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Methods and tools for defining Environmental Flows

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The Nature Conservancy

GEF IW:LEARN Regional Workshop on Application of Environmental Flows in River Basin Management

February, 11-15, 2008

TOPICS

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1. Overview of methods for flow assessment

   a. What is an environmental flow assessment?
   b. Categories of environmental flow assessment methodologies
      - Hydrologic
      - Hydraulic rating
      - Habitat simulation
      - Holistic

2. Examples of practical applications
   - Ecologically Sustainable Water Management (ESWM)

3. Choosing the right method
   a. Advantages and disadvantages
   b. Fitting tools and approaches to the situation

Expected Outcomes

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- Understand what is an environmental flow assessment, when to use and why.

- Know the differences between the four categories of environmental flow assessment methodologies, the advantages and disadvantages of each by a real example application

- Being able to choose the right method based on the “pros and cons” and supported by your objectives.

Premises

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- Reconnaissance that the discussion of environmental flow assessment methodologies is based on the fact that the ecosystems are a beneficiary of the flow regime, in other terms, they are an “user” of the river.

- We need to quantify the ecosystems requirements, as well as other users requirements.

- Based on such requirements we will need to incorporate them into a real scenario to accomplish multiple water uses.

- We will have concrete elements to discuss priorities and **trade offs**.

1. Overview of methods for flow assessment

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What is an environmental flow assessment?

"*Is an assessment of how much of the original flow regime of a river should continue to flow down it and onto its floodplains in order to maintain specified, valued features of the ecosystem hydrological regimes for the rivers, the environmental flow requirements, each linked to a predetermined objective in terms of the ecosystem's future condition...*"

Source: Tharme, 2003

Developing environmental flows

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- Evolution of environmental flows assessment methodologies
- Tharme (2003) identified > 200 different methods
- Review of different methods
- Range from simple ‘rules of thumb’ to complex, multi-year processes integrating modeling and field data

1. Overview of methods for flow assessment

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Categories of environmental flows methodologies and examples

1. Hydrologic
   - Tennant
   - Q_{90}
2. Hydraulic rating
   - Wetted perimeter method
3. Habitat simulation
   - IFIM
   - PHABSIM
4. Holistic methods
   - Building Blocks Methodology (BBM)

Source: Tharme, 2003

1. Overview of methods for flow assessment

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- ***Hydrological* -** Primarily use hydrological data (historical monthly or daily flow records) for making e-flow recommendations for maintaining river health at designated level

- ***Hydraulic rating* -** use changes in simple hydraulic variables (e.g. wetted perimeter) across single river cross-section as surrogate for habitat factors limiting to target biota

- ***Habitat simulation* -** Assess e-flows on basis of modeling of quantity and suitability of physical habitat available to target species under different flow regimes (integrated hydrological, hydraulic and biological response data)

- ***Holistic*** – identify important flow events for all major components of river, model relationships between flow and ecological, geomorphological and social responses, and use in interdisciplinary team approach to establish recommended e-flow regime/implications of flow scenarios (bottom-up or top-down)

Habitat simulation methodologies

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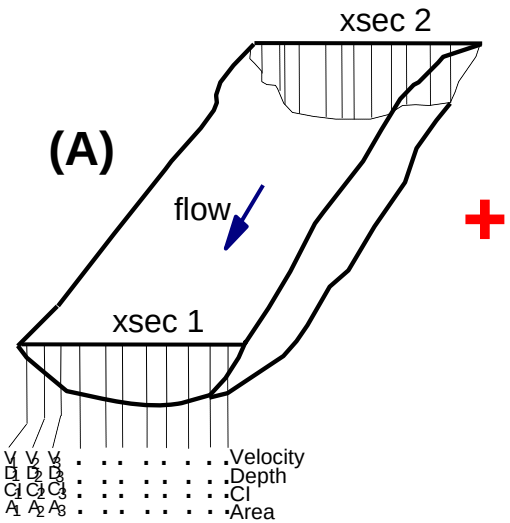
e.g. IFIM/PHABSIM



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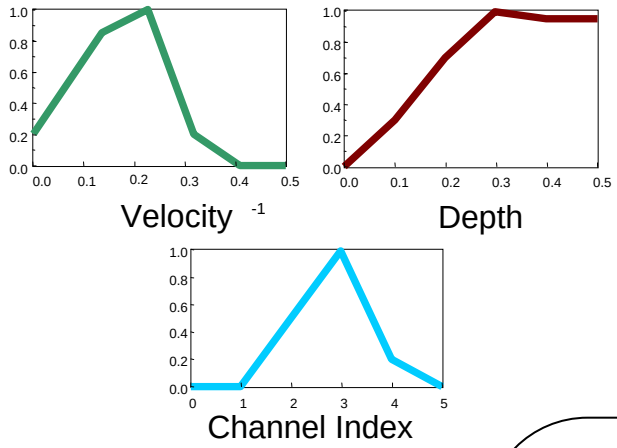
(B) Habitat suitability curves for target sp.



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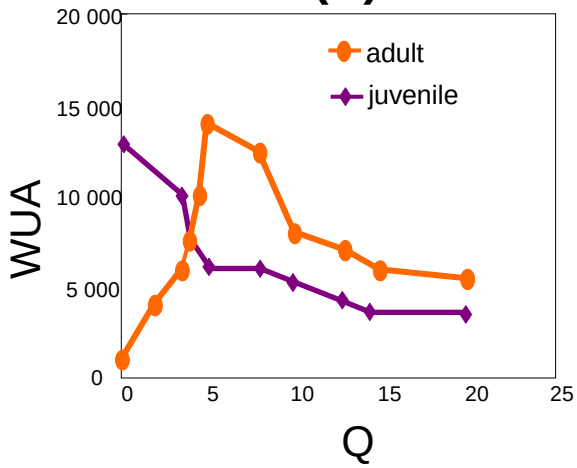

