Coupling SWAT with land cover and hydropower models for sustainable development in the Mekong Basin

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Mekong Flows

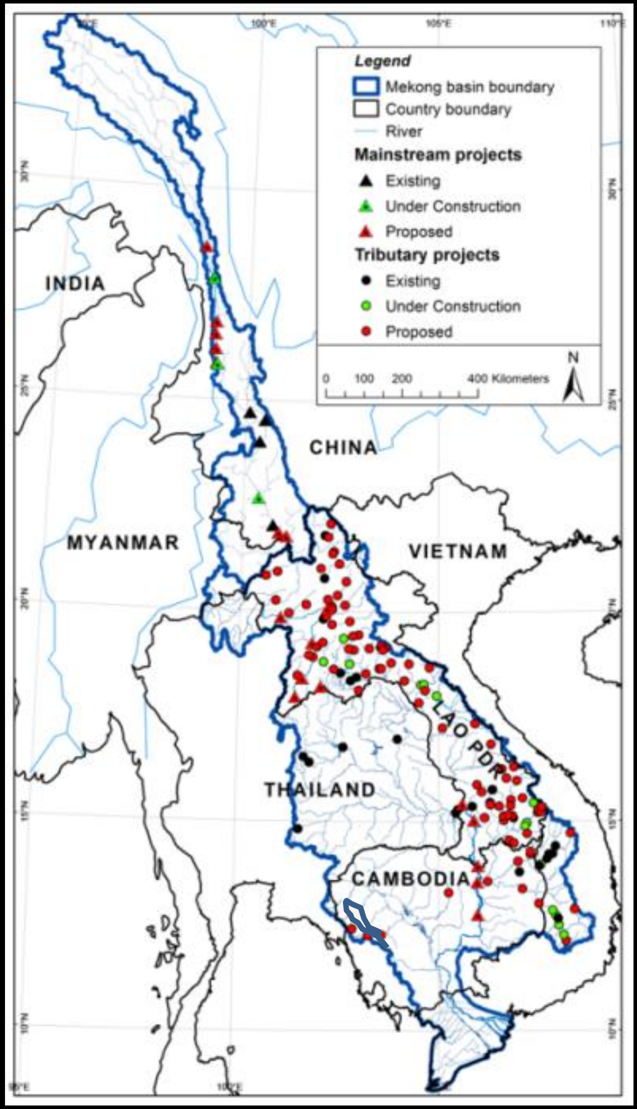
Outline

1. Overview of the Mekong and the 3S
2. Modeling approach
3. Methodological challenges and solutions
4. Results
   a. Land cover change
   b. Baseline river flows and sediment loads
   c. Deforestation effects on sediment loads
   d. Hydropower alterations and sustainable alternatives

The Mekong: context & challenges

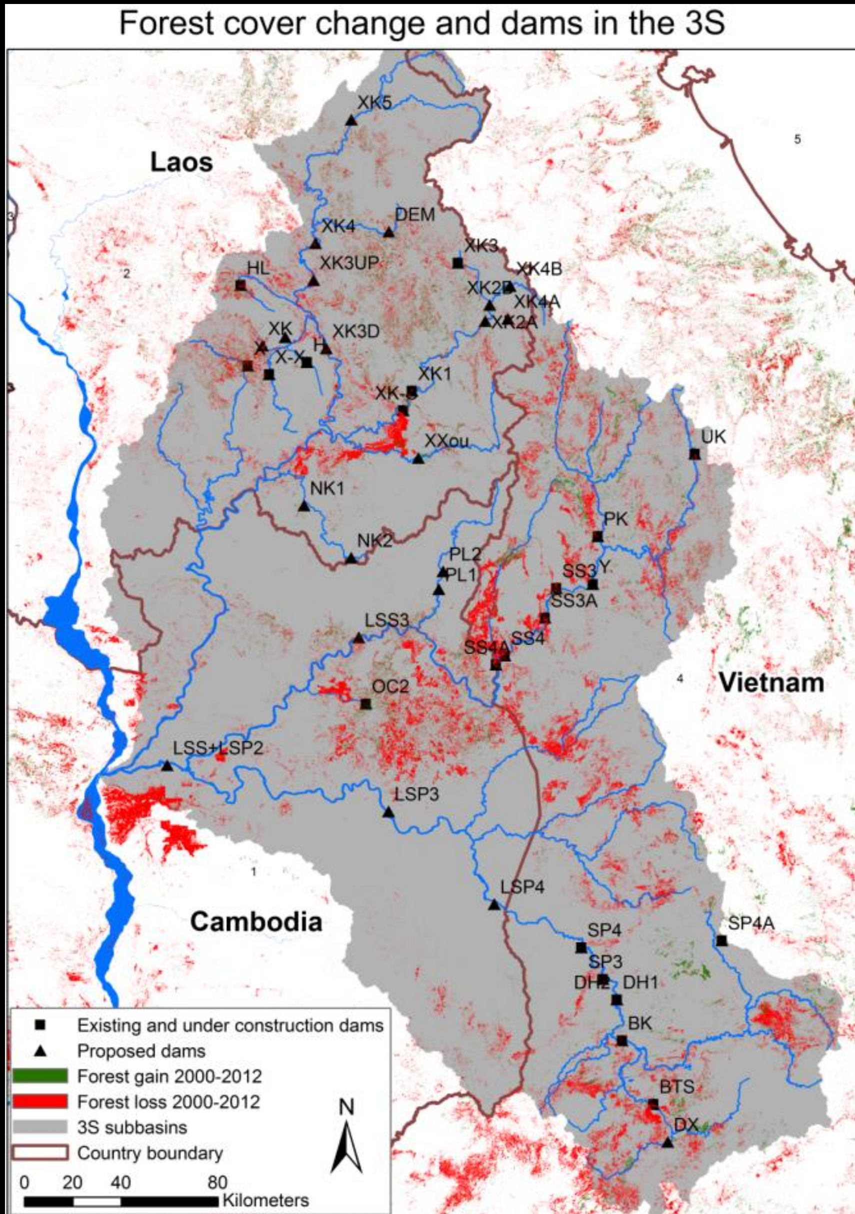
- Largest transboundary river in Southeast Asia
  - Basin area:795,000 km^2
  - River length: 4,200 km
  - Discharge : 14,500 m^3/s
  - Livelihoods/ecosystems adapted to unregulated hydrological cycle
  - Biodiversity hotspot

