An Emerging Approach to Economic Assessment: Demonstrating Value in Use of Geospatial Information

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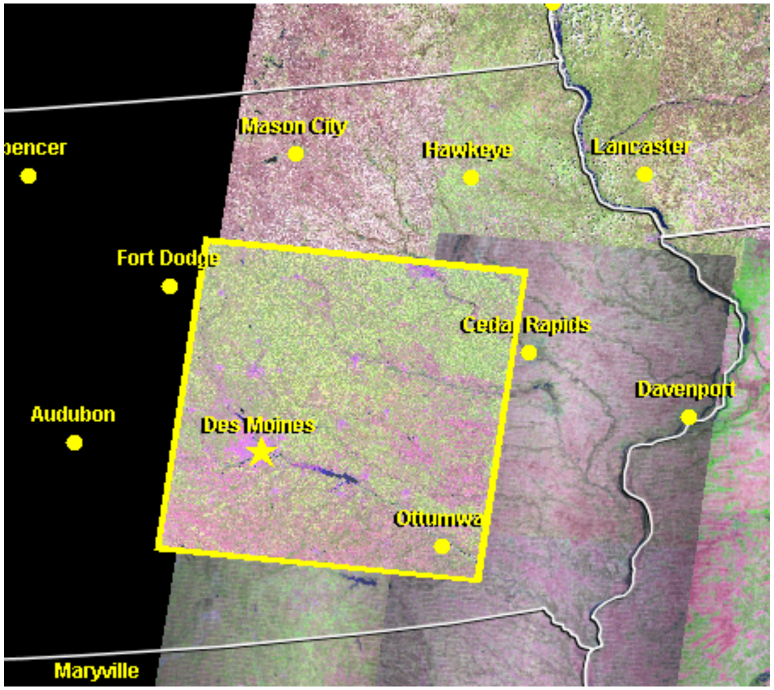

Landsat Scenes: Aug. 7 2001, USGS Global Visualization Viewer

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USGS science for a changing world

Position paper

- Geospatial data is an Intermediate good
  - Big data
  - Digital data is a technological innovation
- Geospatial data can have public or private good attributes
  - General geospatial information is a public good
  - Specific geospatial information is a private good
- Geospatial information value is determined as the impact on final goods
  - The demand for geospatial information is to reduce decision uncertainty
  - The economic value of the technological innovation is an increase in production efficiency
- Determining the value requires an understanding of its use in producing the final good
  - Empirical applications for specific decisions are needed

Use case examples

1. An Inductive Retrospective Model - Environmental regulation of agrochemicals: Geospatial data provide information for regional environmental and health policy decisions