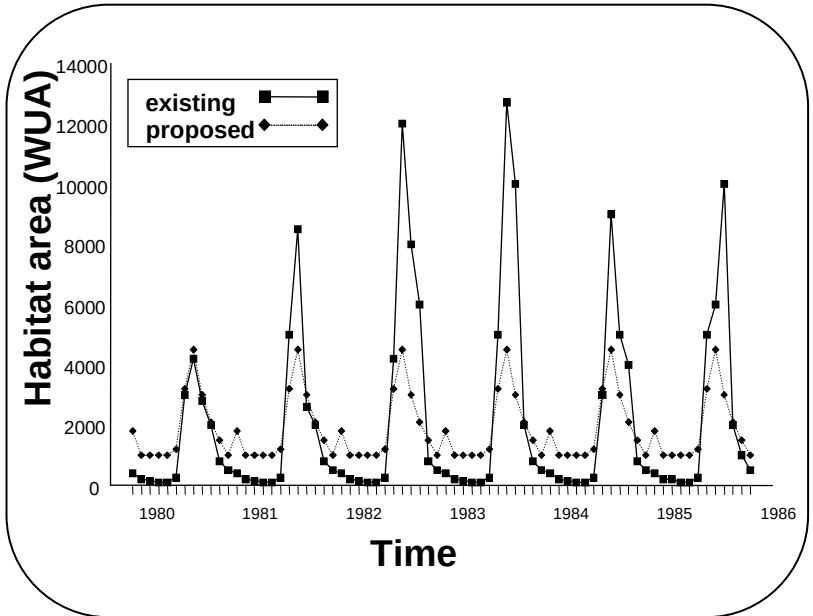

Shift from minimum flow to flow regime:

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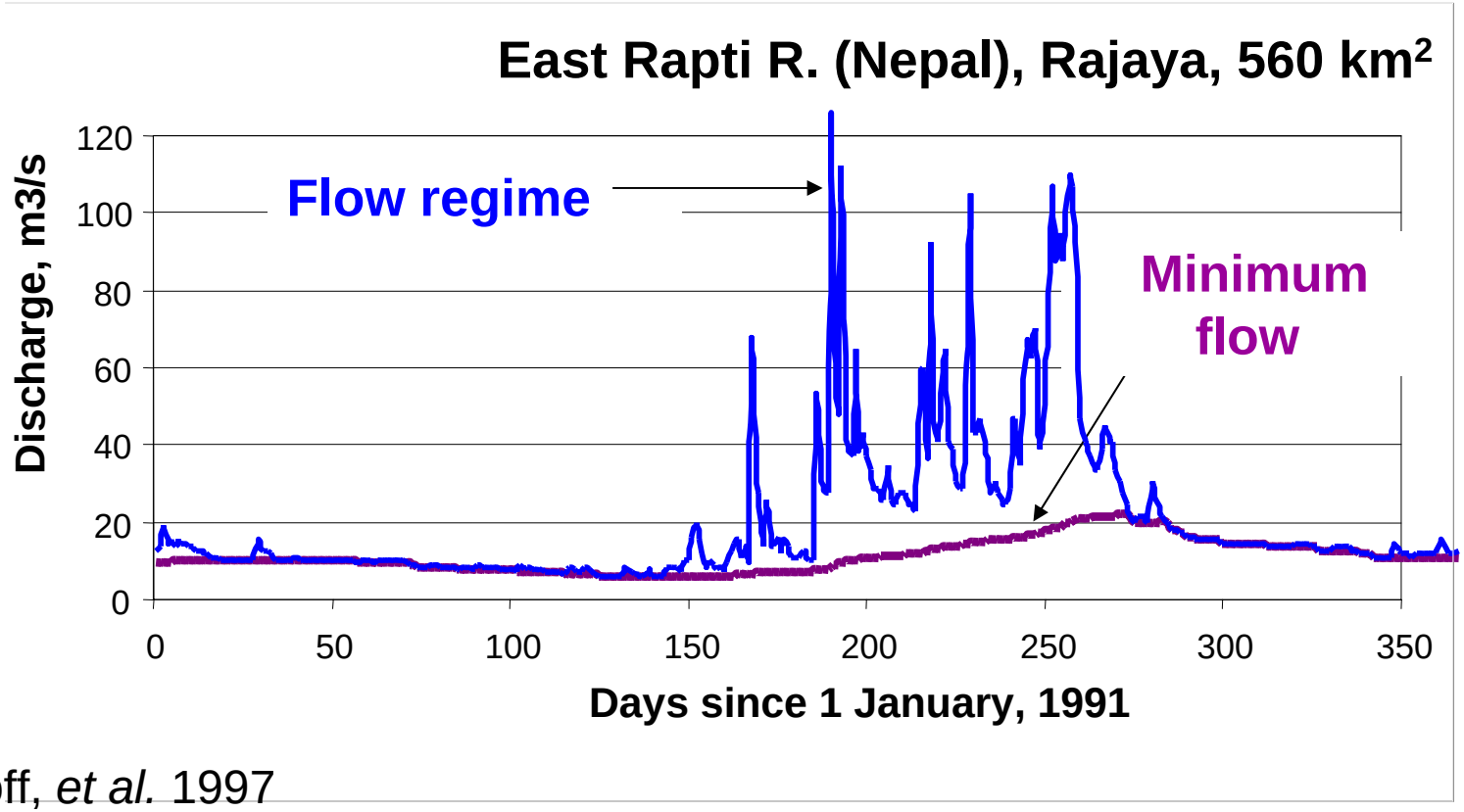
- * magnitude, frequency, duration, timing, rate of change
  * flow components (low flows, freshes, floods)



