Modelling biodiversity impacts from hydropower in LCA

MSc. Erik Olav Gracey

Dr. Francesca Verones

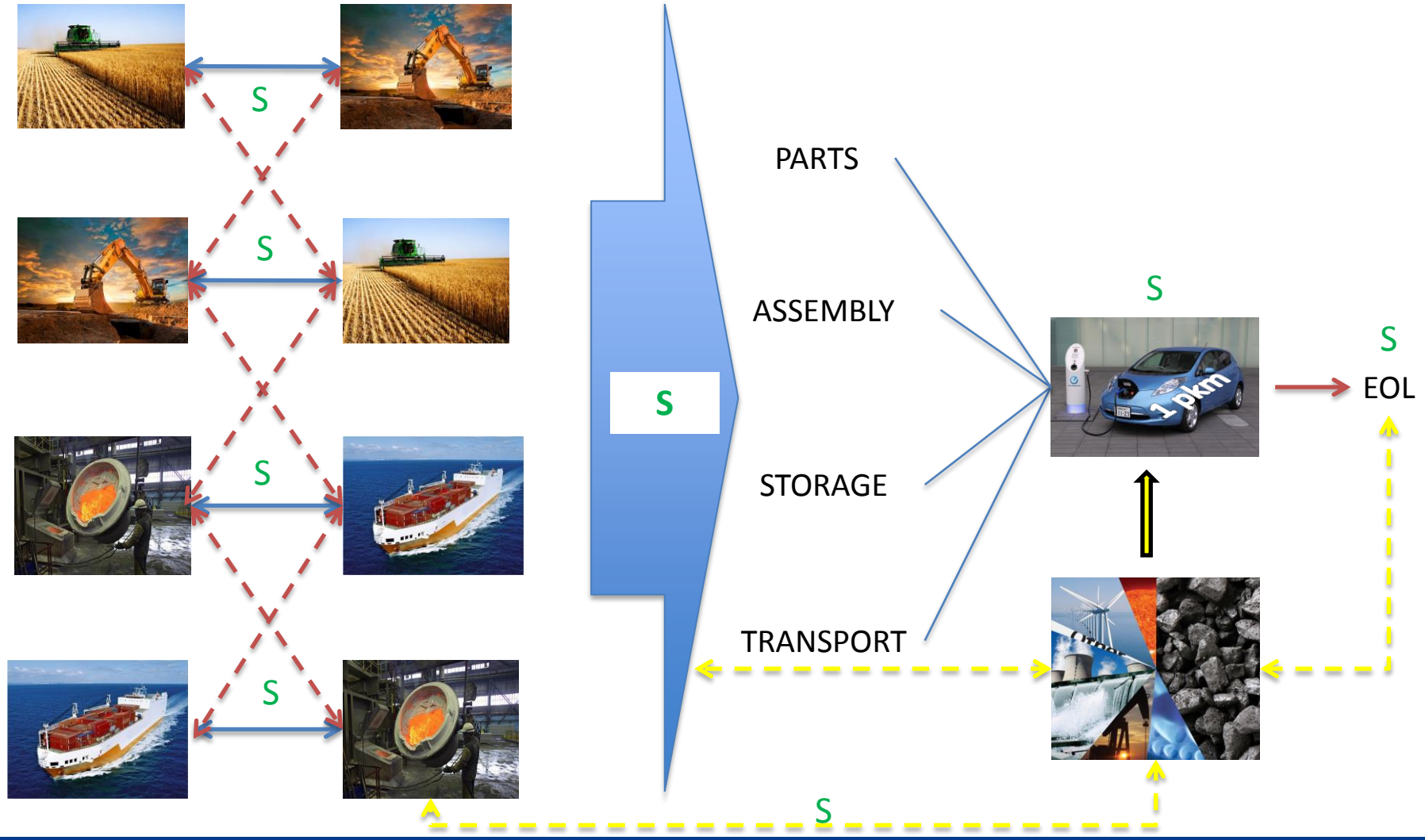
Norwegian University of Science and Technology