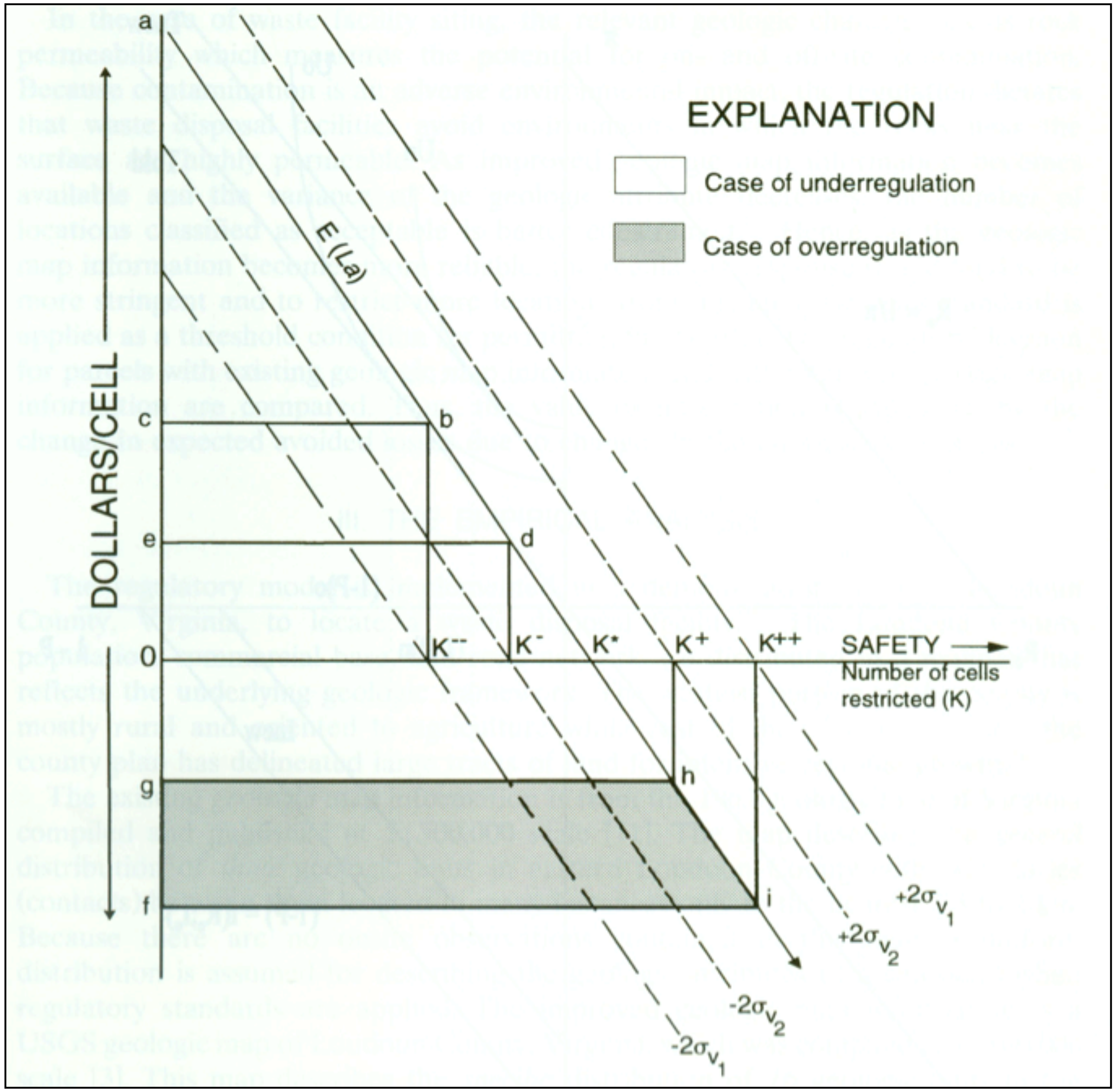
2. An inductive prospective model - An application to earthquake hazards mitigation and income distribution: Geospatial information provides input for earthquake housing risk concentration in a hazard scenario for a hazard scenario

3. A Private – Public integrated market model for ecosystem services markets. An application of geospatial information can provide an objective, replicable accounting framework to reduce transactions costs in environmental market(s) activities

Foundation for economic analysis of information - the demand for reducing uncertainty

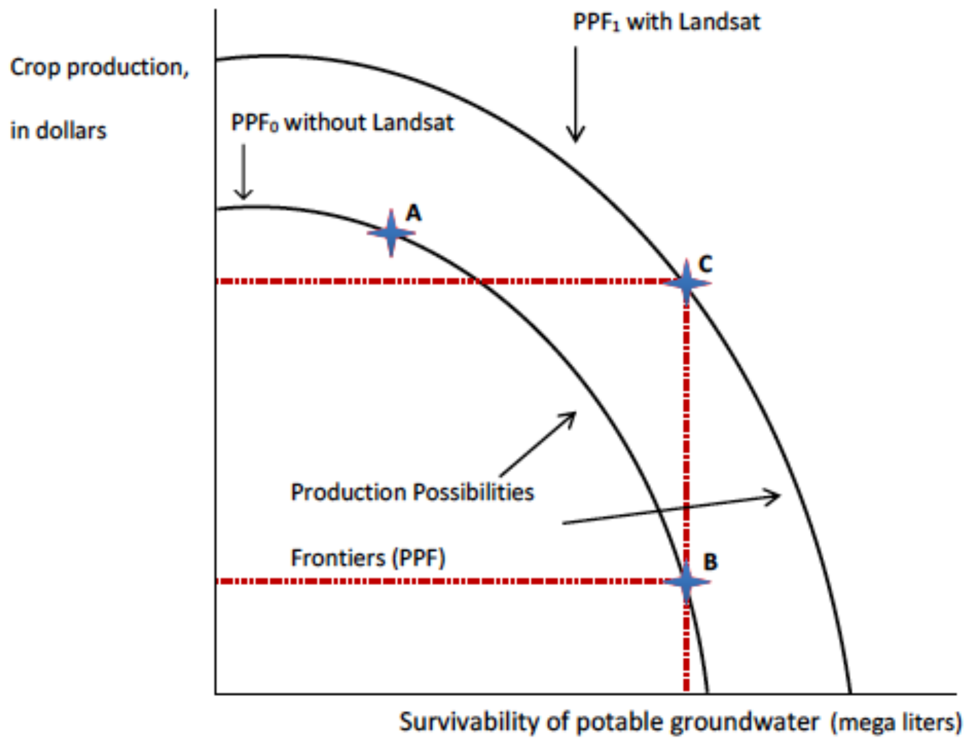
Example: Economic impact of an environmental regulation based on geospatial information. $E(L_a)$ is the marginal expected loss avoided; K^* is the optimal level of safety. $K^{++/--}$ is the safety without improved information and $K^{+/-}$ is the safety with improved. The difference in safety demanded is the VOI