- Mekong challenges
  - **<u>Hydropower</u>**
  - Irrigation
  - Land use change
  - Changing climate



Case study: Sekong, Sesan, and Srepok Rivers

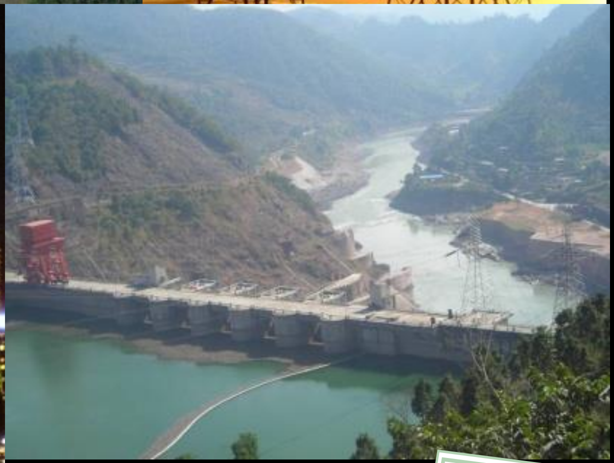
- Largest tributary contribution to the Mekong River (17-20%)
- Basin area: 78,650 km^2
- Hydropower development and deforestation are accelerating
- A transboundary river shared between Lao PDR, Cambodia and Vietnam
- Closest tributary to floodplain and delta
- Important contribution of aquatic biodiversity and ecosystem services: fish, habitats, and migration routes



Forest change data from Hansen et al. 2013. Map by Mauricio E. Arias (mauricio.arias@canterbury.ac.nz







Maximize Hydropower Benefits

Maximize Basin Benefits

Modeling approach

Land cover change

- Dinamica
- Weight of Evidence / cellular automata
- 250-m grid cells
- Forest cover maps

Surface hydrology and erosion

- SWAT
- Curve number / USLE
- 2,282 hydrological response units
- Daily water flows and sediment loads

Dam operations and reservoir water routing

- HEC-ResSim
- 1-D river hydraulics
- 41 reservoirs/106 river reaches
- Daily regulated river flows

Reservoir sediment trapping and routing

- SedSim
- Daily mass balance
- 41 reservoirs/106 river reaches
- Daily dam trapping and sediment loads