Source: Poff, *et al.* 1997

Holistic Methodologies: natural flow paradigm

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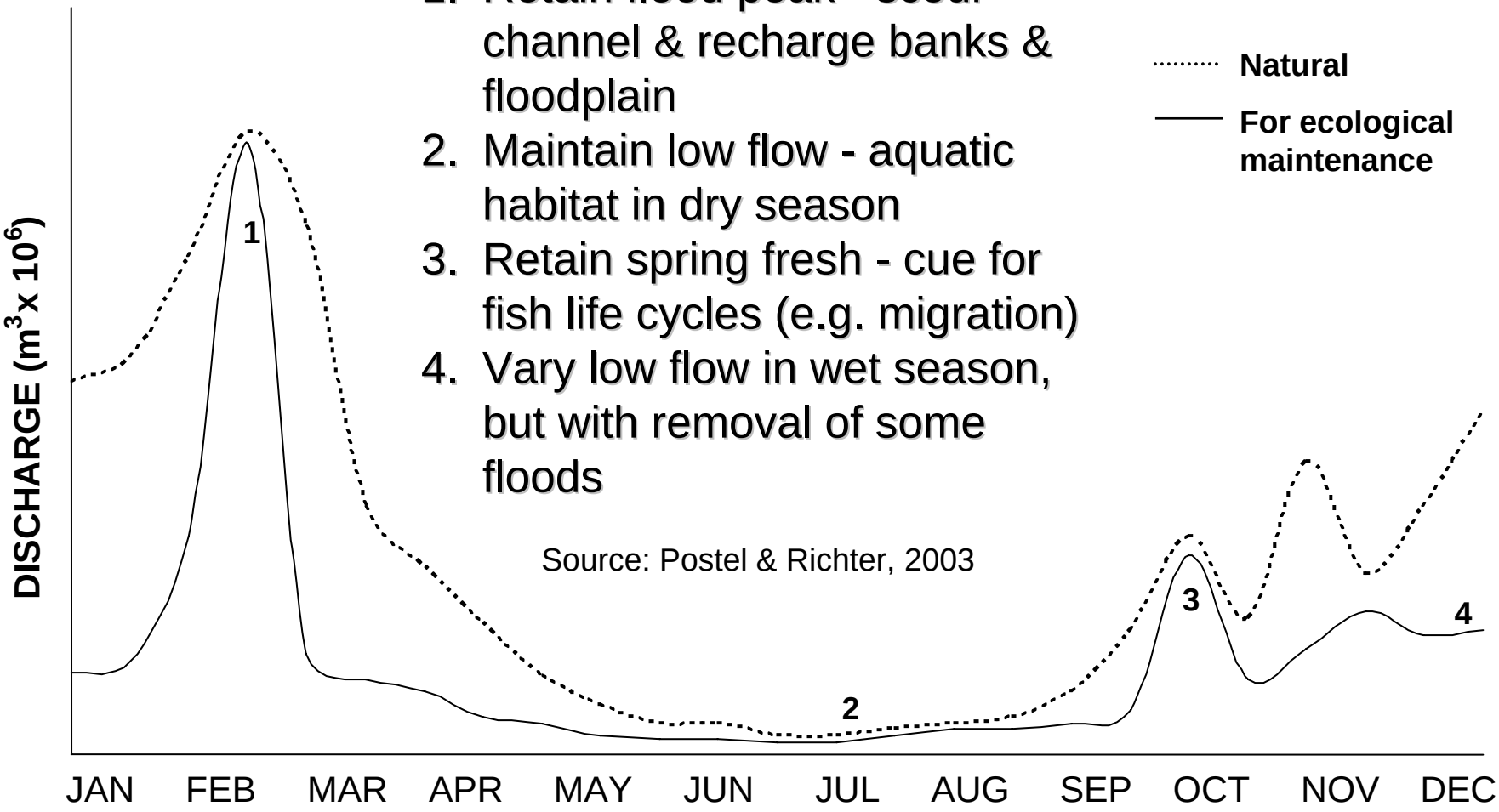
1. Retain flood peak - scour channel & recharge banks & floodplain
2. Maintain low flow - aquatic habitat in dry season
3. Retain spring fresh - cue for fish life cycles (e.g. migration)
4. Vary low flow in wet season, but with removal of some floods