(source: Bernknopf et al 1993)



An economic model of production efficiency and technological innovation for geospatial information

Production efficiency and the production possibility frontier (PPF). The PPF represents production tradeoffs of an economy given fixed resources. Movement from PPF_0 to PPF_1 is an increase in productivity. Movement along a PPF is a tradeoff between goods.



A production possibility curve for a technological innovation in geospatial data (source: Forney et al 2012)

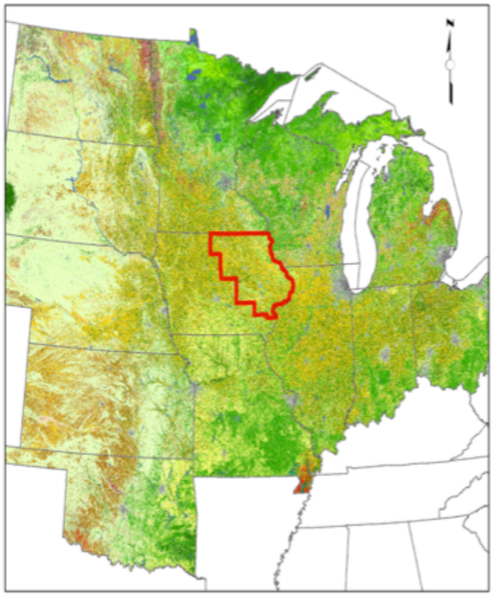
Example 1. An Inductive Retrospective Model - Environmental regulation of agrochemicals: Geospatial data provide information for regional environmental and health policy decisions

Background: Health impact and regulation, earth observation	**Investment issue:** Does Moderate Resolution Land Imagery provide economic benefits to society? **Biophysical process:** Nitrate reacts with other chemicals to create carcinogenic compounds **USEPA health standard:** Drinking water water cannot exceed nitrate concentration of 10mg/L. Exceeding the standard has been linked to multiple types of cancers, disruption of thyroid function, birth defects, methemoglobinemia (blue-baby syndrome) and hypertension **Moderate Resolution Land Imagery (MRLI):** Spatial data having a pixel resolution of 30 – 250 m. Global land use and land cover data updated on a regular basis since the 1970's

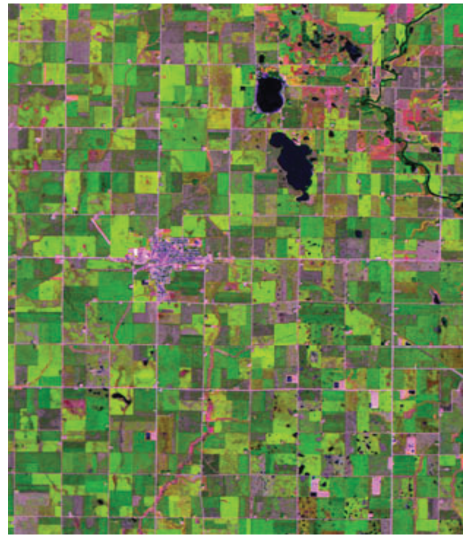
Example 1. An Inductive Retrospective Model (cont.)

Project:	
Project: Estimation of the benefits of Landsat imagery	**Approach:** Couple individual producers and regional resource managers using information from markets and natural systems to aid in maximizing agricultural production and sustaining potable groundwater **Implementation:** • MRLI archive provides a baseline for analysis • Statistical model estimated for time-dependent nitrate accumulation • Production efficiency model applied in a regulatory decision **What was measured:** • Estimated a .01 chance of exceeding the health standard from 2001 – 2010 and forecasted survivability for the next 10 years • Estimated the VOI of MRLI as an input to revising regional land use in 35 Iowa counties and 2 aquifers for production of corn and soybeans and sustaining groundwater quality