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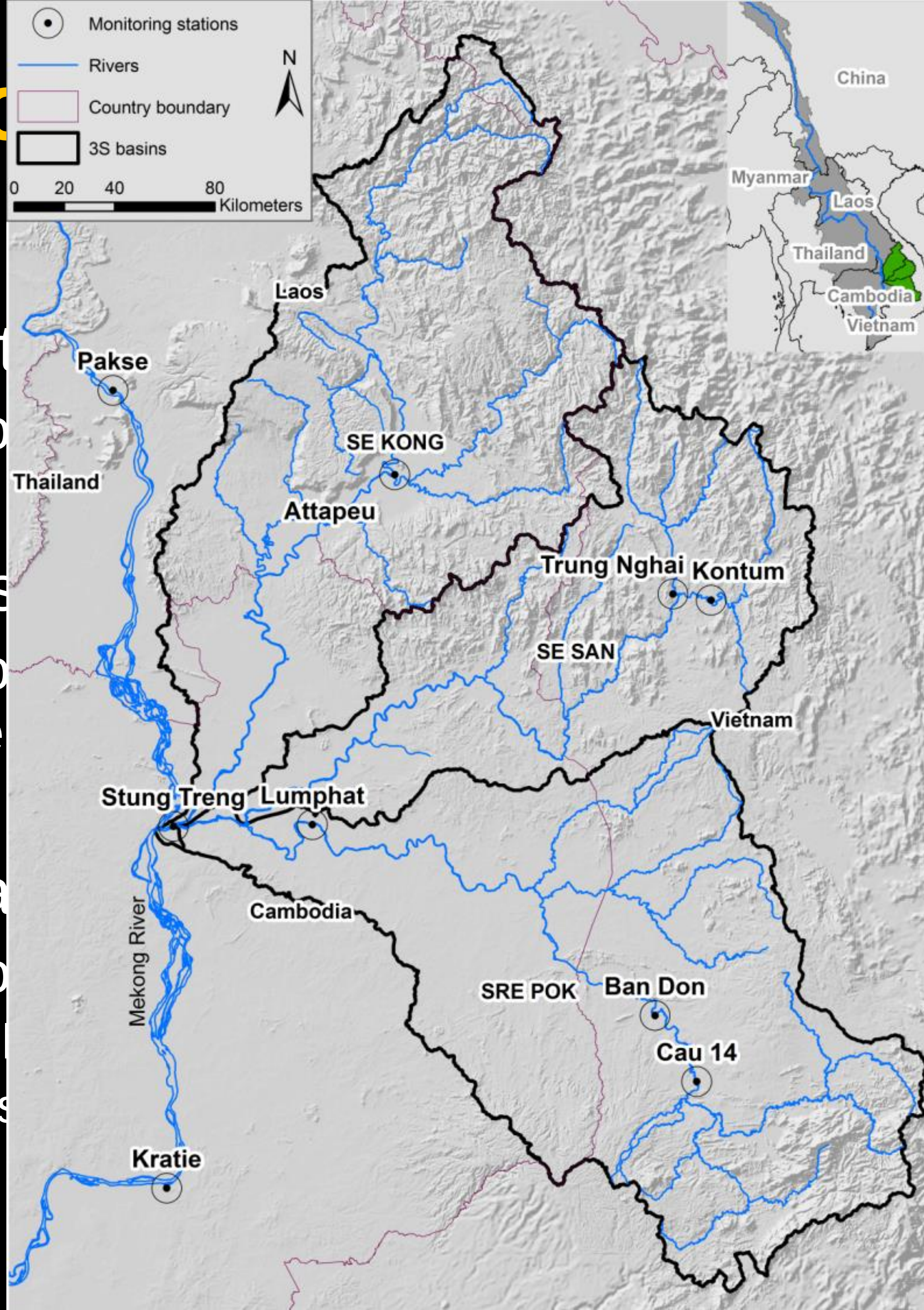
