Modelling Flood Regulation as an Ecosystem Service using Artificial Intelligence

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Outline

- Importance of flood protection
- Benefit/Beneficiary Based Approach
- The ARIES Modelling Platform
- Example of Flood Protection (Chehalis River Basin).

Importance of Flood Protection

- Flood protection here is defined as:
  - ❖ Mechanism for Preventing damage and Reducing hazards which affects
    - ➢ People (loss of lives and property)
    - ➢ Economy (transportation costs, delay, damaged infrastructure etc .)
    - ➢ Environment (loss in ecosystem services e.g. erosion, contamination, biodiversity loss etc).

- Understanding how flood protection is provided is vital for making good private and public investment decisions.

A benefit- and Beneficiaries- Based Approach to Flood Protection

- Flood protection is a benefit provided by
- Both Natural and Built structures can be overwhelmed by excessive floodwaters.
- Often the provisioning of flood protection services are unmapped and unvalued, impaired, neglected or destroyed. (nature provides them freely and continuosly)
- Understanding the economic values of built and natural capitals is critical to providing sustainable flood protection investments.
- When these benefits (ecosystem services)are lost people pay.

ARIES Modelling Platform

- With growing interest in using ecosystem services for decision making, demand has grown for systematic methods and tools to quantify ecosystem service values.

- ARtificial Intelligence for Ecosystem Services (ARIES) redefines ecosystem services assessment and valuation in decision-making.

- The ARIES approach to mapping benefits, beneficiaries, and service flows is a powerful new way to visualize, value, and manage flood protection benefits

ARIES Modelling Platform

- (ARIES) maps the potential provision of ecosystem services (sources), their users (use), and biophysical features that can deplete service flows (sinks).
- ARIES is a modeling platform rather than a single model or collection of models.
- Uses ecological process models where appropriate, and turns to ad hoc models or Bayesian models where existing process models do not exist or are inadequate for local contexts.
- ARIES then uses a series of agent-based flow algorithms to map actual service flow from ecosystems to people.

ARIES Modelling Capability for Flood Protection Services

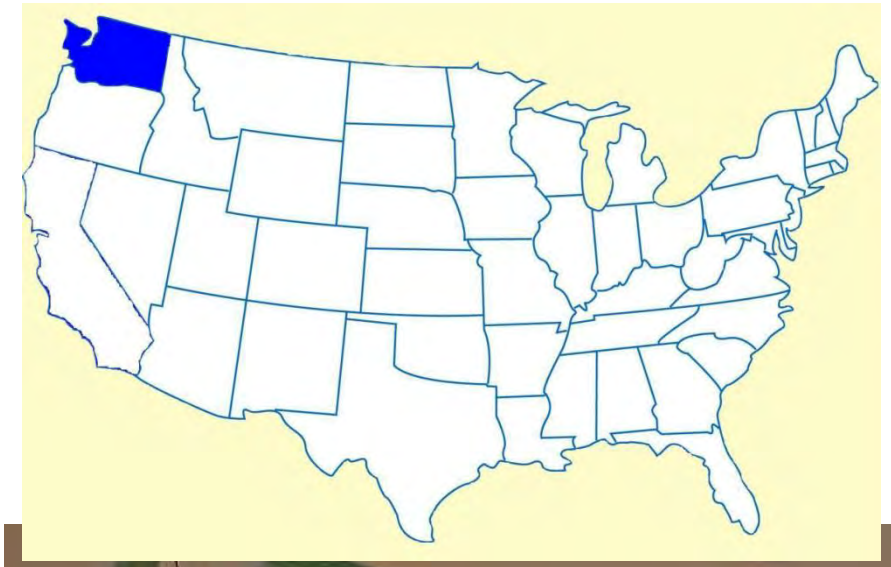
- a. **Provisioning maps** to show where flood protection and other ecosystem services and goods are produced;
- b. **Beneficiary maps** to show who is benefiting from existing flood protection and other ecosystem services;
- c. **Flood source maps** to show how flooding is created, and where provisioning of
- flood protection and other ecosystem services are being impaired, such as a
- bridge that might restrict the floodway causing increased flooding upstream, or a
- steep and unstable slope that could slide to block river flows;
- d. **Critical Path maps** to show how the service of flood protection (which can
- include moving people out of the floodway) is transferred to beneficiaries, and to
- identify critical areas for flood protection and ecosystem service provisioning.
- **Develop scenario analysis.** Create scenario analysis with modeling to help choose and prioritize project proposals against established criteria. These analyses might include:
- a. Scenarios of different flood levels and rainfall patterns across the watershed;
- b. Scenarios of single flood protection projects and combinations of projects.

