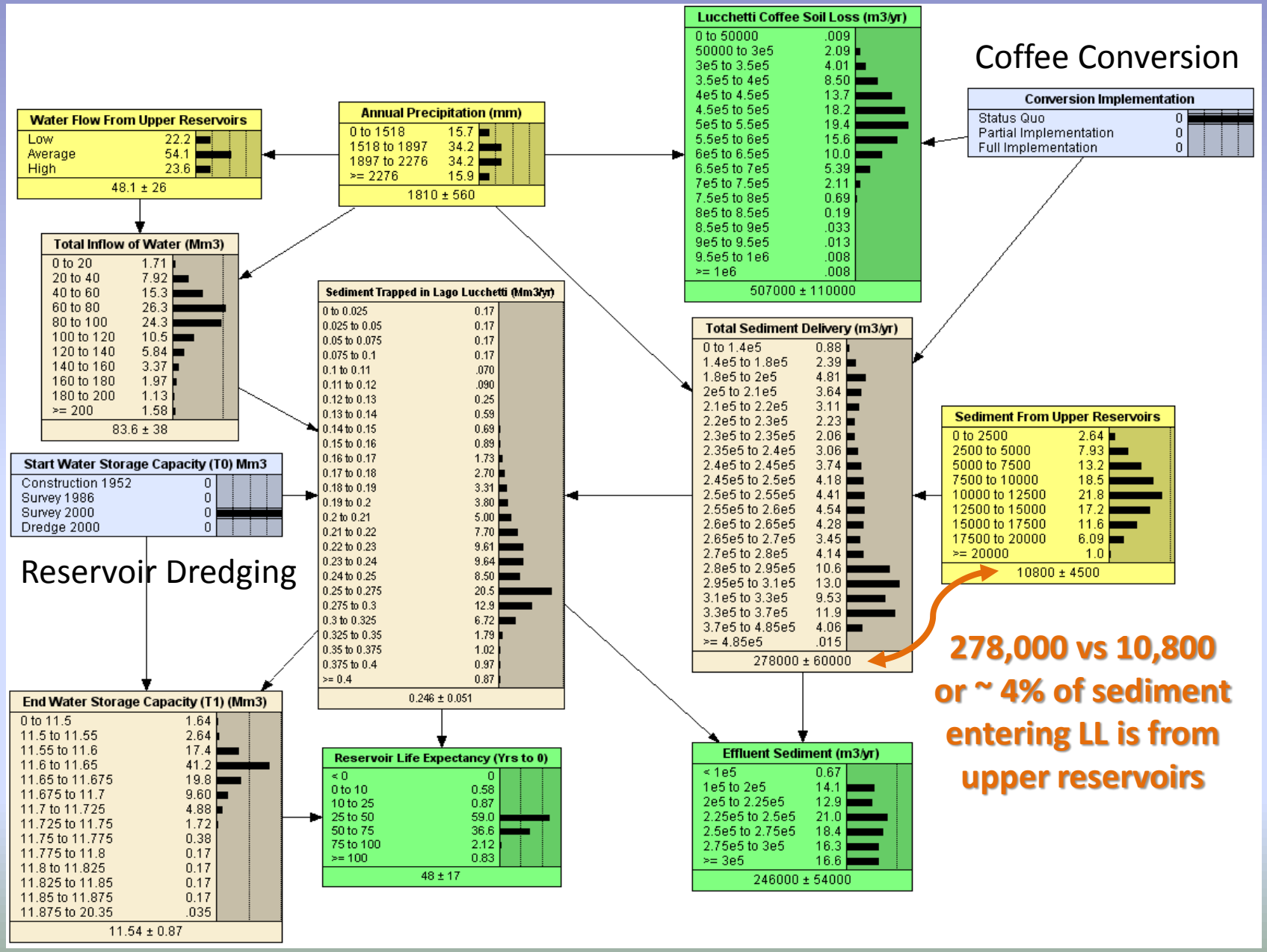
Accumulated sediment reduces reservoir storage capacity