Agenda

- Introduction to life cycle assessment
- Life cycle impact assessment (LCIA)
- Freshwater biodiversity and hydropower
- LCIA terrestrial/riparian example
- LCIA aquatic example
- Improving LCIA of hydropower

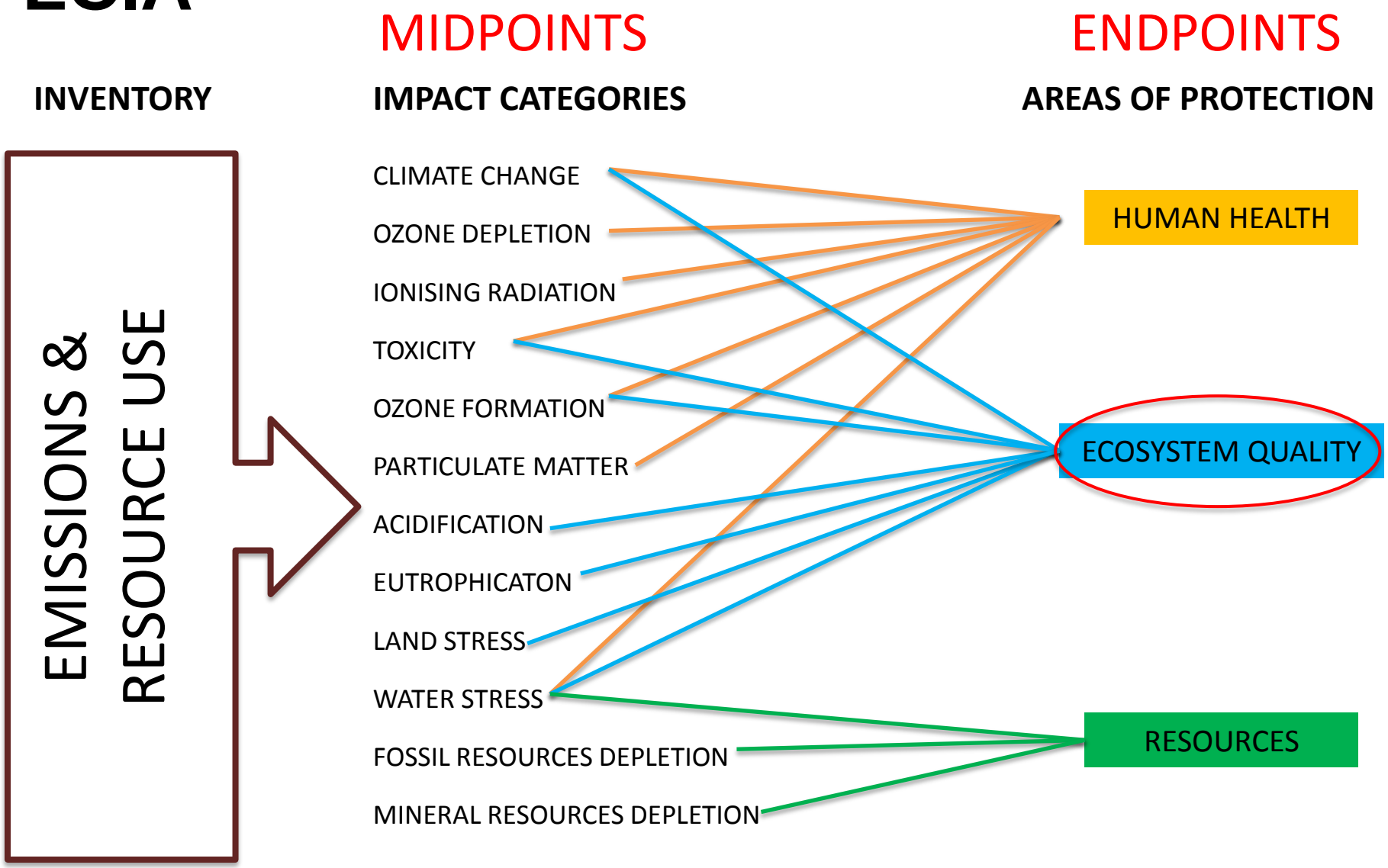
Local production, global impacts

Life Cycle Assessment



http://agriculturalrev.weebly.com/effect-on-modern-agriculture.html; http://www.mecaracking.com.au/industries/Mining
http://www.theguardian.com/business/2009/dec/07/rusal-flotation-aluminium-russia-deripaska; http://blogs.ucl.ac.uk/chemdeptblog/2012/10/15/global-energy-mix-in-2050-scenarios-policies-cps-lecture-2;
http://www.extremetech.com/extreme/136894-will-high-mileage-nissan-leafs-need-costly-battery-replacements-soon; http://www.cccme.org.cn/shop/bsigroup/product---17.aspx

LCIA


MIDPOINTS
ENDPOINTS
INVENTORY
IMPACT CATEGORIES
AREAS OF PROTECTION
EMISSIONS & RESOURCE USE
CLIMATE CHANGE
OZONE DEPLETION
IONISING RADIATION
TOXICITY
OZONE FORMATION
PARTICULATE MATTER
ACIDIFICATION
EUTROPHICATON
LAND STRESS
WATER STRESS
FOSSIL RESOURCES DEPLETION
MINERAL RESOURCES DEPLETION
HUMAN HEALTH
ECOSYSTEM QUALITY
RESOURCES

When to use LCA

✓ *Suited for*

- Finding improvement potentials (weak points)
- Comparison of env. performance of different products (with the same function, e.g. EPDs)
- Scenario comparisons for finding optimal strategies