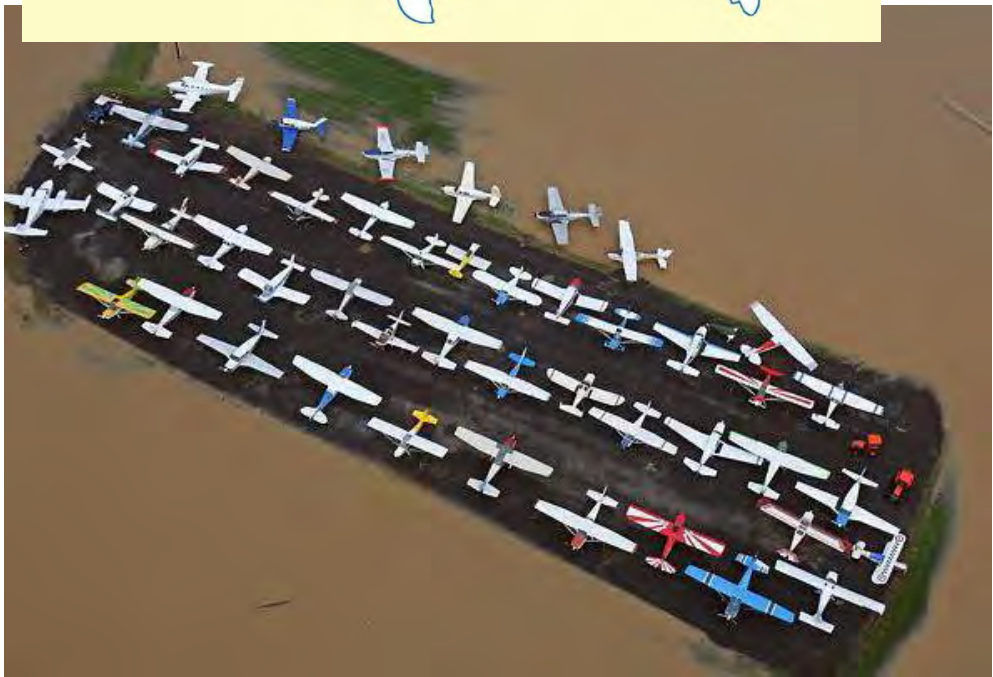
Accessibility

- ARIES is accessible from any internet browser, with all functions handled remotely and returned to the user via a web interface.

- Data and model storage, data transformations, model runs, and reporting of results take place behind the scenes without the need to purchase and gain proficiency using commercial GIS or modeling software.