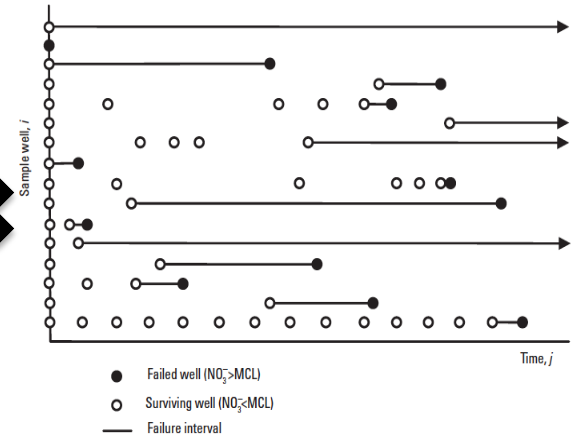
Observation, spatiotemporal patterns, earth science and statistics



Study region of 35 Iowa counties (source: Forney et al 2012)

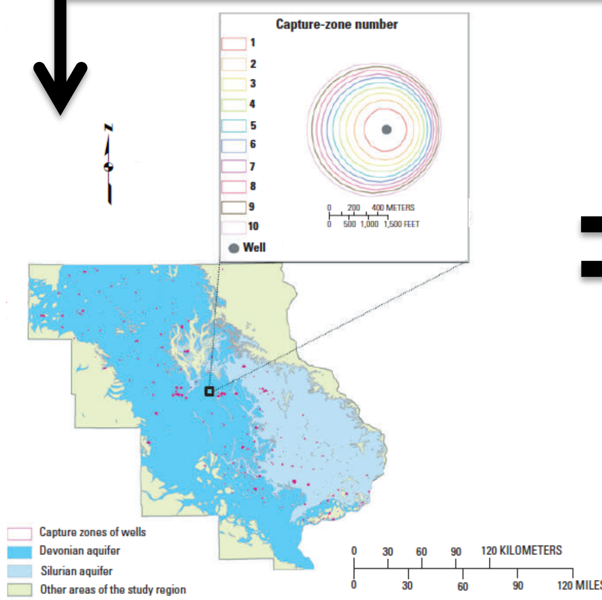


Moderate resolution land imagery (Landsat – 30m)



Wells tested for nitrates over time (NAWQA and State wells)

Map showing the distribution of capture zones (CZ's) for the northeastern Iowa study region. The CZ's are used for calculating annual nitrate loading. The insert map shows the CZ's for a particular well and their annual location during a 10-year period.



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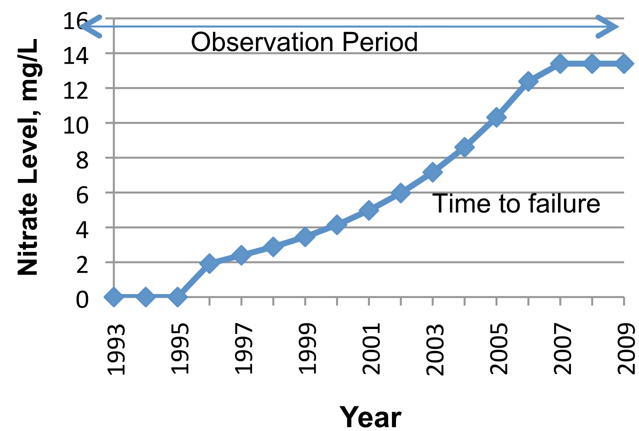