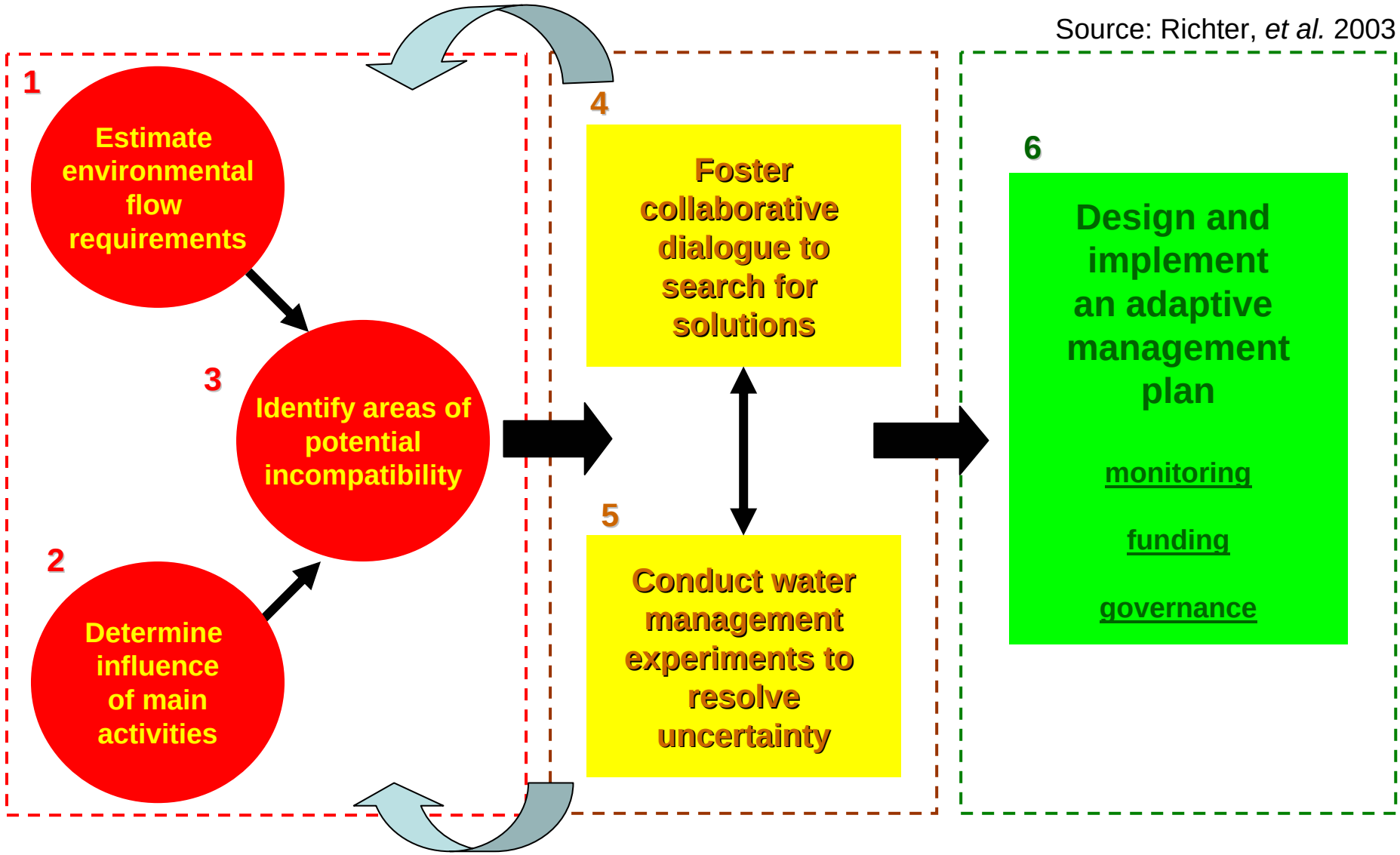


Source: Postel & Richter, 2003

2. Example of a holistic method application

Ecologically Sustainable Water Management (ESWM) – The Nature Conservancy

Source: Richter, *et al.* 2003



2. Example of a practical holistic method application

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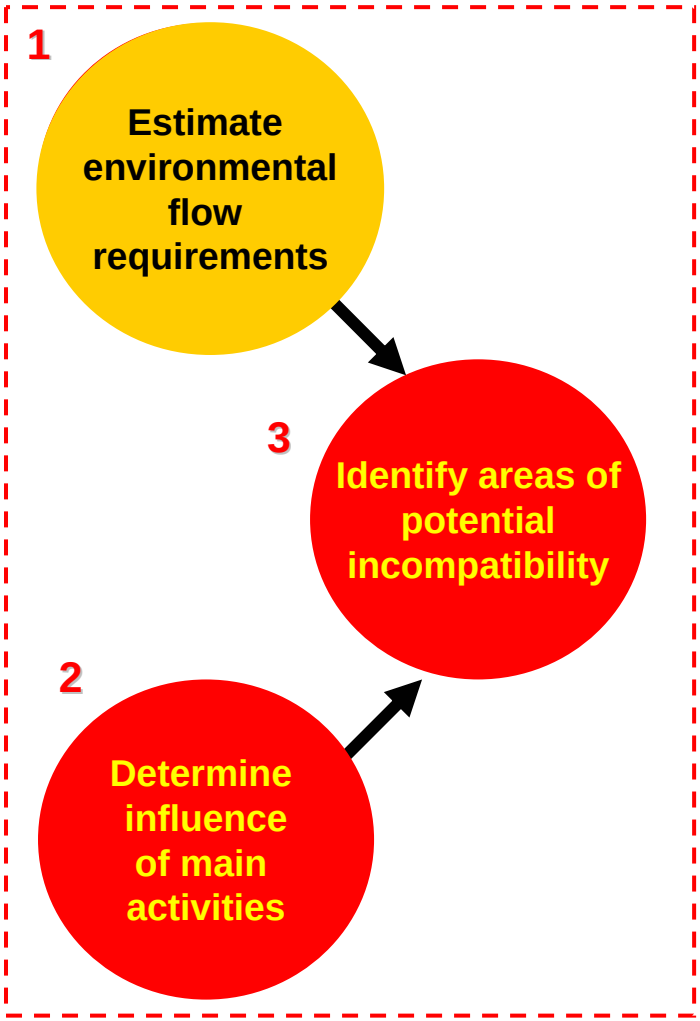

1. Estimate ecosystem flow requirements

- Gathering historical hydrological flow data series (*hydrological desk top analysis*)
- Characterization of the natural flow regime (*hydrological and hydraulic analysis*)
- Identification of critical flow events
- Development of simulation models to assess how biodiversity is related to the natural flow regime (*habitat modeling ex. PHABSIM*)

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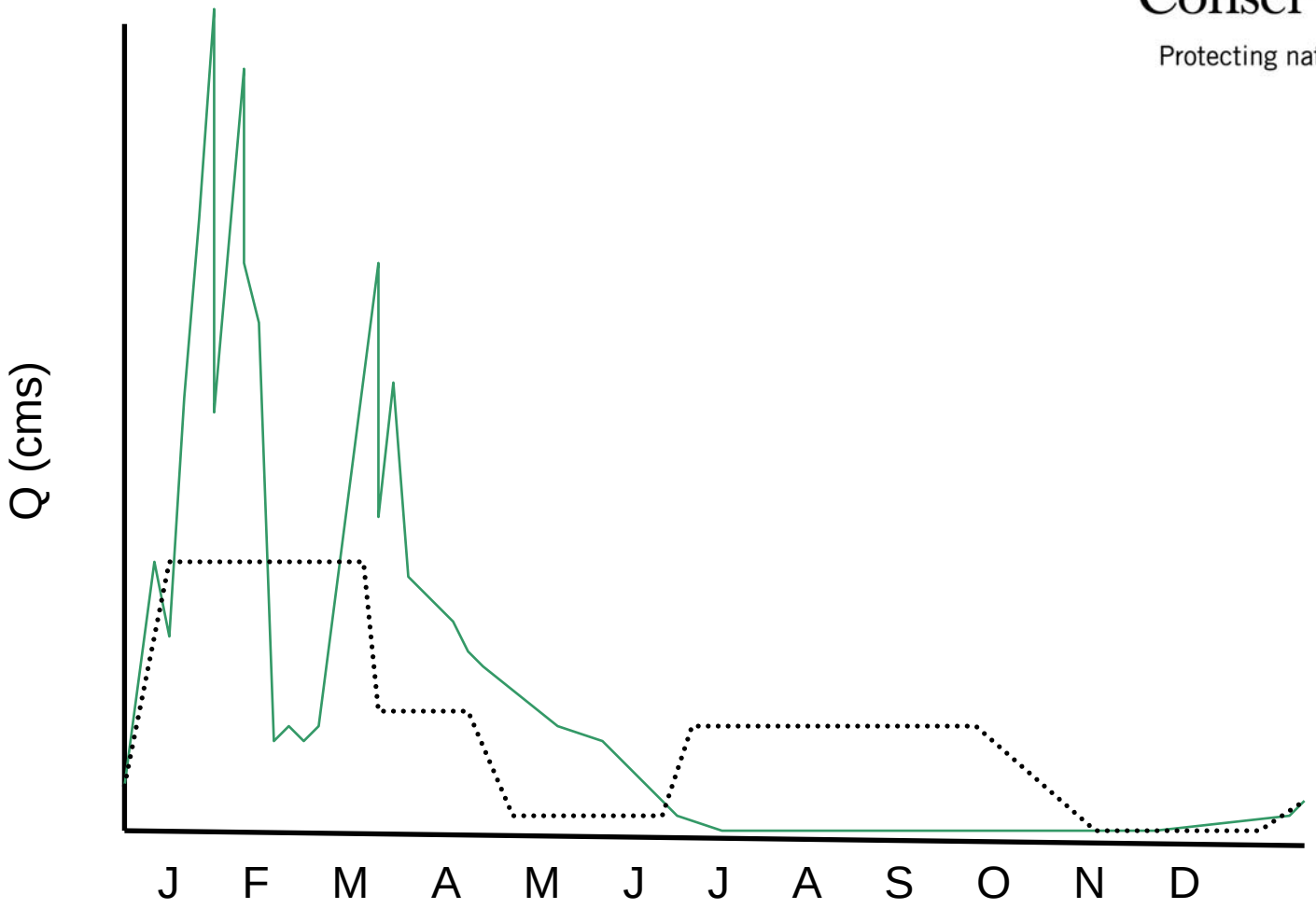

Natural hydrograph ——— **Regulated hydrograph** .....