Example: Flood Protection in Chehalis River Basin, WA

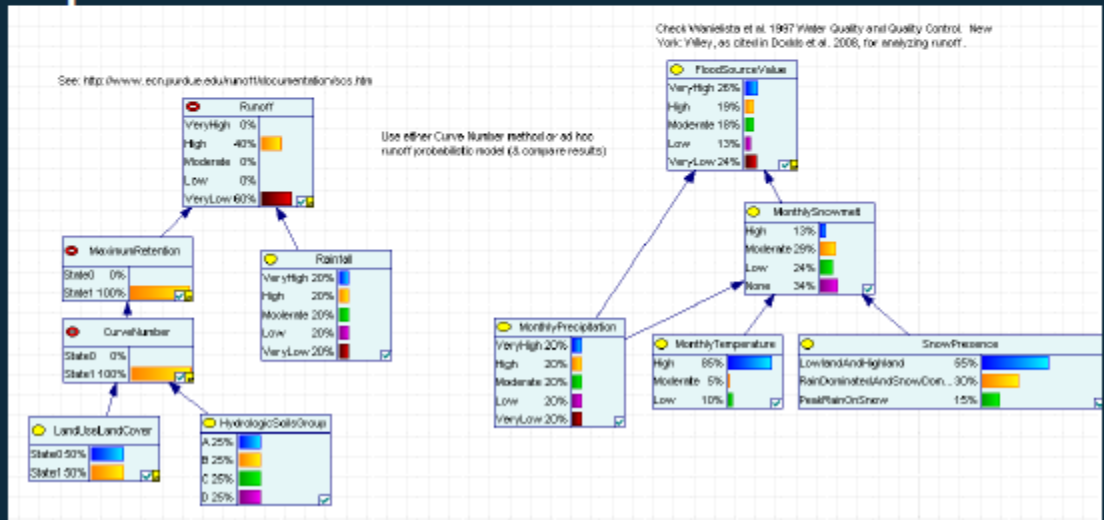




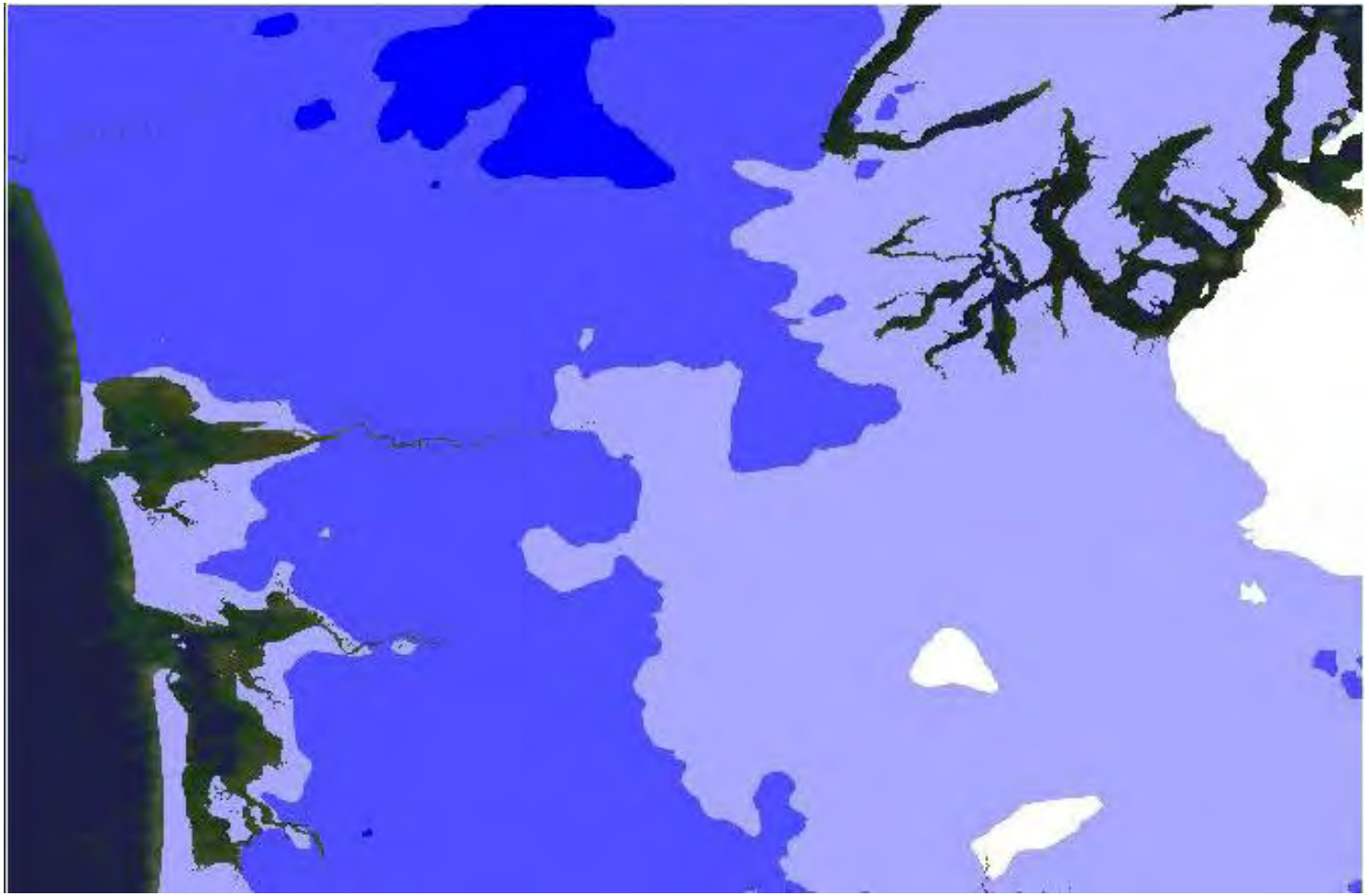