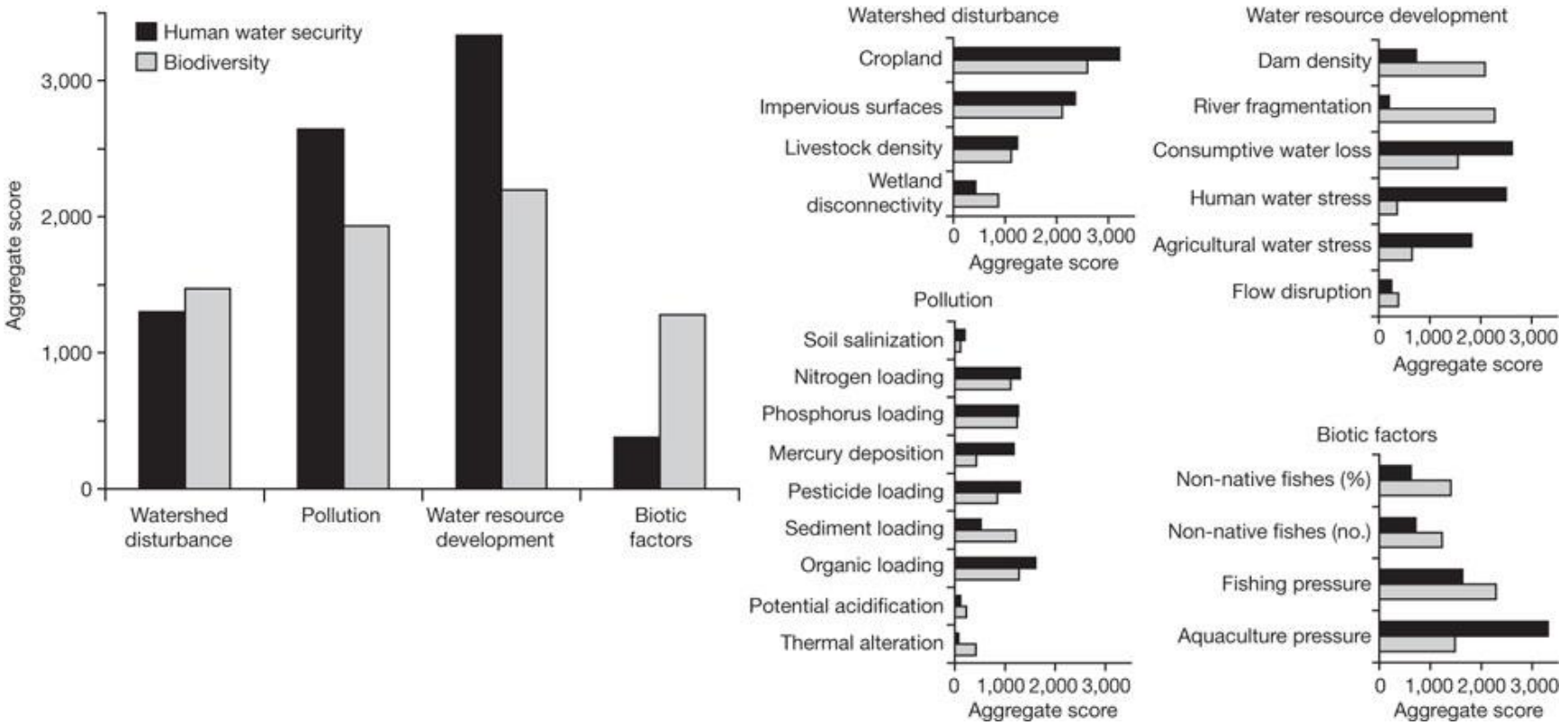
✓ *NOT suited for*

- Answering questions with only one material
- Rating of env. performance of just one company
- Pulses of emissions (e.g. chem spills)

Hydropower impacts and LCIA

	Impact compartment	
	Terrestrial	Aquatic
✓ Reservoir GHG emissions	✓	✓
✓ Dam construction	✓	✓
✓ Transmission	✓	