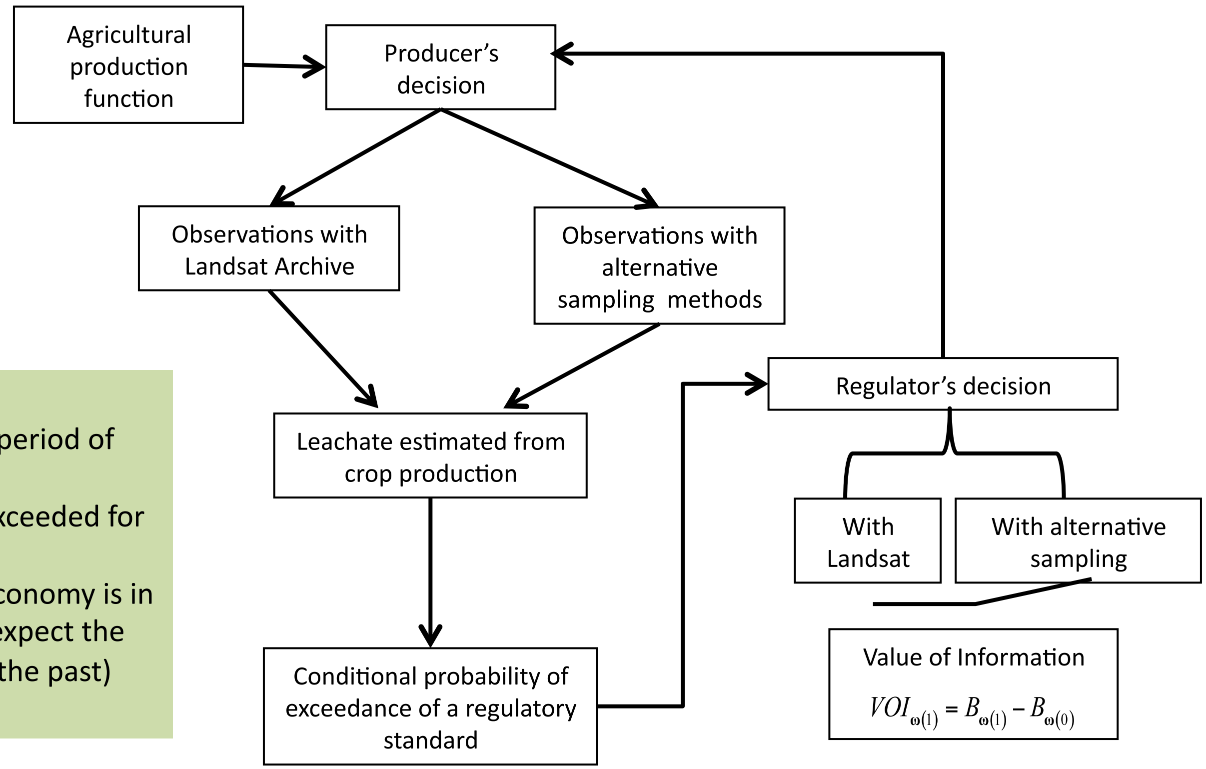
Cumulative nitrate indicator (source: Bernknopf et al 2012)

Estimating VOI

Conceptual framework: Producer and regulator choices and monetized benefits are based on the relative market value of crops and an environmental health standard

Model assumptions:

- Land use has been in agriculture during period of analysis
- Nitrate standard of 10 mg/l cannot be exceeded for the foreseeable future
- Rational expectation that the regional economy is in equilibrium (consumers and producers expect the future to be reasonably consistent with the past)



Results

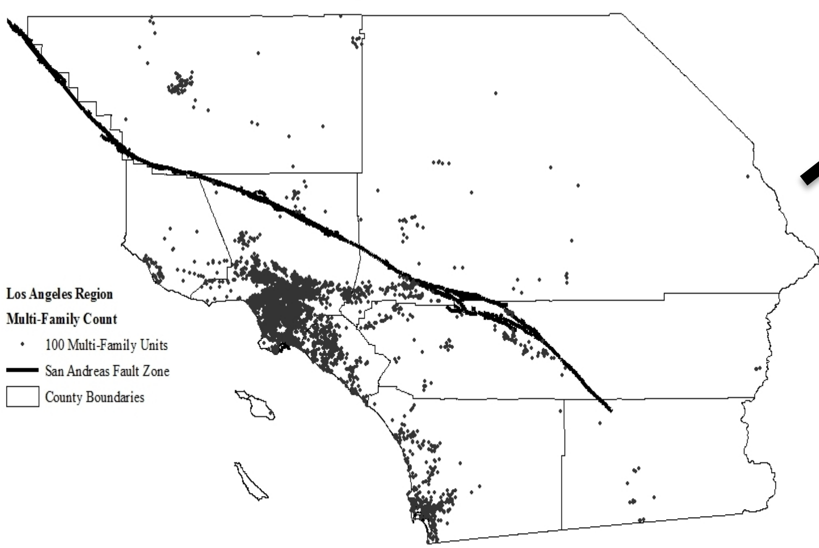
- Some groundwater wells are threatened by nitrate contamination and could fail to maintain drinking-water quality in the next 10 years. Other locations where the topography, soils, well characteristics (e g., depth and operations), and surficial geology are less likely to transport the contaminate the water supply in the future.
- Maximum estimated VOI for MRLI is an annualized \$858M ± \$197M / yr (in \$2010) and has a net present value of \$38.1B ± \$8.8B for northeastern Iowa. Estimate is an optimal solution to a benefit maximization problem with one constraint (i.e. EPA MCL).
- However, the quality of available datasets varies. Existing policies are taken as given. VOI estimates change with particular land use policies such as alterations to land uses (e.g. crop rotation patterns) and to land management (e.g. production practices).
- A conservative (more realistic) rate of land use change that yields a 1% improvement in land allocation has an estimated VOI for MRLI of an annualized \$43M / yr (in \$2010) and has a net present value of \$1.91B for the 35 counties in Iowa.