Example: Data resources

Flood Model

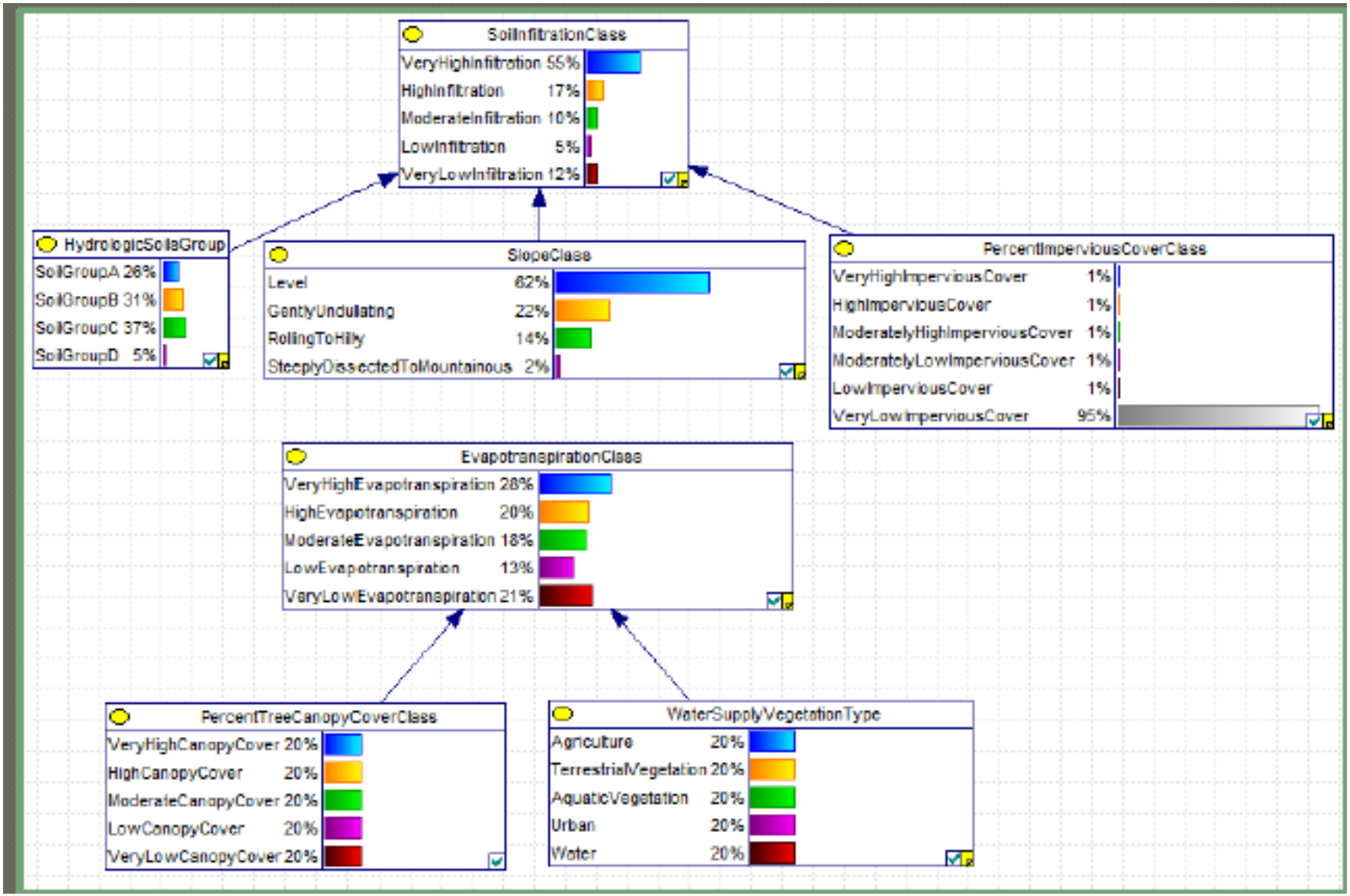
- Source: precipitation
- Sink: Sum of “gray infrastructure” and BN-calculated “green infrastructure”
- Use: property, infrastructure, farmland in 100-yr floodplain