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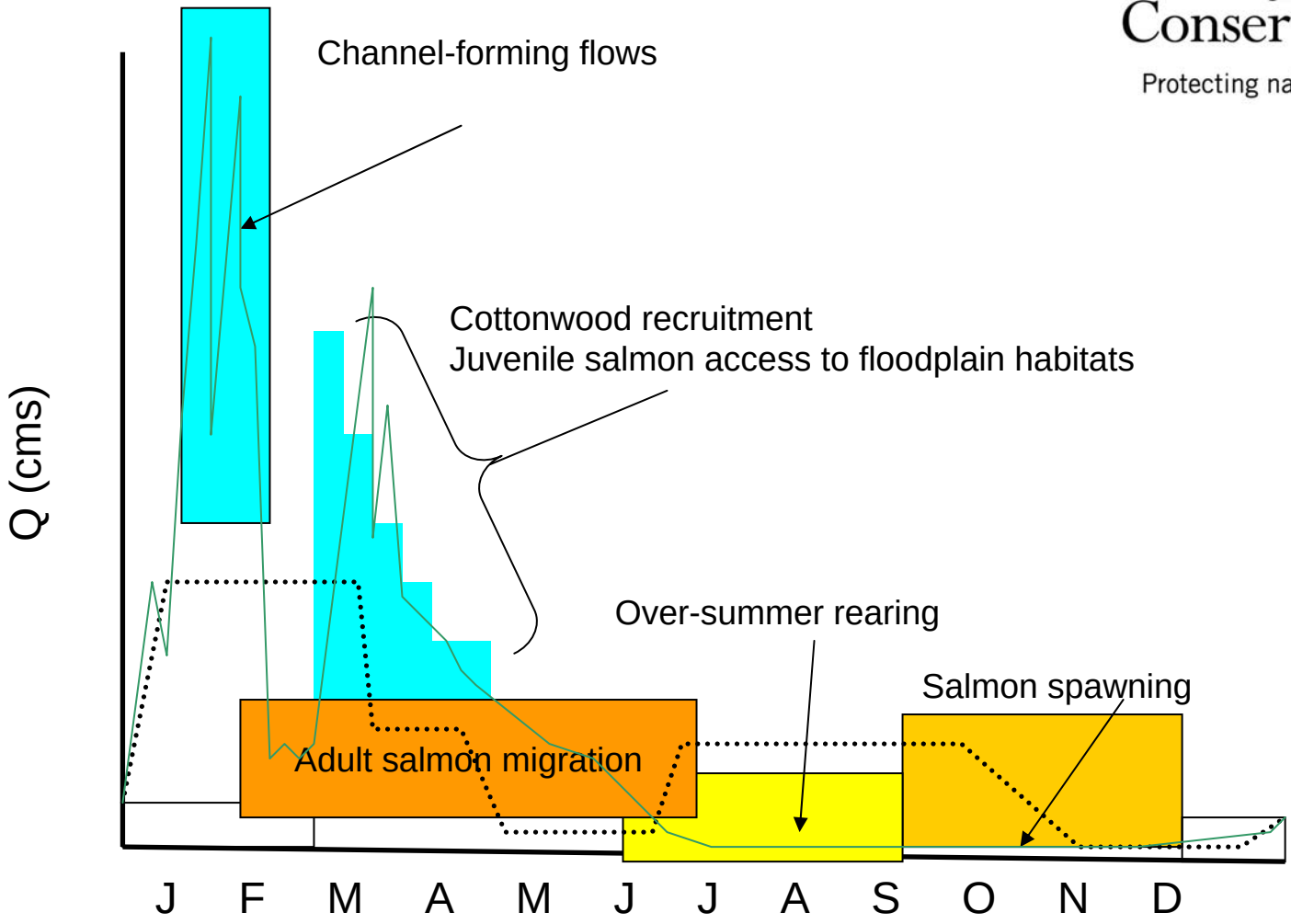