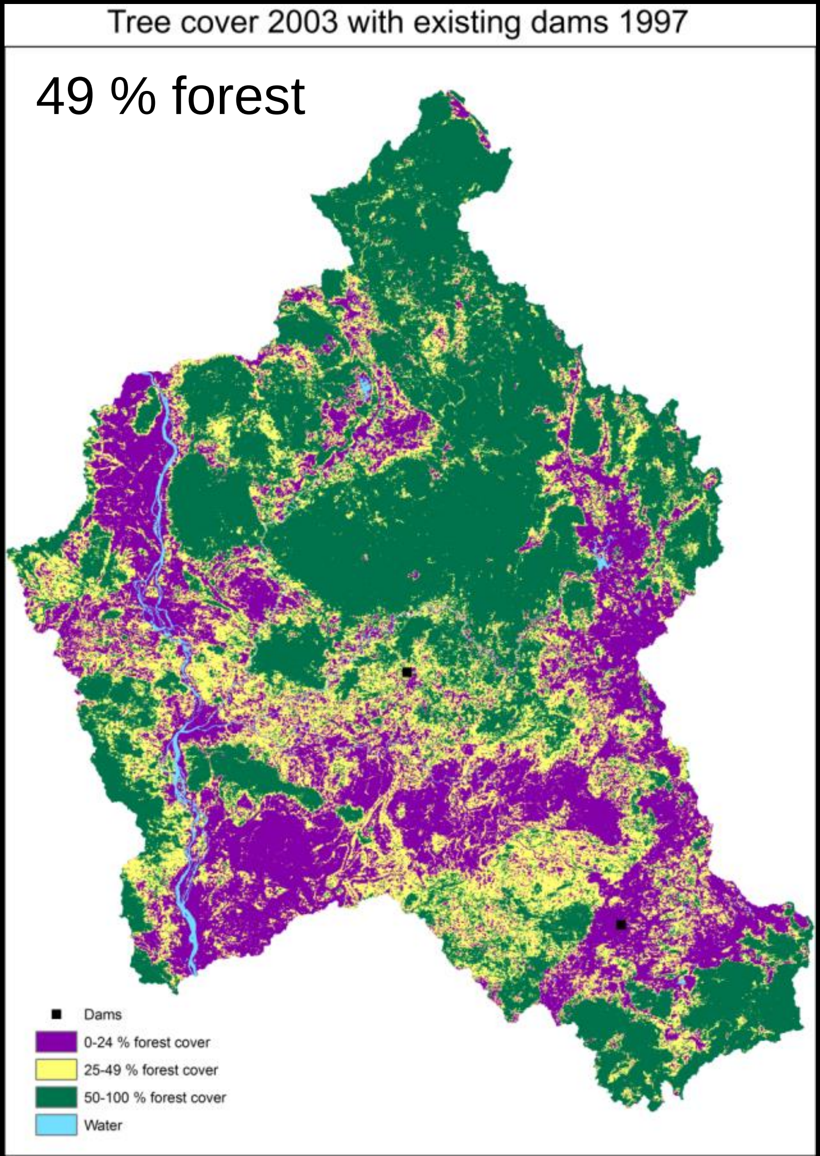
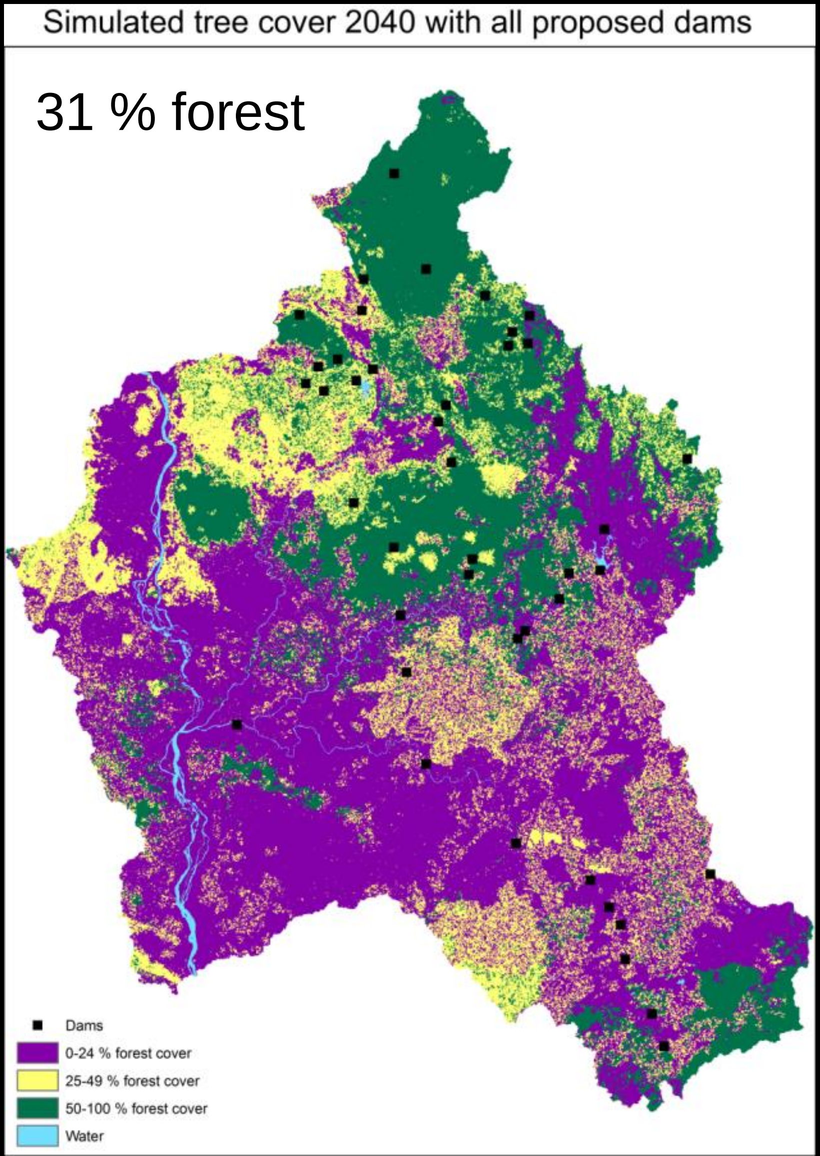
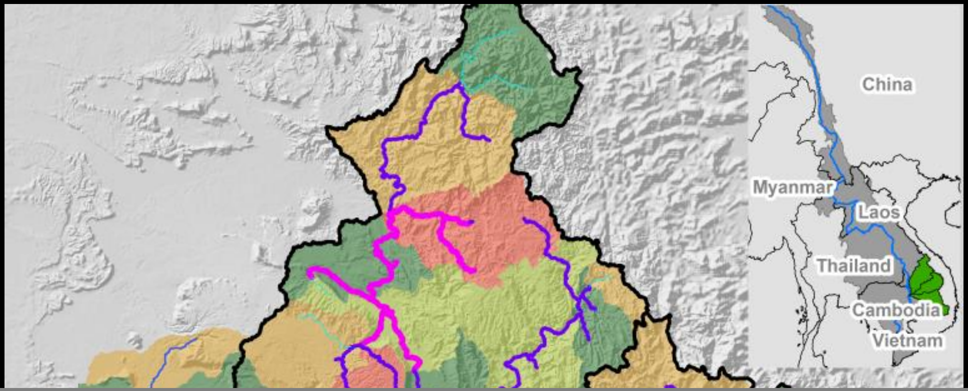