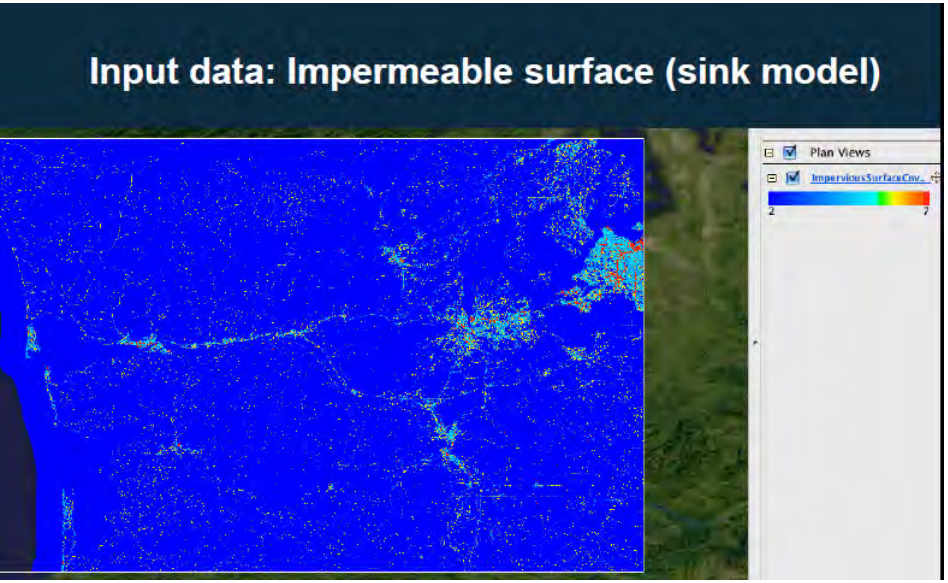
Monthly Rainfall: Source

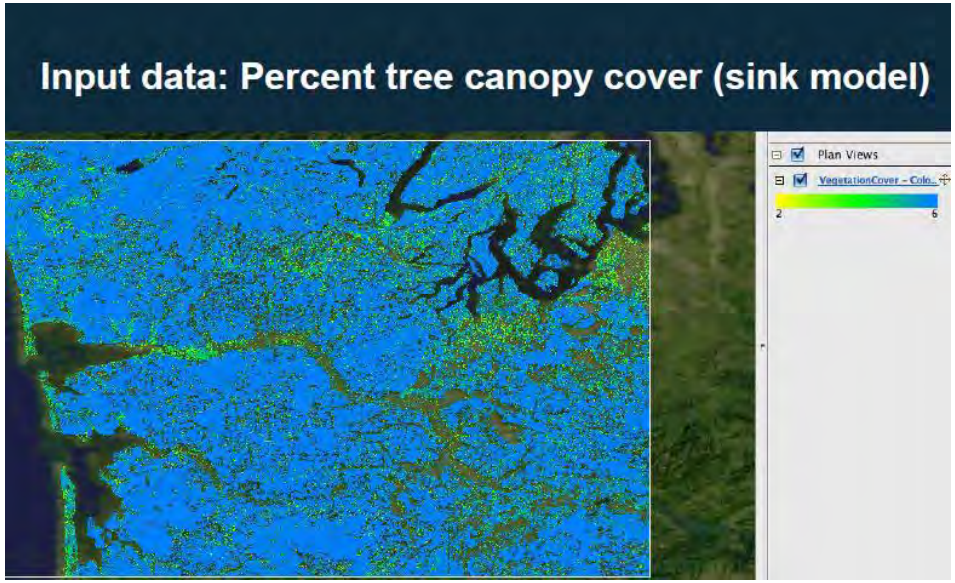


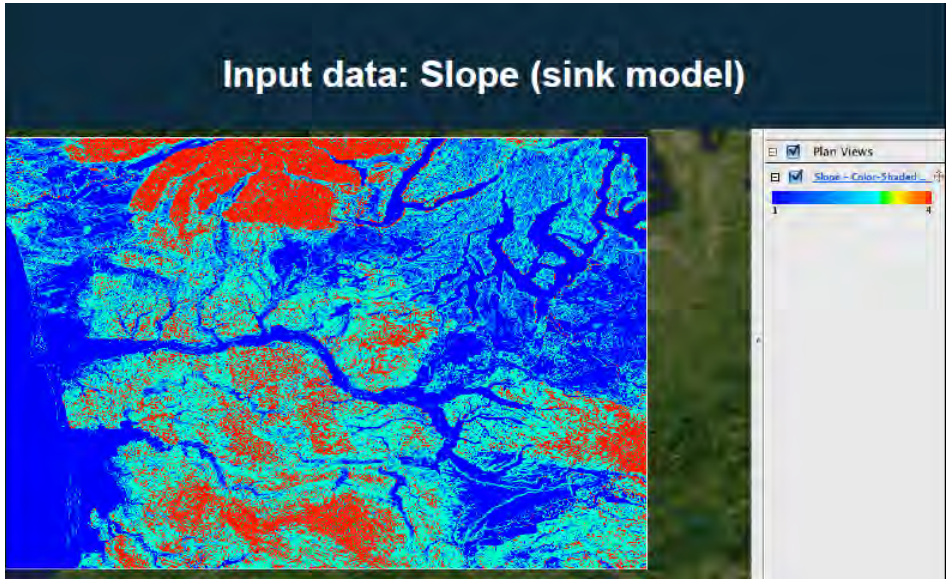
Surface water sinks (Bayesian Models)