Example 2. An inductive prospective model – Application of an earthquake scenario: Spatiotemporal natural science process models provide input for estimating earthquake housing risk concentration and mitigation

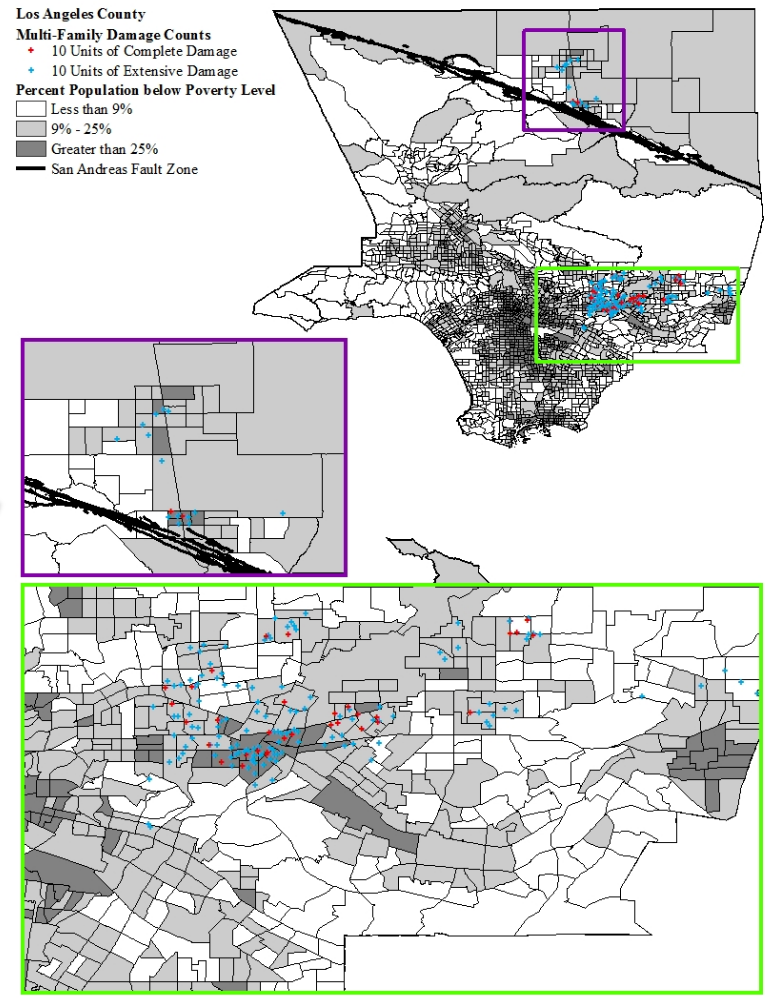
Project: Estimation of the benefits of an earthquake scenario that relies on geospatial data.	**Investment issue:** Does an earthquake scenario provide economic benefits to society? **Approach:** Couple individuals' housing and income status and regional earthquake hazards to aid in minimizing housing damage and sustaining economic production and growth **Implementation:** • Geospatial information provides baseline for analysis, natural science process models provide a scenario • Statistical model estimated for housing damage and low income concentration by census tract • Production efficiency model applied in a building regulation. **What was measured:** • Housing risk concentration by building type and income • Benefits of a retrofit building code based on mitigation efficiency and income status in Los Angeles County, CA

Pattern of expected damage to multifamily buildings in a M=7.8 earthquake scenario in southern CA