Water Flow From Upper Reservoirs
Low 22.2
Average 54.1
High 23.6
48.1 ± 26
Annual Precipitation (mm)
0 to 1518 15.7
1518 to 1897 34.2
1897 to 2276 34.2
>= 2276 15.9
1810 ± 560
Lucchetti Coffee Soil Loss (m3/yr)
0 to 50000 .009
50000 to 3e5 2.09
3e5 to 3.5e5 4.01
3.5e5 to 4e5 8.50
4e5 to 4.5e5 13.7
4.5e5 to 5e5 18.2
5e5 to 5.5e5 19.4
5.5e5 to 6e5 15.6
6e5 to 6.5e5 10.0
6.5e5 to 7e5 5.39
7e5 to 7.5e5 2.11
7.5e5 to 8e5 0.69
8e5 to 8.5e5 0.19
8.5e5 to 9e5 .033
9e5 to 9.5e5 .013
9.5e5 to 1e6 .008
>= 1e6 .008
507000 ± 110000
Coffee Production
Total Inflow of Water (Mm3)
0 to 20 1.71
20 to 40 7.92
40 to 60 15.3
60 to 80 26.3
80 to 100 24.3
100 to 120 10.5
120 to 140 5.84
140 to 160 3.37
160 to 180 1.97
180 to 200 1.13
>= 200 1.58
83.6 ± 38
Sediment Trapped in Lago Lucchetti (Mm3/yr)
0 to 0.025 0.17
0.025 to 0.05 0.17
0.05 to 0.075 0.17
0.075 to 0.1 0.17
0.1 to 0.11 .070
0.11 to 0.12 .090
0.12 to 0.13 0.25
0.13 to 0.14 0.59
0.14 to 0.15 0.69
0.15 to 0.16 0.89
0.16 to 0.17 1.73
0.17 to 0.18 2.70
0.18 to 0.19 3.31
0.19 to 0.2 3.80
0.2 to 0.21 5.00
0.21 to 0.22 7.70
0.22 to 0.23 9.61
0.23 to 0.24 9.64
0.24 to 0.25 8.50
0.25 to 0.275 20.5
0.275 to 0.3 12.9
0.3 to 0.325 6.72
0.325 to 0.35 1.79
0.35 to 0.375 1.02
0.375 to 0.4 0.97
>= 0.4 0.87
0.246 ± 0.051
Total Sediment Delivery (m3/yr)
0 to 1.4e5 0.88
1.4e5 to 1.8e5 2.39
1.8e5 to 2e5 4.81
2e5 to 2.1e5 3.64
2.1e5 to 2.2e5 3.11
2.2e5 to 2.3e5 2.23
2.3e5 to 2.35e5 2.06
2.35e5 to 2.4e5 3.06
2.4e5 to 2.45e5 3.74
2.45e5 to 2.5e5 4.18
2.5e5 to 2.55e5 4.41
2.55e5 to 2.6e5 4.54
2.6e5 to 2.65e5 4.28
2.65e5 to 2.7e5 3.45
2.7e5 to 2.8e5 4.14
2.8e5 to 2.95e5 10.6
2.95e5 to 3.1e5 13.0
3.1e5 to 3.3e5 9.53
3.3e5 to 3.7e5 11.9
3.7e5 to 4.85e5 4.06
>= 4.85e5 .015
278000 ± 60000
Sediment From Upper Reservoirs
0 to 2500 2.64
2500 to 5000 7.93
5000 to 7500 13.2
7500 to 10000 18.5
10000 to 12500 21.8
12500 to 15000 17.2
15000 to 17500 11.6
17500 to 20000 6.09
>= 20000 1.0
10800 ± 4500
Drinking Water
Hydroelectric
End Water Storage Capacity (T1) (Mm3)
0 to 11.5 1.64
11.5 to 11.55 2.64
11.55 to 11.6 17.4
11.6 to 11.65 41.2
11.65 to 11.675 19.8
11.675 to 11.7 9.60
11.7 to 11.725 4.88
11.725 to 11.75 1.72
11.75 to 11.775 0.38
11.775 to 11.8 0.17
11.8 to 11.825 0.17
11.825 to 11.85 0.17
11.85 to 11.875 0.17
11.875 to 20.35 .035
11.54 ± 0.87
Reservoir Life Expectancy (Yrs to 0)
< 0 0
0 to 10 0.58
10 to 25 0.87
25 to 50 59.0
50 to 75 36.6
75 to 100 2.12
>= 100 0.83
48 ± 17
Effluent Sediment (m3/yr)
< 1e5 0.67
1e5 to 2e5 14.1
2e5 to 2.25e5 12.9
2.25e5 to 2.5e5 21.0
2.5e5 to 2.75e5 18.4
2.75e5 to 3e5 16.3
>= 3e5 16.6
246000 ± 54000
Downstream habitats