Determining flow needs for various ecosystem processes

2. Example of a practical holistic method application

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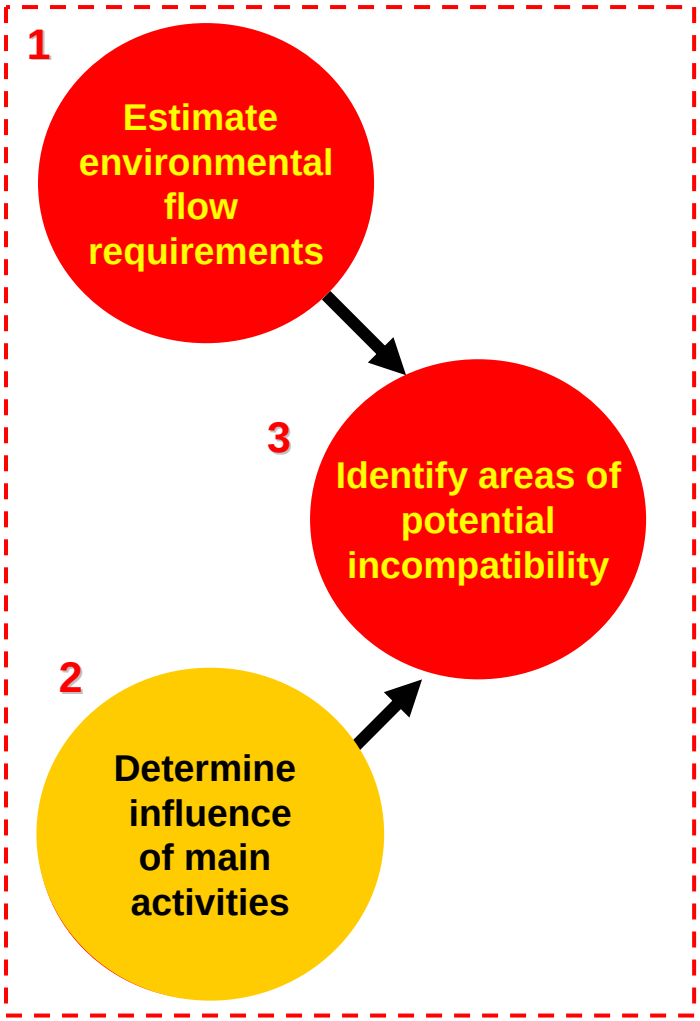
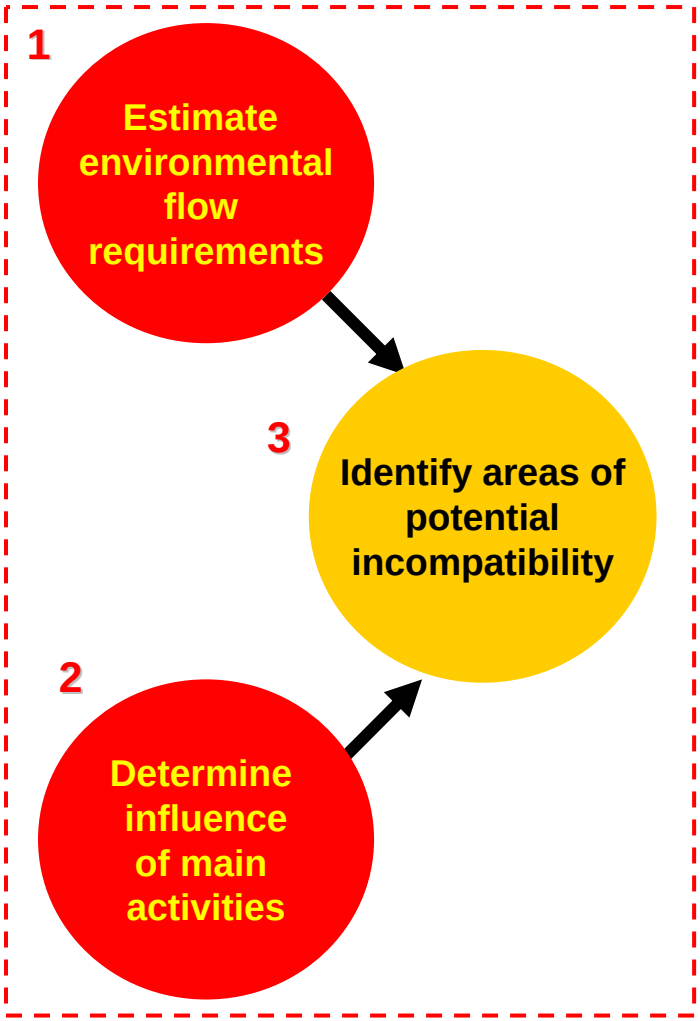


2. Determine influence of human activities

- How much the human presence is influencing the natural flow regime and the critical flow events?
- Hydrological models (ex. water budget analysis)
  - Water withdrawals, evaporation, transpiration x rainfall, etc.

2. Example of a practical holistic method application



3. **Identify areas of potential incompability**

- Hydrological alteration analysis (ex. IHA software)
- Range of variability approach (RVA)
- Flow recommendation workshop / multi disciplinary teams
- Understand the natural and altered flow regimes
- How the biodiversity and socio economy is impacted
- Scenario analysis and hydrogram prescriptions (spatial and temporal analysis)

2. Example of a practical holistic method application

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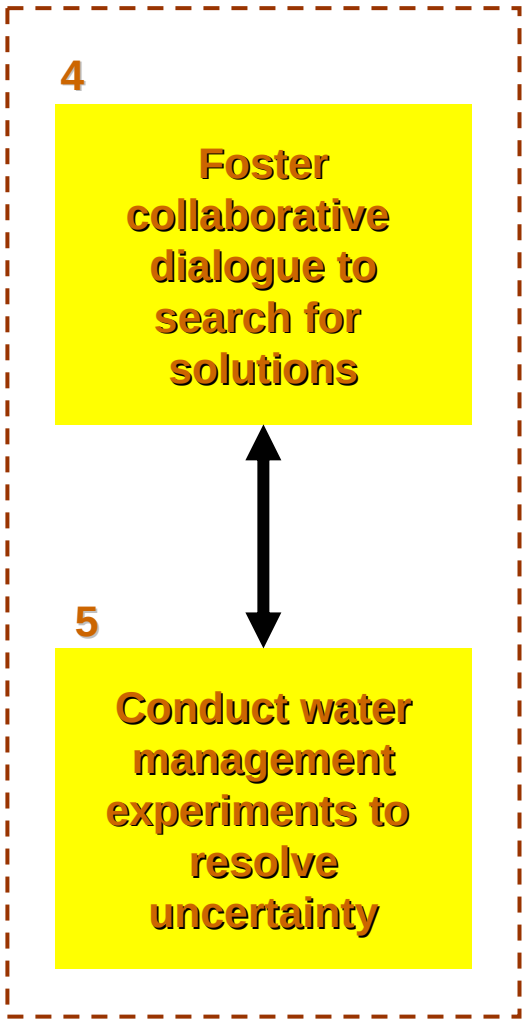

4. **Foster collaborative dialogue to search for solutions**
   - Participatory meetings and workshops to assess the scenarios and flow recommendations
   - Search for the accomplishment of distinct objectives
   - Trade off analysis engaging decision makers, users, local communities, etc.
   - Discuss “win win” solutions

5. **Conduct water management experiments to resolve uncertainty**
   - Experimental implementation of the best scenario(s) (“win – win” situations)

2. Example of a practical holistic method application

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6

Design and implement an adaptive management plan

monitoring

funding

governance

Design and implement an adaptive management plan using the knowledge gained in steps 1-5, create an adaptive management program to facilitate ecologically sustainable water management for the long term, including monitoring, funding and governance