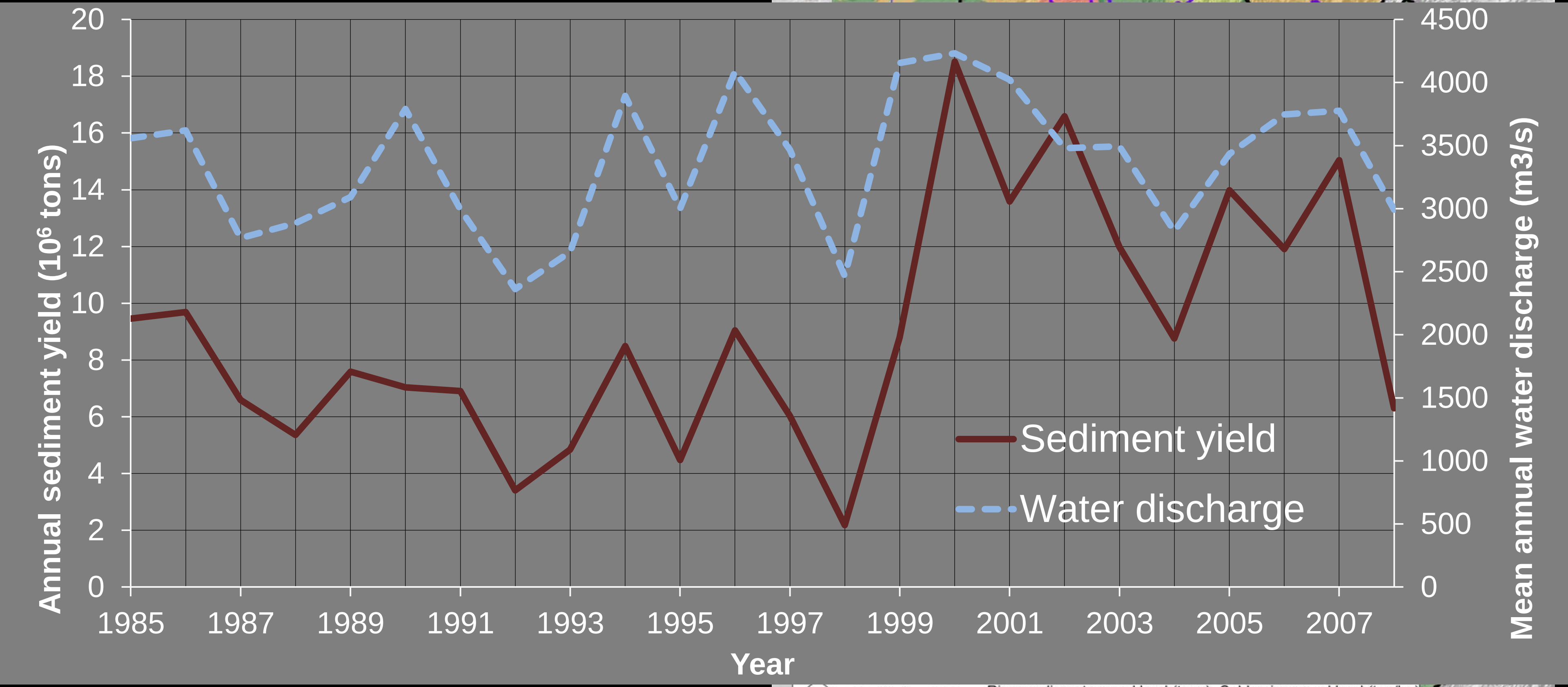
Land Cover Change



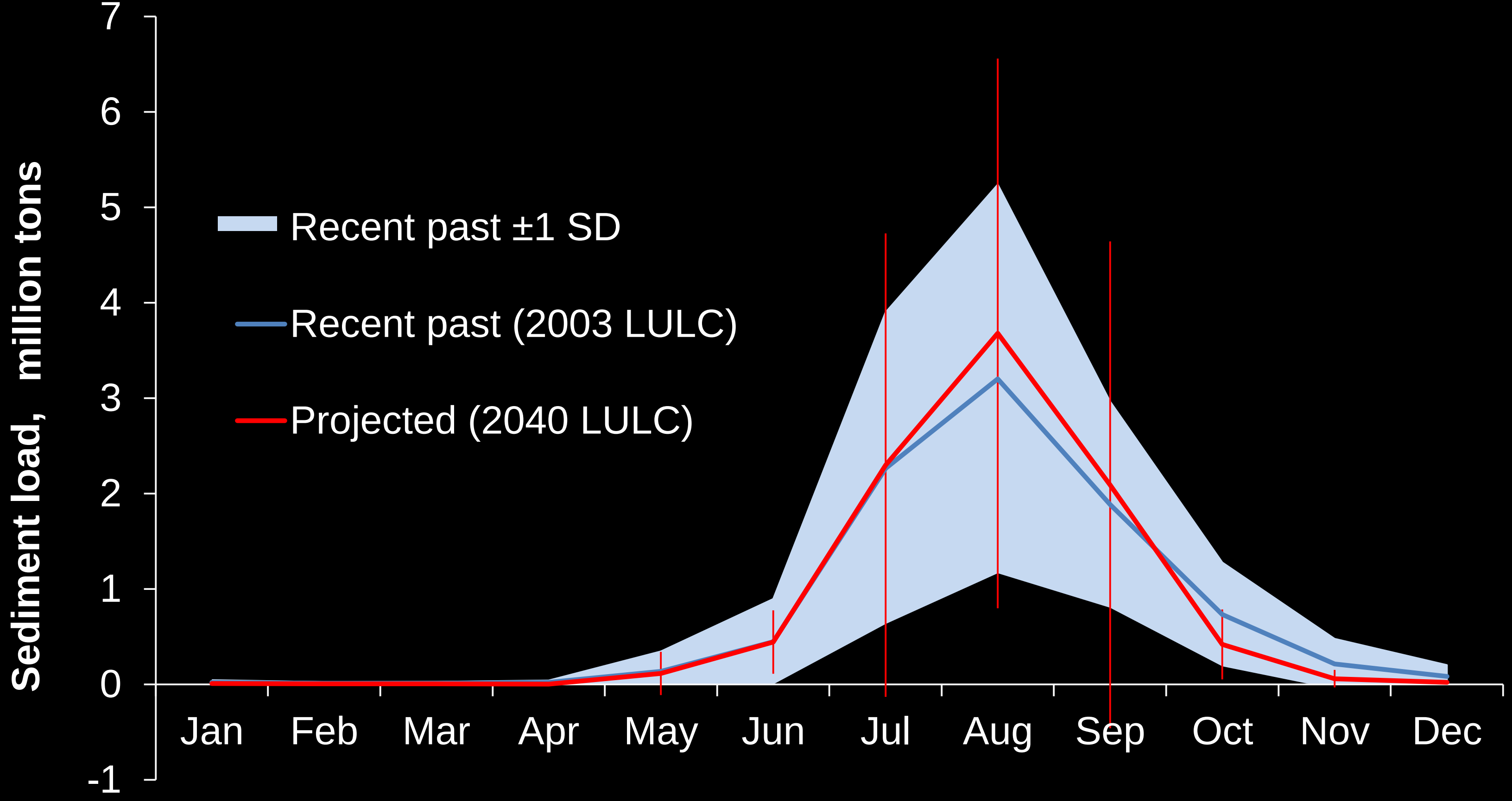


Sediment Yields

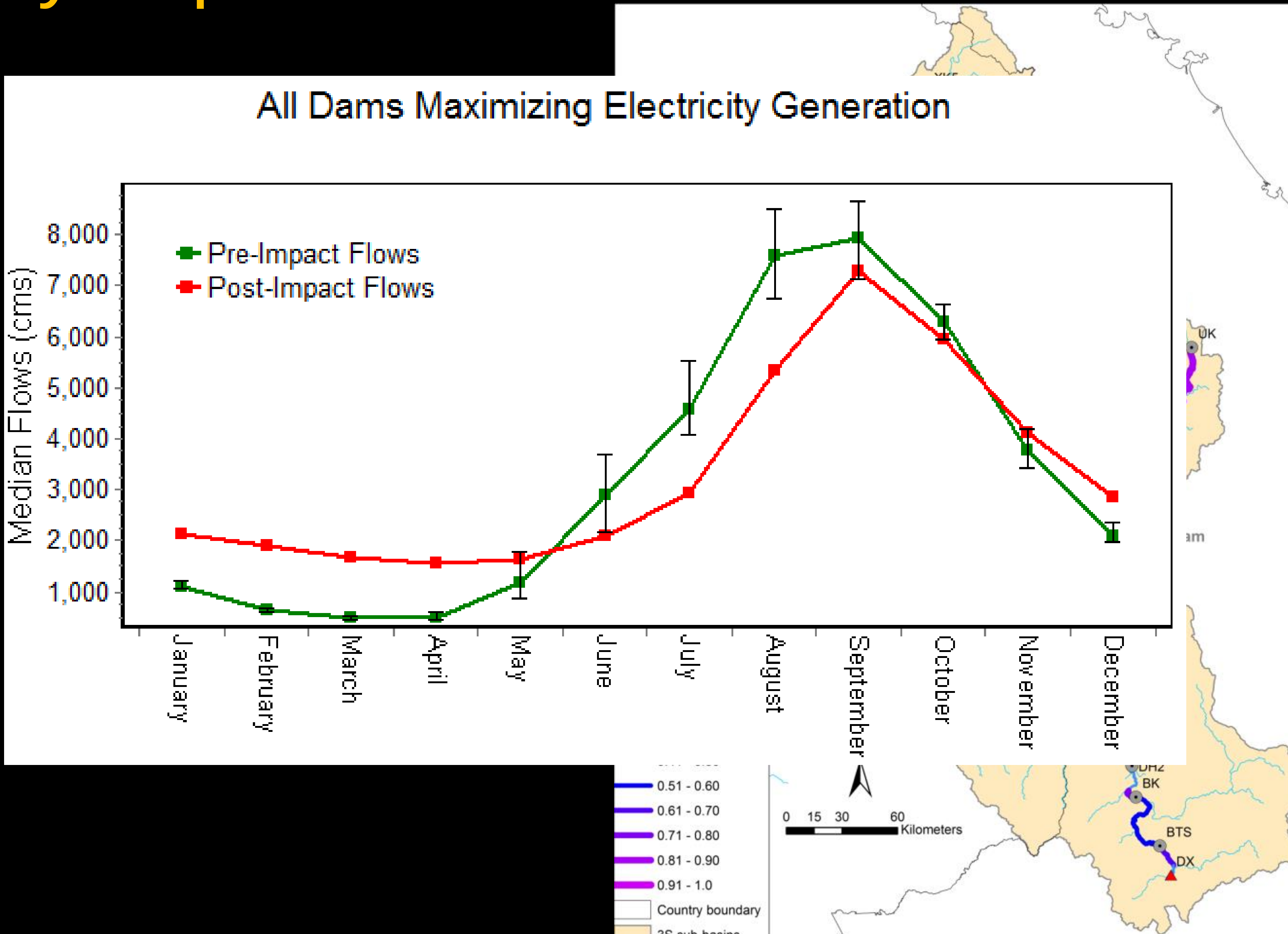




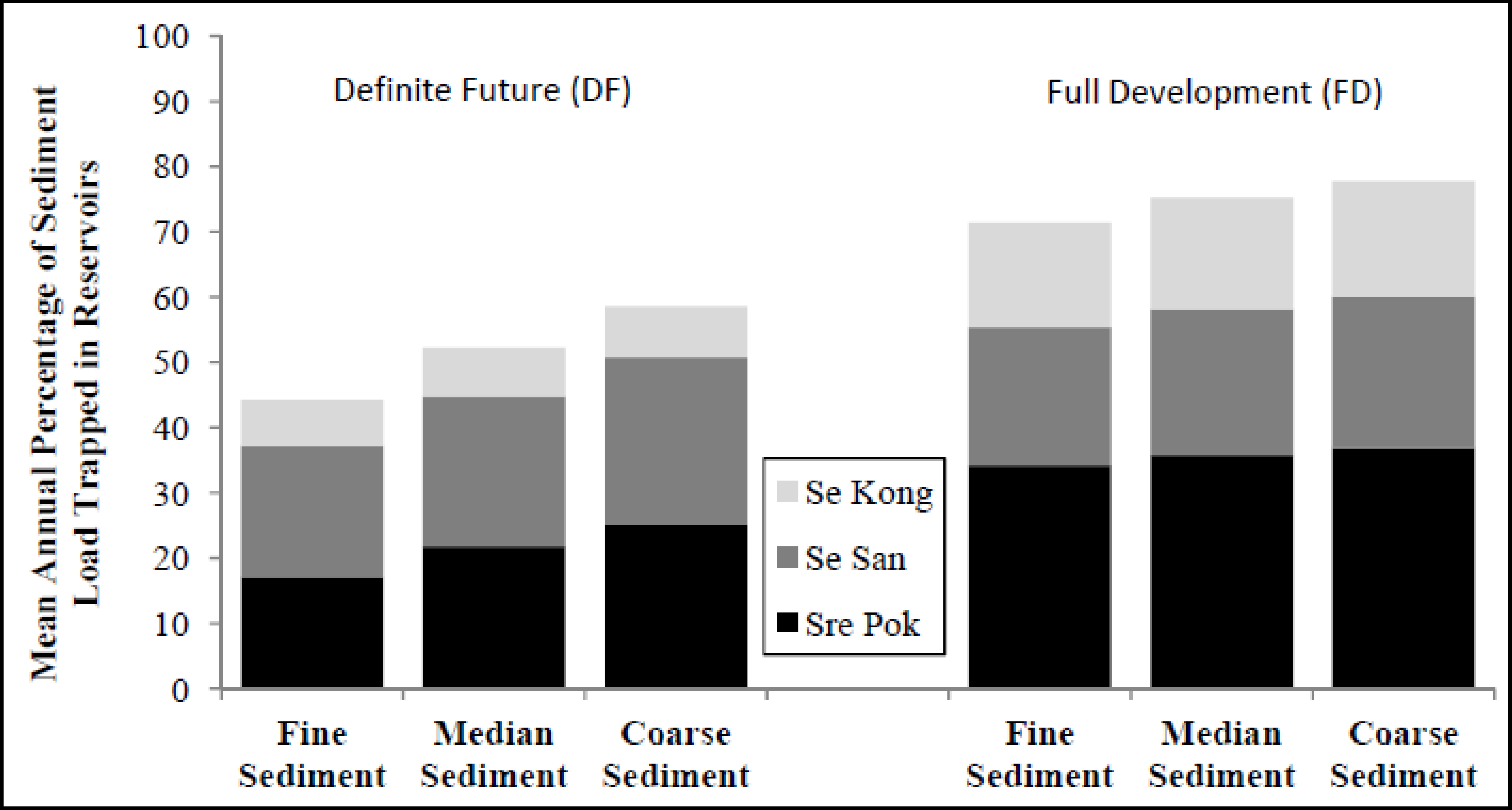
Land Cover Change Effects on Sediments



Hydropower Effects on River Flows



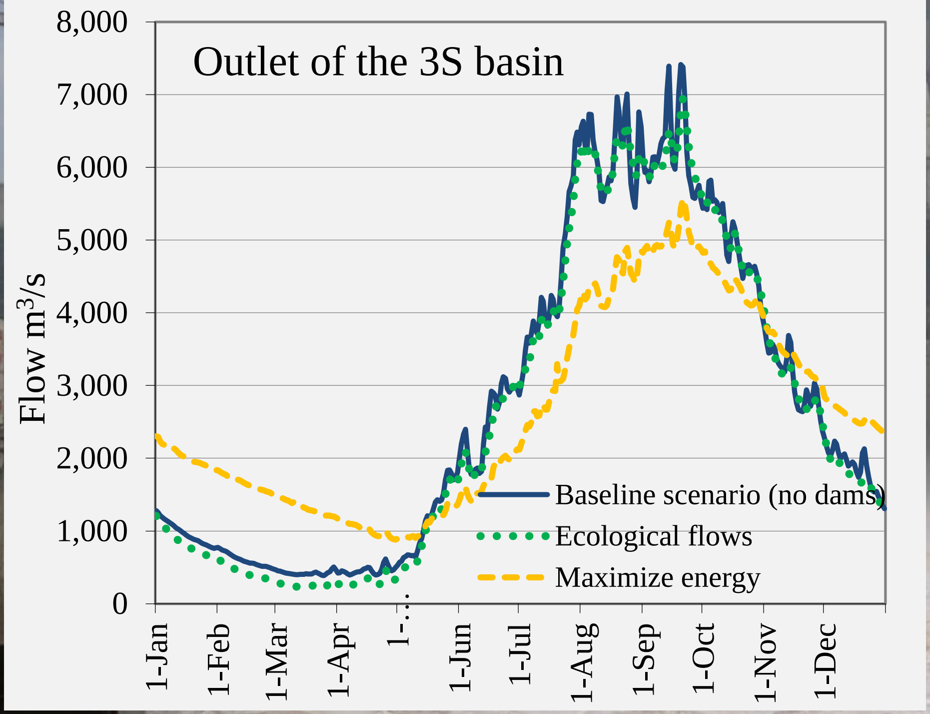
Hydropower Effects on Sediments



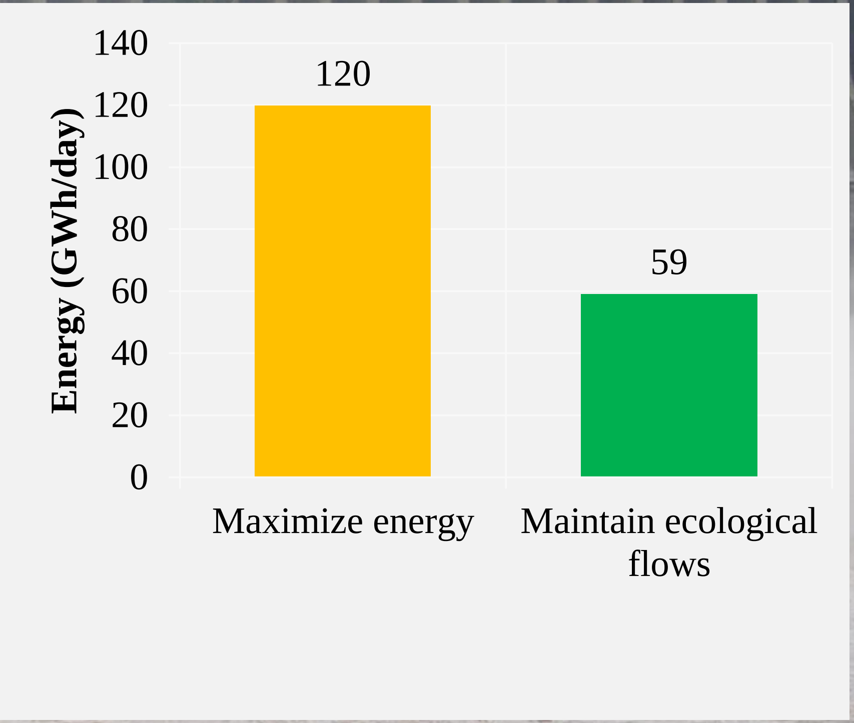
From Wild and Loucks (2014). Water Resources Research

Sustainable Hydropower Alternatives: Environmental Flows

Downstream water flows



Energy output



Need to find the optimal operation regime to balance energy production and downstream ecosystem services

Conclusions

- Forest cover expected to decrease from 50 to 31% by 2040
- Large temporal and spatial variability in sediment loads
- Construction of all dams would increase dry flows by 63% and decrease wet season flows by 22%
- Dams could trap 40-80% of annual sediment load
- Mitigation strategies:
  - Catchment protection through Payment for Ecosystems Services
  - Establishment of ecological flow criteria
  - Sediment release mechanisms

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- Collaborators: Aalto University, EIA Ltd Finland, University of Washington, National Heritage Institute