✓ Inundation	✓	✓
Altered flow regimes	✓	✓
Altered sediment flows	✓	✓
Altered thermal regimes		✓
Connectivity	✓	✓

The state of river biodiversity

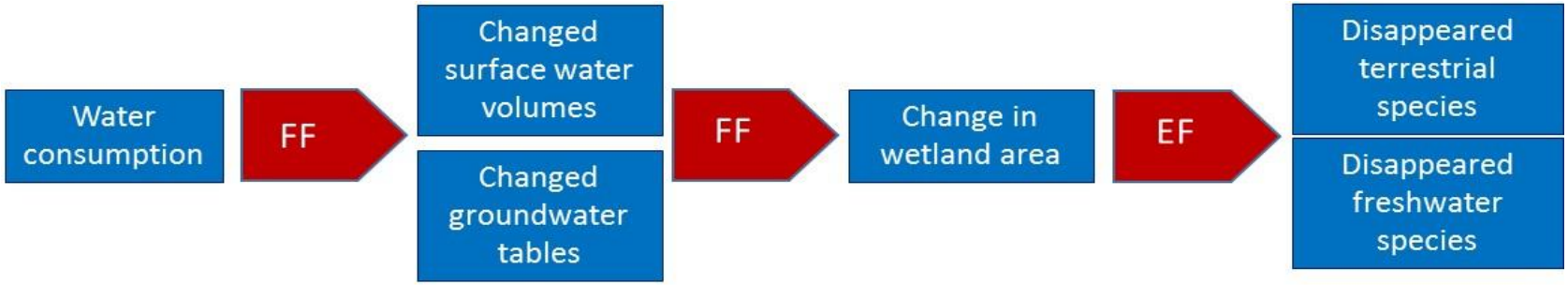


CJ Vörösmarty *et al. Nature* **467**, 555-561 (2010) doi:10.1038/nature09440

Quantifying biodiversity impacts in LCA, example: Water stress impacts on wetlands