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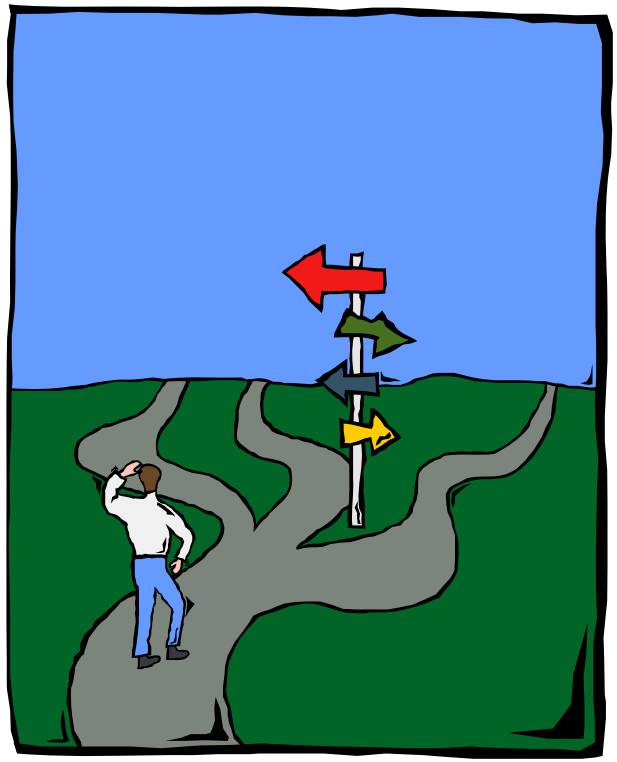
3. Choosing the right method



3. Choosing the right method

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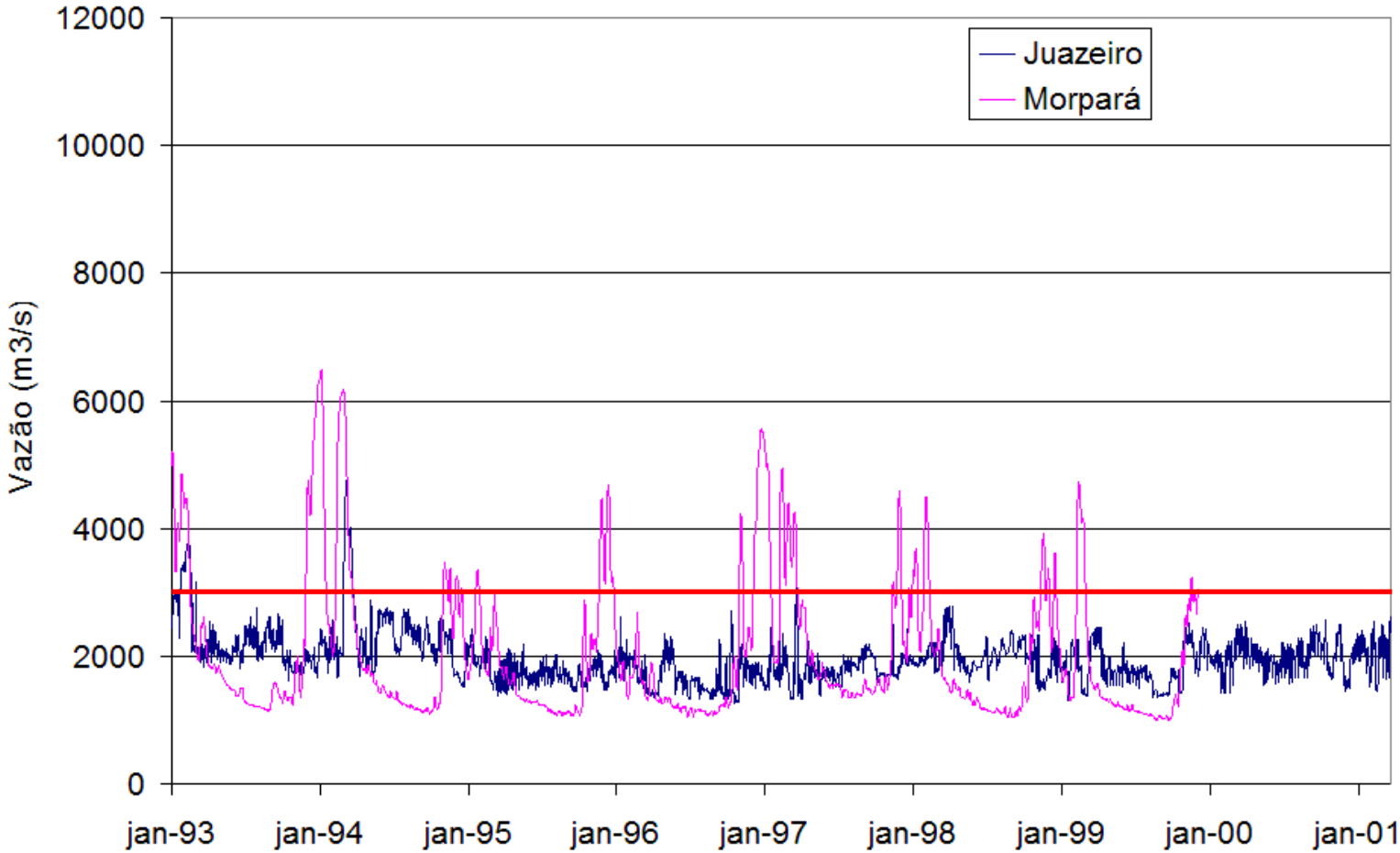
Hydrological methodologies: strengths and deficiencies

- Simple, rapid, inexpensive desktop approaches
- Low data needs, primarily flow data
- Suitable for water resource planning purposes
- Potential for regionalization for different river ecotypes
- Simplistic, inflexible, low resolution output
- Direct ecological links absent or limited (but recent advances made to improve ecological relevance of flow indices and to set flow targets)
- Dynamic nature of flow regime seldom addressed
- Suitable for low controversy situations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Habitat simulation methodologies: strengths and deficiencies

- High resolution habitat-flow relationships for target species
- Generate alternative e-flow scenarios for different species
- Advanced technical support
- Focus on target species, not whole ecosystem
- Not applicable for some ecosystem components
- Limited links with characteristics of flow regime
- Output restricted to flow-hydraulic habitat relationships
- Resource intensive relative to output
- Poor links with biological responses to flow change

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Holistic methodologies: strengths and deficiencies

- Whole-ecosystem focus
- Generates alternative environmental flow scenarios for different ecological and social conditions
- Use of interdisciplinary expert judgement in structured, consistent process
- Usable in data rich and data poor contexts (use of available techniques and understanding)
- Explicit links with characteristics of flow regime and with biological and social responses to flow change
- Reliant on expert judgement
- Difficulties in reconciling opinions of different experts
- Moderate to high resource demands

