Ensuring that Environmental Flows from Dams will Sustain Biodiversity

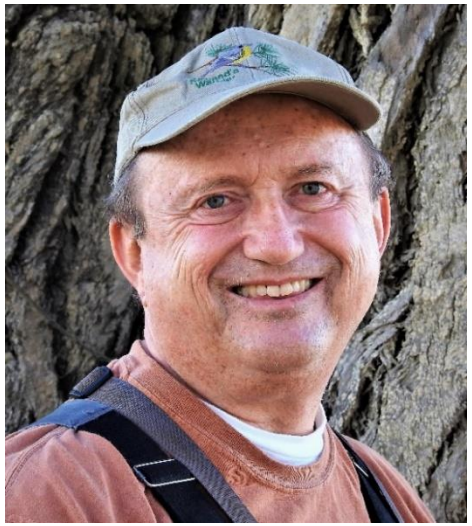
George C. Ledec, Ph.D.

World Bank Lead Ecologist (Retired)

United States

Email: **gcledec@gmail.com**

Phone: +1-703-346-8368



Aquatic Biodiversity at Great Risk Worldwide

- **The Other Global Environmental Crisis: Biodiversity Loss (rapid, irreversible).**
  - **Biodiversity is the variety of life on Earth, including different ecosystems, species, and genes.**
  - **Biodiversity sustains people and livelihoods; underpins key ecosystem services.**
- **Freshwater Biodiversity at Greatest Risk:**
  - **Pollution (excess nutrients, sediment, toxics)**
  - **Overharvest--direct and incidental take**
  - **Invasive non-native species (e.g. Lake Victoria)**
  - **Water abstraction and diversion**
  - **Dams: Inundation, waterway fragmentation, and flow regulation**

E-flows: Key Tool for Conserving Downstream Biodiversity

- **Main Tools for Conserving Biodiversity with Hydropower, other Dams:**
  - **Site selection: Upstream inundation; consider river segments to protect.**
  - **Upstream reservoir and catchment management.**
  - **Off-site compensatory measures (biodiversity offsets).**
  - **Environmental Flows to manage downstream impacts!**

- **Applies to all water storage dams: Hydropower, irrigation, water supply, multi-purpose (where any control of flows).**
- **Multiple objectives for downstream water releases (power generation, irrigation, water supply, pollution and sediment management, other downstream uses)--Biodiversity must also be factored in (as an objective or a binding constraint).**

E-flow Type #1: Enough Water in Dry Periods

- What many people think "environmental flows" means: Not letting the river run too dry.
- For water supply, irrigation, or multi-purpose dams (consumptive water uses), concern might cover entire downstream waterway.
- For hydropower projects, largely a risk for de-watered stretches (dam wall to tailrace) or diverted tributaries.
- Example: Yacyreta (Argentina-Paraguay)--Ana Cua Branch of Parana River (~25 km to become dry most of year):
  - Initial solution: E-flow equivalent of turbines down for maintenance (2 of 20).
  - Longer-term solution: Install turbines for e-flow generation.
- Dry season "base flow" typically not enough year-round to maintain downstream biodiversity.
  - Most aquatic life cannot survive if low-flow (high stress) periods become year-round (analogous to year-long winter in northern regions).

E-flow Type #2A: Enough Seasonal Variation: Wet enough in the Wet Season

Enough Water in Wet Season to maintain Biodiversity including:

- **Floodplain forests.**
- **Lakes, lagoons, marshes, seasonal wetlands.**
- **Floodplain grasslands.**
- **River islands with successional vegetation.**
- **Reproductive cycles of fish and other aquatic life: Flow pulses stimulate breeding or migration).**

E-flow Type #2B: Enough Seasonal Variation: Dry enough in the Dry Season

- **Biodiversity also needs: Not too much water in dry season!**
- **Key habitat features needing low(er) dry season flows:**
  - **Sandbars, gravel bars, shingle: Nesting and resting habitat for many birds, turtles, other wildlife.**
  - **Emergent boulders, rocky outcroppings: Rare plants (seasonally submerged), specialized birds (Rock Pratincole), other wildlife.**
  - **Seasonal pools: Important for amphibians, aquatic insects, other wildlife.**

