

InVEST: A Tool for Integrating Ecosystem Services into Policy and Decision-Making

The integration of ecosystem services into decisions relies on access to good scientific information showing where ecosystem services are provided and how they will be affected by alternative plans and policies. InVEST (Integrated Valuation of Ecosystem Services and Trade-offs) is a suite of ecosystem service models developed by the Natural Capital Project to provide such information. InVEST is designed to help local, regional and national decision-makers incorporate ecosystem services into a range of policy and planning contexts for terrestrial, freshwater and marine ecosystems, including spatial planning, strategic environmental assessments and environmental impact assessments.

InVEST models are based on production functions that define how an ecosystem's structure and function affect the flows and values of ecosystem services. The models account for both service supply (e.g. living habitats as buffers for storm waves) and the location and activities of people who benefit from services (e.g. location of people and infrastructure potentially affected by coastal storms). Since data are often scarce, the first version of InVEST offers relatively simple models with few input requirements. These models are best suited for identifying patterns in the provision and value of ecosystem services. With validation, these models can also provide useful estimates of the magnitude and value of services provided. The Natural Capital Project is also developing more complex, data intensive models for informing policies that require more certainty and specificity in results.

In terrestrial and freshwater ecosystems, InVEST models habitat quality (terrestrial only) and the benefits of: carbon sequestration; annual water yield for hydropower, water purification (for nutrients); erosion control (for reservoir maintenance), crop pollination; timber production, and non-timber forest product harvest. In coastal and marine systems, InVEST models the benefits of food from fisheries, food from aquaculture, coastal protection, wave energy conversion, the provisioning of aesthetic views and recreation. InVEST is spatially explicit, allowing the production of maps indicating where ecosystem services are provided and where they are consumed. It can provide biophysical results (e.g. meters of shoreline retained) and economic values (e.g. avoided cost of damage to property). A relative index of habitat quality is also provided, but biodiversity is not given an economic value directly.

The process of using InVEST begins by identifying critical management choices being considered by stakeholders. From these, alternative scenarios can then be developed to explore how the current delivery of services is likely to change under alternative decisions or conditions such as climate change. InVEST models how these alternative futures influence ecosystem processes, and how such changes affect biodiversity and the flows and values of ecosystem services. Model outputs can inform:

- **Spatial planning** by assessing the current and potential status of ecosystem services under alternative, spatially-explicit future scenarios.
- **SEA and EIA** by identifying how policies, plans and programs can affect multiple ecosystem services and guiding selection of the best alternatives.
- **Payments for ecosystem services (PES)** by identifying how payments can affect multiple goals, where to distribute payments or establish programs, and how to improve investment efficiency.
- **Permitting and mitigation** by assessing impacts of proposed activities and providing guidance for where mitigation activities will provide the greatest ecosystem service benefits.
- **Climate adaptation strategies** by showing how future changes in climate patterns will influence the delivery of services that affect human well-being.

The Natural Capital Project is a joint initiative of the University of Minnesota, The Nature Conservancy, Stanford University and World Wildlife Fund. InVEST is freely downloadable at: <http://invest.ecoinformatics.org/>. Background information on InVEST and the Natural Capital Project is available at www.naturalcapitalproject.org

Applying InVEST to Spatial Planning: China, Colombia, Hawaii and Indonesia

China¹: Provincial and county planners in China now base land use plans on ‘Ecosystem Function Conservation Areas’, which reflect areas of critical importance for ecosystem services and biodiversity. In Baoting County, an ecosystem service mapping and modeling tool called InVEST was used to design development zones that avoid areas of high ecosystem service provision and importance for conservation. This is helping local policy makers to integrate biodiversity and ecosystem service status into cross-sectoral, multi-objective land-use plans. The mapping exercise highlighted that development activities are planned in areas important for several priority ecosystem services. These developments are now being reconsidered by local government as the next Baoting county Land Use Master Plan is drafted.

Colombia²: Water funds link water users to nature, the source of the clean water upon which they depend. Users have an incentive to find the lowest cost option for maintaining access to a clean, regular water supply. In the Andean region, natural ecosystems provide these ecosystem services at low cost so investing in nature conservation makes economic sense. One such investment – water funds – are proliferating in the Andes. Water funds are long-term trust funds that involve a public-private partnership of water users who determine how to invest financial interest in conservation activities in priority areas. InVEST, an ecosystem service mapping and modeling tool, was used in the East Cauca Valley Water Fund in Colombia to help direct the fund’s conservation investments towards areas with the highest potential for reducing sedimentation and maintaining water yield.

Hawai‘i³: A quantitative ecosystem services assessment helped Kamehameha Schools (KS), the largest private landowner in Hawai‘i, to design and implement a plan that fulfils its mission to balance environmental, economic, cultural, educational, and community values. With the Natural Capital Project, KS used InVEST software to evaluate the impacts on ecosystem services of alternative planning scenarios on its iconic 10,500 hectare landholding on the North Shore of O‘ahu. The scenarios included returning agricultural lands to sugarcane as a biofuel feedstock, diversified agriculture and forestry, and residential development. The quantified services were carbon storage and water quality, as well as financial return from the land. Cultural services were incorporated qualitatively. The results informed KS’ decision to rehabilitate irrigation infrastructure and make the other investments required to pursue diversified agriculture and forestry.

Indonesia⁴: District and provincial government policy makers in Sumatra, Indonesia are integrating ecosystem services and biodiversity into Sumatra’s next land-use plan. This ecosystem-based spatial plan guides local government planners in decisions on whether, and where, to award concessions for economic activities, such as oil palm and pulp and paper plantations. An ecosystem service mapping and modeling tool called InVEST was used to assess the quantity and location of high quality habitat, carbon storage and sequestration, annual water yield, erosion control, and water purification under two scenarios, representing implementation of the current government spatial plan and an ‘Ecosystem Vision’ of sustainable land use that better balances environmental, social and economic considerations. This information is helping to design and locate the best areas for forest restoration, payments for carbon and watershed services, and best management practices for forestry and plantations.

¹ Wang Yukuan, Chris Colvin, Driss Ennaanay, Emily McKenzie, Chen Min. Mapping Ecosystem Function Conservation Areas to Integrate Ecosystem Services into Land Use Plans in Baoting County, China. TEEB D2 Case Study.

² Rebecca L Goldman, Silvia Benitez, Alejandro Calvache, Sarah Davidson, Driss Ennaanay, Emily McKenzie, Heather Tallis. Linking People and Nature through Watershed Conservation in the East Cauca Valley, Colombia. TEEB D2 Case Study.

³ Joshua H. Goldstein, Giorgio Caldarone, Chris Colvin, T. Ka‘eo Duarte, Driss Ennaanay, Kalani Fronda, Neil Hannahs, Emily McKenzie, Guillermo Mendoza, Kapu Smith, Stacie Wolny, Ulalia Woodside, Gretchen C. Daily. Integrating Ecosystem Services into Land-Use Planning in Hawai‘i. TEEB D2 Case Study.

⁴ Thomas Barano, Nirmal Bhagabati, Marc Conte, Driss Ennaanay, Oki Hadian, Emily McKenzie, Nasser Olwero, Heather Tallis, Stacie Wolny, Ginny Ng. Integrating Ecosystem Services into Spatial Planning in Sumatra, Indonesia. TEEB D2 Case Study.