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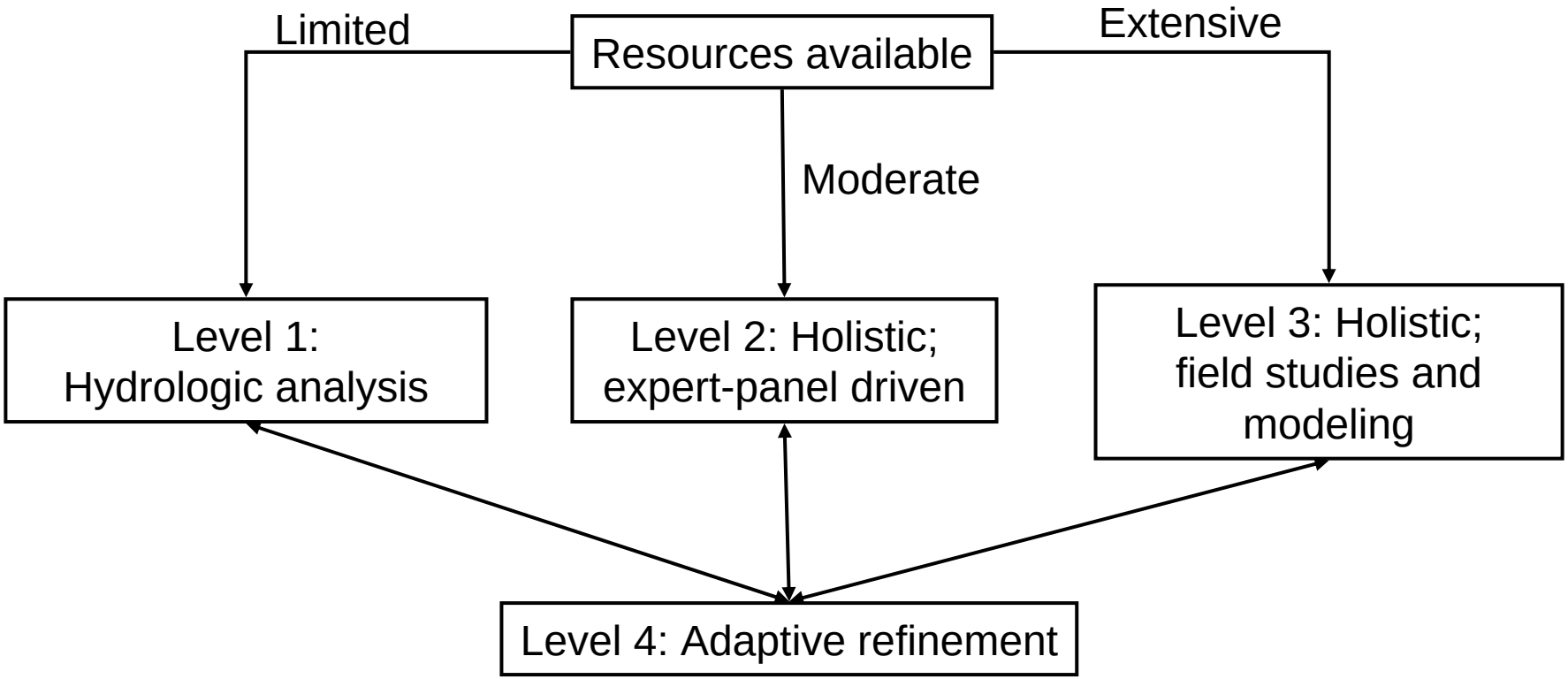

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Time

Funds

Months 1 - 5

Level 1: Hydrologic analysis

~ $10,000

Months 6 - 12

Level 2: Holistic; expert-panel driven

~ $100,000

Years 2 – 5 +

Level 3: Holistic; field studies and modeling

~ $1,000,000 +

Level 4: Adaptive refinement

Requires sustainable budget

3. Choosing the right method

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Enabling conditions

Step 1: Establish data collection

Step 2: Identify expertise

Step 3: Create a data centre

Step 4: Conduct training courses

Step 5: Develop and start implementing a research programme

Step 6: Conduct pilot studies

References

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Benetti, A. D.; Lanna, A. E.; Cobalchini, M. S. 2003 Current practices for establishing environmental flows in Brazil. *River research and applications*, Vol. 19 pp. 1-18.

COLLISCHONN, W. ; SOUZA, C. F. ; FREITAS, G. K. ; PRIANTE, G. R. ; AGRA, S. G. ; TASSI, R. . Em busca do hidrograma ecológico. In: José Nilson Campos. (Org.). Recursos Hídricos: Jovem Pesquisador 2005. Fortaleza: ABRH, 2005, v. , p. -.

Dyson, M., Bergkamp, G., Scanlon, J. (eds). (2003) Flow. The Essentials of Environmental Flows. IUCN, Gland, Switzerland and Cambridge, UK. xiv + 118 pp.

Poff, N. L.; Allan, J. D.; Bain, M. B.; Karr, J. R.; Prestegaard, K. L.; Richter, B. D.; Sparks, R. E.; Stromberg, J. C. 1997 The natural flow regime: a paradigm for river conservation and restoration. *Biosicence*, Vol. 47 No. 11 pp. 769-784.

Postel, S.; Richter, B. 2003 *Rivers for life: Managing water for people and nature.* Island Press. Washington. 253p.

References

Richter, B. D.; Baumgartner, J. V.; Powell, J.; Braun, D. P. 1996 A method for assessing hydrologic alteration within ecosystems. *Conservation Biology* Vol 10 No. 4 pp. 1163-1174.

Richter, B. D.; Baumgartner, J. V.; Wigington, R.; Braun, D. P. 1997 How much water does a river need? *Freshwater Biology*, Vol. 37 pp. 231-249.

Richter, B. D.; Mathews, R.; Harrison, D. L.; Wigington, R. 2003 Ecologically sustainable water management: Managing river flows for ecological integrity. *Ecological Applications*, vol. 13 No. 1 pp. 206-224.

Tennant, D.L., 1976. Instream flow regimens for flush, wildlife, recreation and related environment resources. *Fisheries* 1(4) 6-10.

Tharme, R. E. 2003. A global perspective on environmental flow assessment: emerging trends in the development and application of environmental flow methodologies for rivers. *River Research and Applications* 19: 397-441.

TNC 2003 *Indicators of hydrologic alteration: User's manual.* TNC – Smythe Scientific Software. 36p.

THANKS

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