Southern CA scenario region



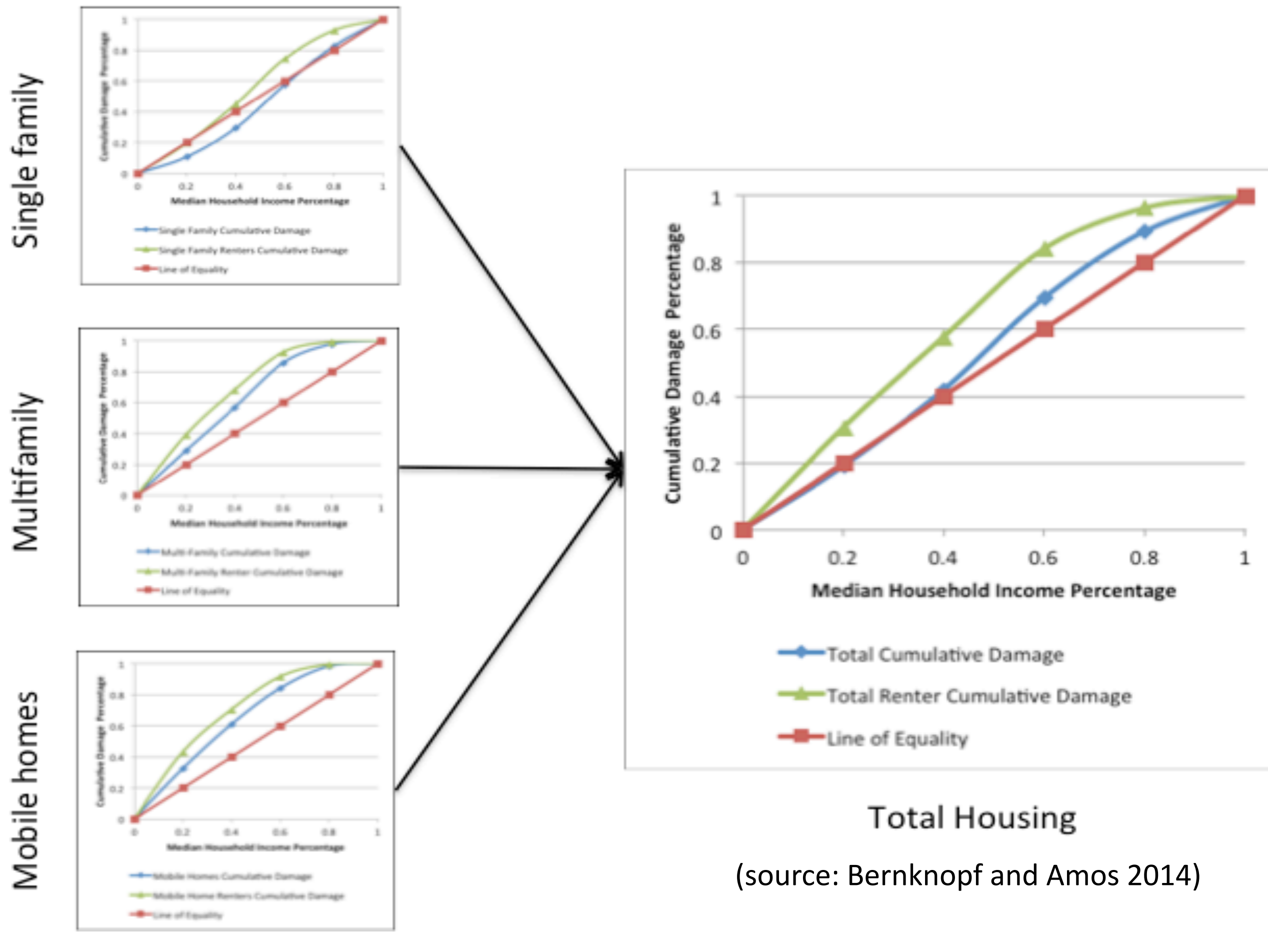
Regional distribution of multifamily building damage estimated at $2.9B



Distribution of multifamily building damage and poverty by census tract in LA County; 42.2% of county population in multi-unit structures in 2000

Map of the USGS ShakeOut scenario in southern CA and multifamily building damage (Jones et al 2008) and census tracts with high levels of poverty in LA County (source: Bernknopf and Amos 2014)

Statistical indicator of earthquake risk concentration of building damage ranked by median household income



Total Housing

(source: Bernknopf and Amos 2014)

LA County results:

- Expected net benefit of voluntary mitigation $1.1B ($0.4B) if mitigation costs are 10% (50%) of exposed real estate value
- 2,054 (2.6%) census tracts in LA County meet the income criterion for public investment (> 9% of the population below the poverty line) and would receive public investment in mitigation
- Combined program increases the net benefits by $59M and 163 more buildings mitigated