Management Actions



Management Actions

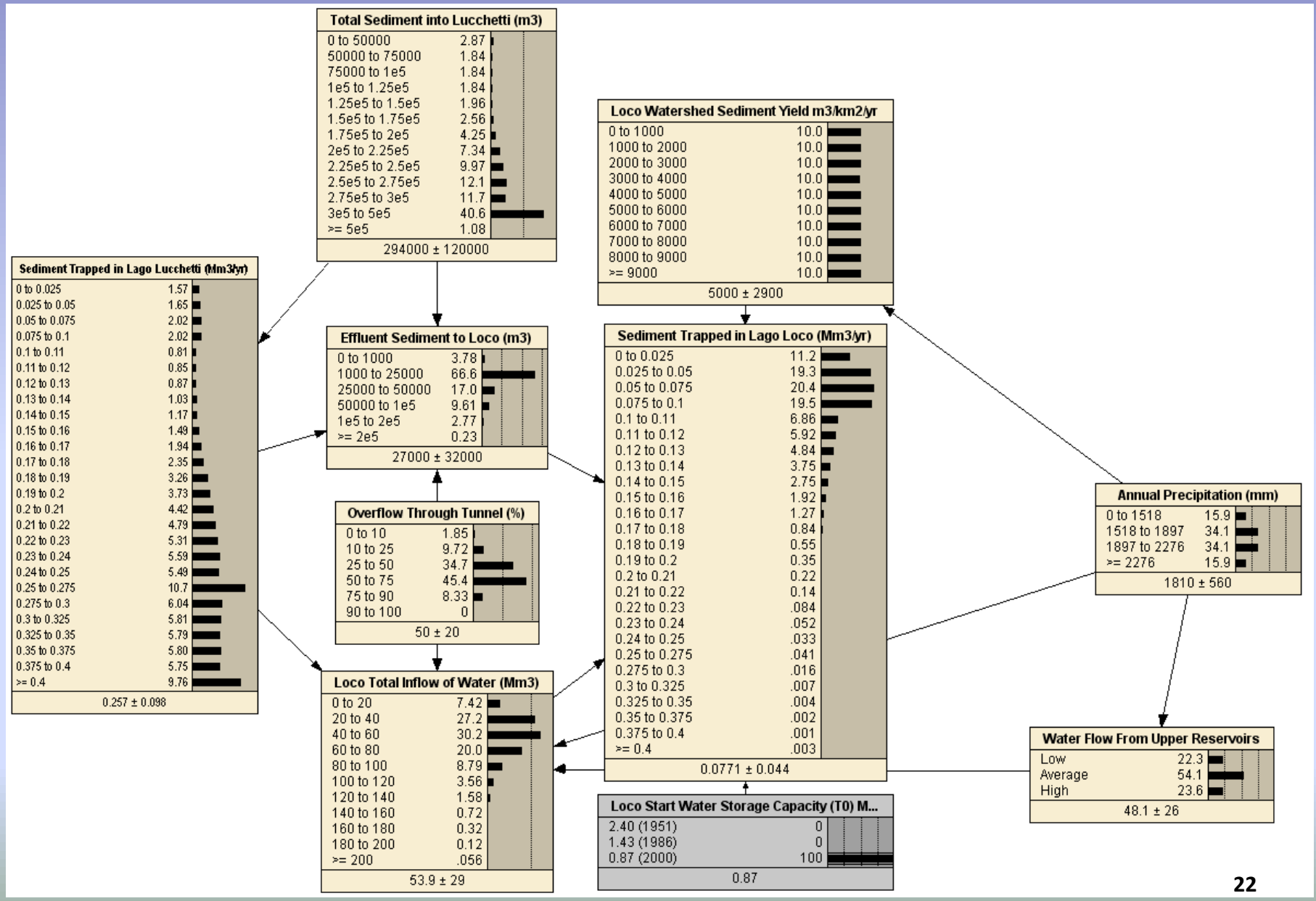


Consequence Table

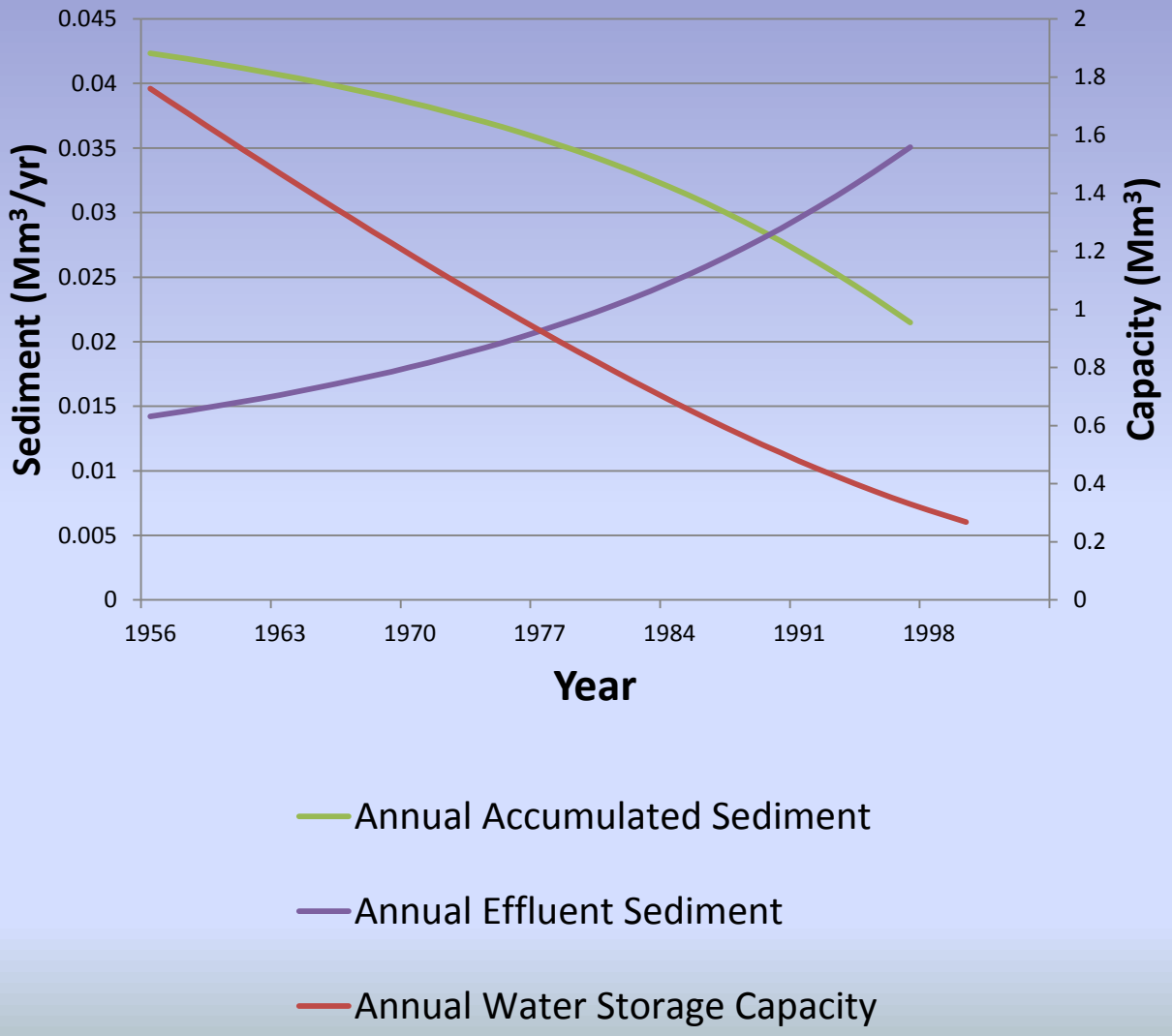
Management Scenario	Effluent Sediment ($x10^5$ m^3/yr)	Reservoir Expected Life (Years to 0)	Coffee Soil Loss ($x10^5$ m^3/yr)
Status Quo	2.46 ± .54	48.0 ±17	5.07 ± 1.5
Partial Coffee	2.34 ± .55	51.6 ±17	3.91 ± 1.0
Full Coffee	2.19 ± .56	56.0 ±18	2.50 ± 1.0
Dredge Only	2.45 ± .54	70.6 ±23	5.07 ± 1.5
Dredge & Partial Coffee	2.33 ± .54	75.7 ±23	3.91 ± 1.0
Dredge and Full Coffee	2.18 ±. 56	81.3 ±22	2.50 ± 1.0

Dredging is most effective for extending reservoir life expectancy