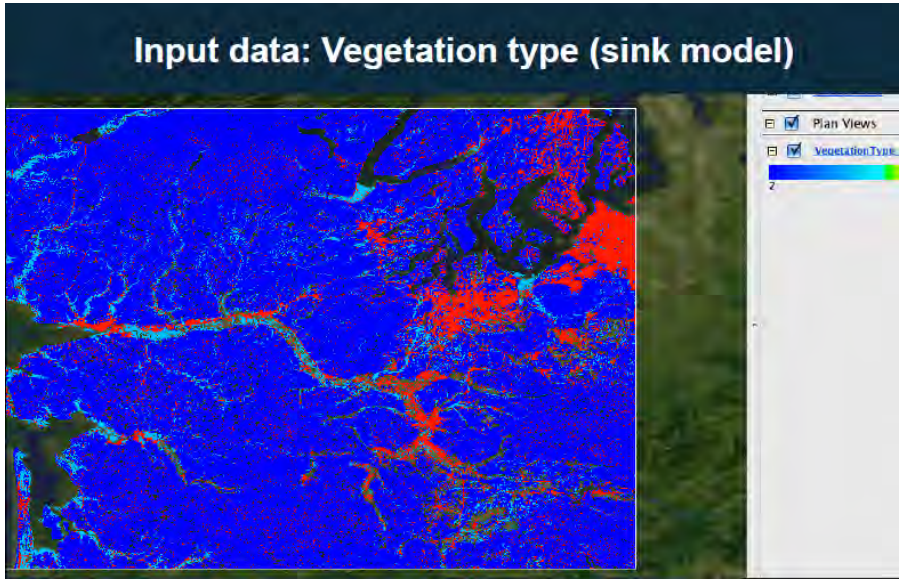


Input: GIS data

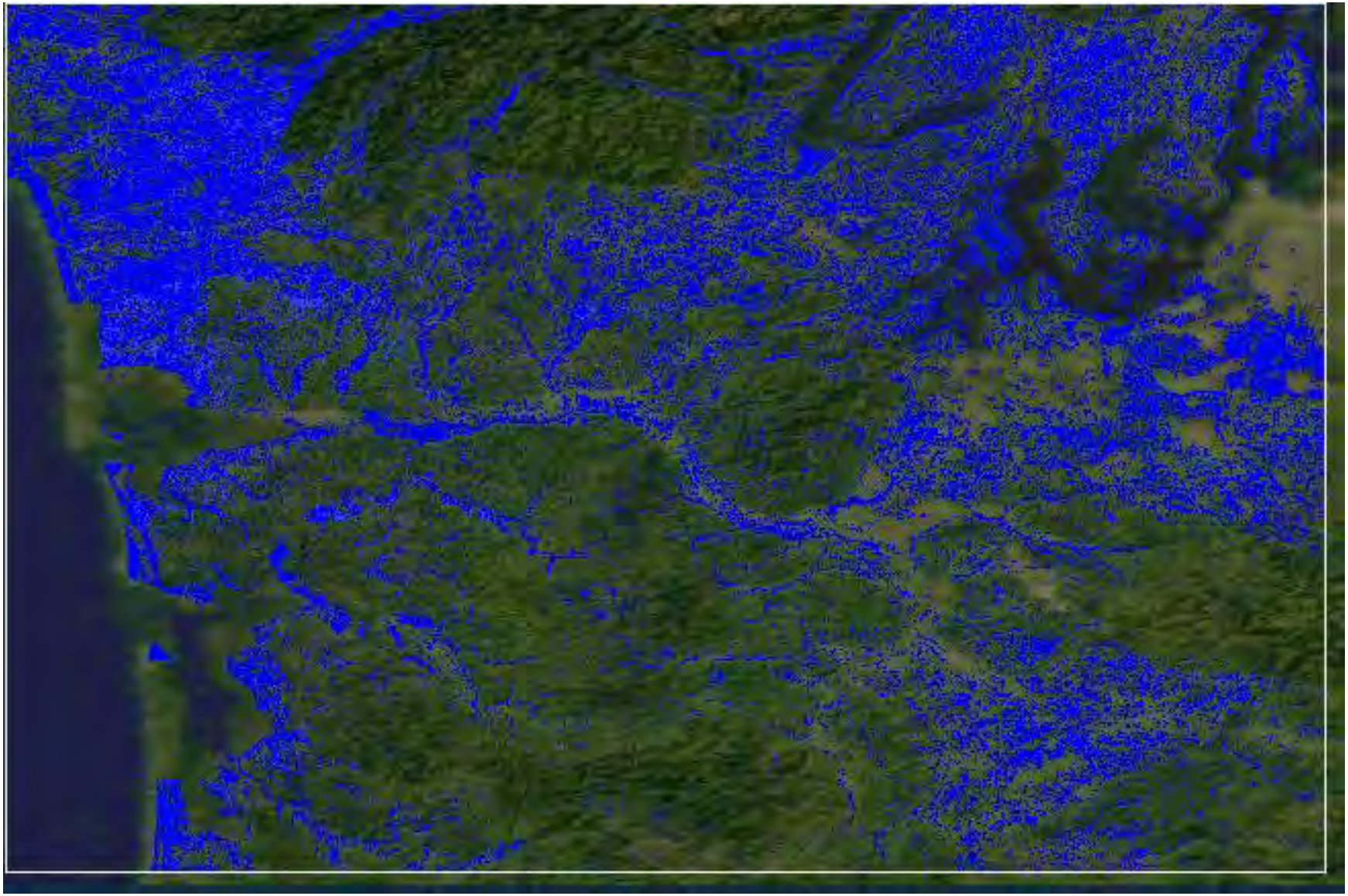








Output: Areas Providing Flood Protection Benefits



Incorporating GIS Overlays

- Which geo-spatial datasets are useful for analyzing flood information and producing overlays? e.g.
  - Population, settlements, agriculture fields, transport networks, infrastructure
- What are the sources of the data, and is it readily available?
- How is the integration done practically? e.g.
  - Overlaying the vector datasets of interest on the flood polygon
  - Intersecting population grid with flood polygon to determine how many people affected
- What useful end products can be produced from these overlays?
  - Affected/flooded settlements
  - Estimate of number of affected people
  - Estimate of crop hectarage lost due to flooding
  - Affected transportation routes, and clear transportation routes
  - Inaccessible (marooned) settlements
  - Affected infrastructure
- Who are the likely users of these information products (overlays)?
  - Potentially affected communities
  - Disaster Management Authorities and related agencies
  - Agriculture and crop estimate authorities

Conclusions

- Flood protection begins with drawing the boundaries of jurisdictions, such as flood districts correctly.
- Boundaries based on areas of flooding –usually lower portions of watershed and not on entire river basin does not encompass true scale of flood generation and protection.
- Floods and ecosystem services have distribution and equity elements. The rural/urban distribution of floods and ecosystem services is important.
- While rural areas such are the net providers of ecosystem services, it is large urban areas that are the net consumers of these ecosystem services.