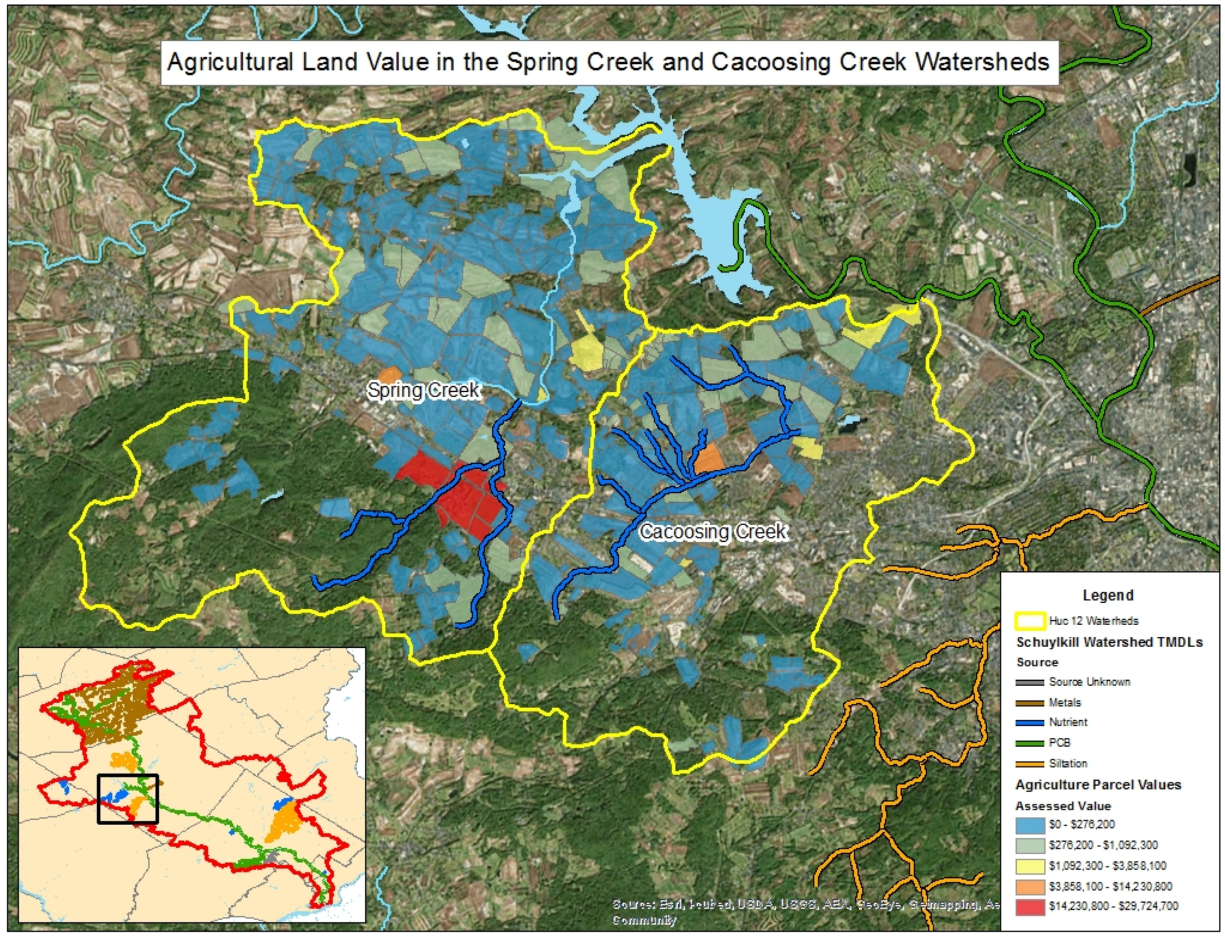
Example 3: A Private – Public integrated market model for ecosystem services markets: An application of geospatial information to reduce transactions costs in environmental market(s) activities

Project: Estimation of the benefits of a joint private-public monitoring system for ecosystem services markets	**Investment issue:** Can remotely sensed data reduce the transactions and enforcement costs of a cap and trade market? **Approach:** Couple open access and private geospatial data to aid in monitoring and enforcement of ecosystem services markets **Implementation:** • Geospatial information provides baseline for analysis and monitors change • Spatiotemporal portfolio model estimates the expected return and risk of a ecosystem service(s) market **What could be measured:** • The economic benefits of multi-scale, multispectral data in an ecosystem services market oriented program to reduce environmental externalities

Geospatial data can inform an ecosystem services market by: providing ecosystem service quality and quantity baseline, frequent monitoring to verify quantities and any changes over time, and potentially reducing onsite inspection costs

Entire market monitored on a regular basis
General: 30m – 250m resolution panchromatic and spectral bands
Specific: 0.3m resolution panchromatic and 1.4 m spectral bands

Geospatial information is
- Objective and replicable for any disputes at lower cost than without the information
- Lowers transactions costs
- Improves market efficiency
- May reduce cheating because landowners would be aware they are being observed



Map of land use, sub-watersheds, property values and impaired waterways (source: P. Amos 2014)

Summary

- Digital geospatial data is a technological innovation. Investment in the technologies that deliver geospatial data have economic benefits.

- Economic analysis can be used in specific applications to inform decisions as a Value in Use of geospatial information

- The third use case is proposed as a joint public (‘general’ information) - private (‘specific’ information) example with global implications such as reducing environmental externalities in ecosystem services markets.

Thank you

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