Conversion of coffee is most effective for control of soil loss

Next Step: Extending the Model to Rio Loco



Sands of Time



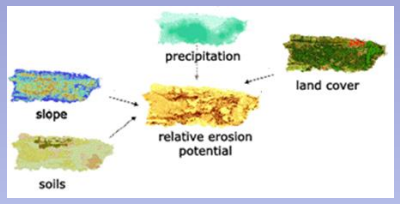
Scenarios

Decisions

Sun-Grown → Shade-Grown Coffee

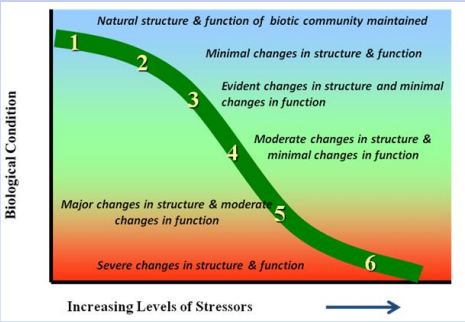
Stressors

Models of sediment delivery



GSSHA

Coastal ecosystem



-Coral
-Seagrass
-Mangroves

Scenario Evaluation

Effects of decision options on stakeholder objectives:

Tourism economy
Fishing economy
Agricultural economy
Human health
Recreational opportunities
Hazard protection
Ecosystem integrity

Ecosystem Services

ES Production Functions
Coastal & Terrestrial


Thank You