- Institutions of financial mechanisms to compensate rural regions for the benefit they provide to urban regions.

Conclusions

- Flood protection, for some decades, will likely be one of the largest investments (over one hundred million dollars).
- Understanding the hydrology and science of the Basin is key to successful flood protection investments and to fully account for public safety.
- Understanding the economic value of built and natural capital is critical to providing an accurate economic analysis of flood protection proposals.
- Selecting and prioritizing projects requires the determination of selection criteria, understanding of the impediments to flood protection and identification of the location of beneficiaries. It also requires the modeling of flood protection provisioning.
- Tools for examining flood scenarios to test their overall economic costs and benefits, as well as the distribution of benefits, could greatly assist decision-makers.
- In addition, a solid governance structure for project selection, funding, sequencing, and implementation will help decision-makers secure flood protection success.
- This study assists with a number of these key components.

References

Villa, F., et al. 2009. ARIES (ARtificial Intelligence for Ecosystem Services): A new tool for ecosystem services assessment, planning, and valuation. Proceedings of the 11th Annual BIOECON Conference on Economic Instruments to Enhance the Conservation and Sustainable Use of Biodiversity, Venice, Italy, September 2009.

http://www.ucl.ac.uk/bioecon/11th_2009/Villa.pdf

Key users: University of Vermont, Conservation International, Earth Economics, United Nations Environment Program and scientists from around the world.

Thank you for your attention