- Taxa covered: Birds, mammals, amphibians, reptiles & vascular plants

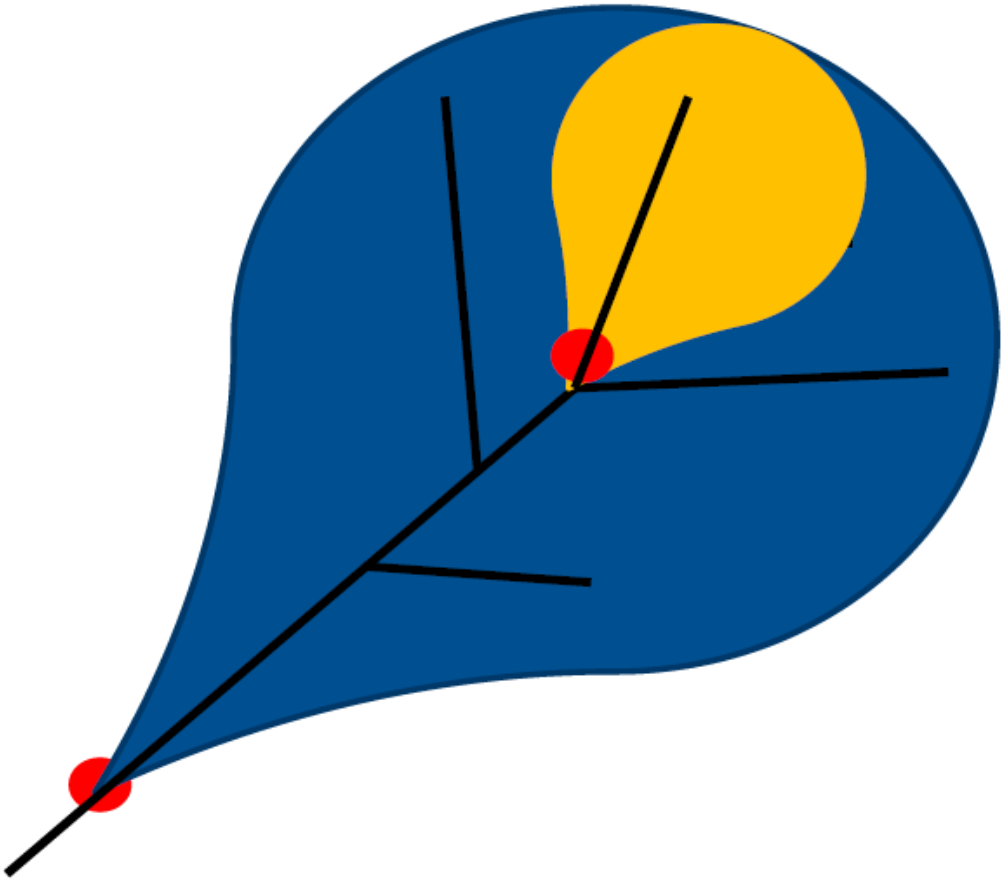
$$CF_{end,i,t} = \sum_{i,k=1}^{n} FF_{k,t} \cdot EF_{k,t}$$



$$FF_k = \frac{\left(A_{reported,k} - A_{new,k}\right)}{x_k}$$

$$EF_{k,t} = \frac{S_{lost,k,t}}{A_{reported,k} - A_{new,k}} \cdot VS_{k,t} \cdot CpA$$

Water stress CFs wetland taxa



Aquatic example….Fish and EPT

- Based on species discharge relationships (SDR) for different zones in a watershed

$$FF_i = \frac{dQ_i}{dW_j}$$

Flow metrics frequency, duration, timing and rate of change are not addressed

$$EF_i = dSDR_i \cdot RF_i \cdot TS_i$$

Species richness is the only indicator of biodiversity

$$dSDR = \frac{dSR_i}{dQ_i}$$

Connectivity and thermal pollution from hypo / epilemnitic releases are not addressed

$$CF_j = \sum_{i=j}^{mouth} FF_i \cdot EF_i$$

All CFs for water stress are currently designed for water **consumption**, not specifically hydropower

Tendall et al., 2014

Improving LCIA of hydropower

- Create CFs for turbined water
  - e.g. Ecological limits of hydrologic alteration (ELOHA)

- Fate and effect factors for flow must have a space and time dimension

- CFs for fragmentation, changes to thermal regime and cumulative effects must be developed

- Normalize for comparison with other EL technologies

Questions

http://www.dartmouth.edu/~jacko/v2/2014/01/an-interview-with-the-man-who-can-only-speak-in-questions/