MacArthur Foundation

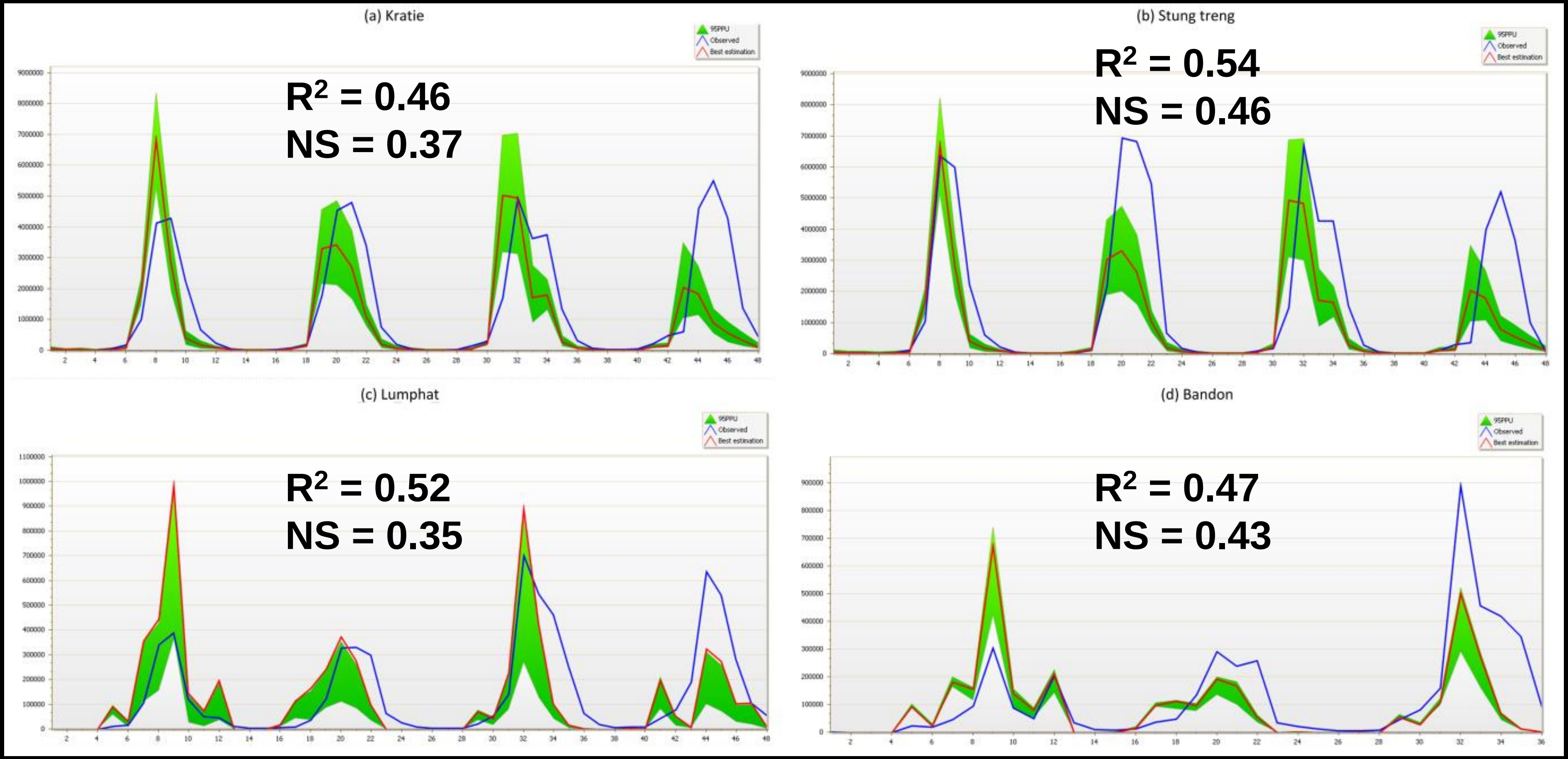
CONSERVATION INTERNATIONAL

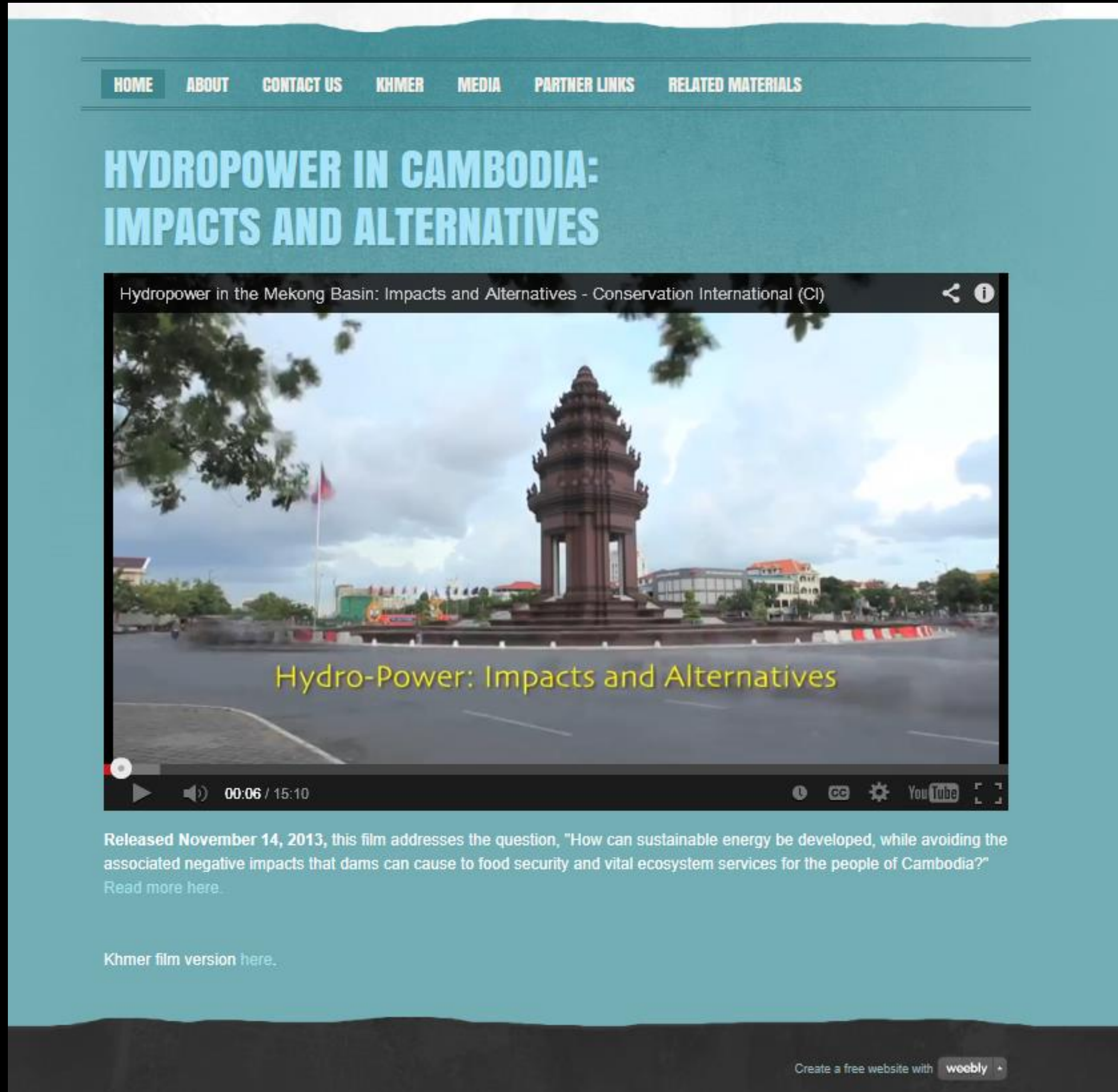
- EVERYONE HERE!

SWAT water flow calibration/validation

			Calibration period (1985-2000)		Validation period (2001-2005)	
Monitoring station	**River**	**Mean annual flow**	**NS coefficient of efficiency**	**Vol ratio (computed /observed)**	**NS coefficient of efficiency**	**Volume ratio (computed /observed)**
Kratie	Mekong	13040	0.97	1.00	0.96	0.99
Stung Treng	Mekong	12548	0.97	1.01	0.96	1.00
Lumphat	Srepok	740	0.60	0.94	0.59	1.16
Attapeu	Sekong	426	0.54	1.01	0.64	0.95
Bandon	Srepok	278	0.64	1.03	0.53	1.12
Cau 14	Srepok	250	0.63	0.99	-	-
Trung Nghai	Sesan	132	0.47	1.00	-	-
Kontum	Sesan	96	0.41	1.01	0.42	1.21

Sediment load calibration





http://cambodiahydropower.weebly.com/