E-flow Type #3: Peaking Flows within Acceptable Limits

- **Peaking Power Generation:** Twice-daily fluctuations in downstream flows, corresponding to electricity demand (morning & evening peaks).
- **Freshwater biodiversity adapted to seasonal changes** in water flows and levels—**not daily ones** (unlike coastal, tidal systems).
- **Run-of-River (baseload) flows preferable** from biodiversity standpoint.
- Options for **making peaking more biodiversity-friendly**:
  - **Keep peaking ratios low** (about 2 to 1 or less). Example: Uganda Bujagali.
  - **Choose lower conservation value waterways and compensate** for the losses. Example: South Africa Ingula Pumped Storage with Biodiversity Offset.
  - Build **regulating dam** to absorb peaking flow variation. Example: Malawi Mpatamanga (will replicate run-of-river flows to protect Majete Wildlife Reserve, Elephant Marsh; also downstream farming).

E-flow Type #4: Flow Changes Not Too Abrupt

- **Abrupt flow changes—during peaking generation, flushing or other maintenance, or equipment testing—can unnecessarily harm biodiversity:**
  - **Sudden flow drops can leave fish stranded (also human safety hazard).**
  - **Sudden flow increases can wash away and drown terrestrial wildlife (also livestock and people).**
- **Dam operating rules should specify more gradual flow release changes (ramping up & down).**

Assess (and Adjust) E-flows for the Most Sensitive Receptors

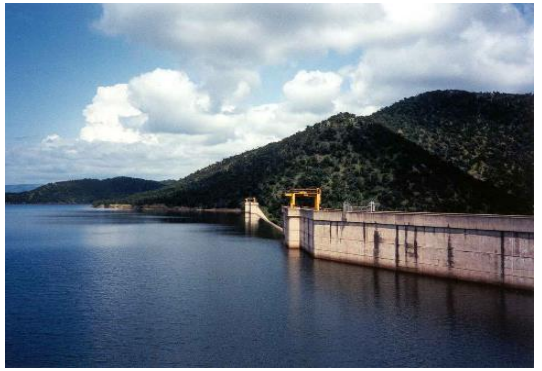
- **Aim to Keep Natural Habitat Features (that depend on sufficiently high or low flows):**
  - **Suitable conditions for these habitat features can be assessed and modelled, even when most species are not known.**
  - **Features to assess and monitor: Floodplain forests, lakes, lagoons, marshes, seasonal wetlands, floodplain grasslands, river islands with successional vegetation, sand and gravel bars, steep riverbanks, emergent boulders, rocky outcroppings, seasonal pools, mangroves.**
- **Focus on Species of Conservation Concern (Red List) or Special Management Interest:**
  - **Example: For Bisri Dam (Lebanon), most sensitive downstream fish are European Eel and Freshwater Blenny.**
  - **Treat Data Deficient species with precautionary approach.**

Making It Happen:
Project Planning, Design, Construction, Operation

- **Apply the Strict Standards now in place for Biodiversity in Hydropower:**
  - **WBG: PS6 (private sector projects) and ESS6 (public sector).**
  - **Other international and national requirements.**
- **Project (and River Basin) Planning: Express biodiversity-friendly E-flow plans (in ESMP/BMP/EFMP) as boundary conditions for dam operating rules:**
  - **Simple Example: Not less than X m3/s, nor more than Y m3/s, during [dry months] and not less than Z m3/s during [wet months].**
- **Project Design: Ensure dam design matches agreed E-flows.**
- **Project Construction: Supervise that dam built and tested per E-flows.**
- **Project Operation: Monitor (1) operating compliance and (2) biodiversity outcomes--with adaptive management.**
- **Need to turn E-flow agreements (ESMP/BMP measures) into binding requirements in Financing Agreement and other Legal Documents.**

E-flows and Biodiversity: Key Takeaways

- Aquatic Biodiversity at Great Risk Worldwide
- E-flows Key Tool for Conserving Downstream Biodiversity
- 4 Different Types of E-flows:
  - (1) Enough Water in Dry Periods
  - (2) Enough Seasonal Variation
  - (3) Peaking Flows within Acceptable Limits
  - (4) Flow Changes Not Too Abrupt



- Assess & Adjust E-flows for the Most Sensitive Receptors:
  - Habitat Features
  - Species of Concern
- Making It Happen: Project Planning, Design, Construction, Operation

Let’s continue the conversation!

Post questions and comments in the IAIA23 app.

IAIA23 KUCHING MALAYSIA

#iaia23

George C. Ledec, Ph.D.

World Bank Lead Ecologist (Retired)

United States

Email: **gcledec@gmail.com**

Phone: +1-703-346-8368