Assessing the societal benefits of healthy forest ecosystems with the Forest Ecosystem Services Toolkit





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Few studies have measured RES (Daily & Matson 2008)



Objectives

Develop methods for measuring RES that draw on long-term experimental research and environmental monitoring

► Quantify watershed ES provision over time, in response to forest management, discrete events (storms), chronic stressors (deposition)



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Approach

FEST identifies when, where, and how ecosystem conditions or functions (ecological data) align with human demand or values, as defined by specific benefits and beneficiaries (social data)

Ecological Data + Social Data → Ecosystem Services

Incorporates functional loads on system, and evaluates changes in probability of ES provision under changing functional loads

Evaluates ES before and after forest harvests, and between experimental and reference watersheds, at long-term research sites





Set aside in 1955 for hydrological research. Ten watersheds:
W1: Wollastonite (CaSiO₄) application in 1999.
W2: Devegetated 1965, herbicides 1966-1968.
W3: Hydrological reference watershed.
W4: Strip cut (25m bands) in 1970, 1972, 1974.

Hubbard Brook

W5: Whole tree harvest, 1983-1984, removed 180 t/ha biomass. W6: Biogeochemical reference watershed. W7, 8, 9: Reference, no treatments.

> Image USDA Farm Service Agency Image © 2012 GeoEye 43 56'20 75" N 71 45'02 49" W elev 1863 ft

JOODIC Bal

USGS experiment established in 1992 on several catchments of the Neversink Reservoir, part of the NYC watershed. Treatments conducted in 1995-1997.



NS25: light selective cutting (7% BA reduction) SS20: heavy selective cutting (29% BA reduction) DC57: clearcut (97% BA reduction) CL25: control

146811

Eve all

Image © 2012 GeoEye

DC57

CL25

Turkey Lakes

Established in 1980. 14 gauged first order watersheds. c31: 10 cm DL harvest (89% BA removal) c32: reference c33: selection harvest (29% BA removal) c34: shelterwood harvest (42% BA removal)

c35: reference Others untreated.

© 2012 Cnes/Spot Image

Google earth

Eye alt 22132 ft



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► Rescale discharge by watershed area proportion of basin



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"the Goldilocks Zone" (GLZ)

Simple binary assessment (service provided or not) yields several metrics

Flow maintenance: percentage of days within high/low thresholds

Cleared watershed has lower overall flow maintenance. This effect persists long-term.



WS2 cleared & herbicide (1965-1968) WS6 reference

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Flow stability: average duration of time without high or low events

Cleared watershed has slightly shorter periods of continuous flow regulation (same rainfall inputs as reference).



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Storage: average runoff ratio

Cleared watershed stores less water on average until ~20 years post-harvest.



WS2 cleared & herbicide (1965-1968) WS6 reference



On average, how much rainfall results in a flood event?

► Mean antecedent 72h rainfall (storm intensity) before high flow events

Cleared watershed required significantly less storm intensity to "flood"

10 years after de-vegetation of WS2 (1966-1975)



On average, how much rainfall results in a flood event?

► Mean antecedent 72h rainfall (storm intensity) before high flow events

Cleared watershed required significantly less storm intensity to "flood"

How large of a moisture deficit results in failure to meet water use demand?

► Mean antecedent moisture deficit (30 days) before low flow events

Cut watershed required **significantly more drought** to result in water deficit

10 years after de-vegetation of WS2 (1966-1975)

Flow regulation & climate



Flow regulation & climate



Water quality regulation

Selected thresholds for several pollutants / conditions

►NO³ ►SO⁴

► Cl-

▶pH

►A

Threshold selection priority:

- 1. State or local
- 2. Federal secondary standards

We used EPA TRACI to estimate eutrophication potential of stream water, based on three solutes http://www.epa.gov/nrmrl/std/traci/traci.html

Evaluated monthly stream chemistry based on thresholds

Several metrics produced...



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Does the watershed mitigate eutrophication of surface water by removing pollution in rainfall?

Ratio of eutrophication potential (TRACI) of stream water : rainfall

Unharvested forest watershed removes between 10-95% of bulk deposition inputs on an annual basis

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How does forest management affect this regulation service?

Harvested watersheds become large but transient N sources

Forest regeneration enhances N removal, but how long does it take to <u>offset</u> harvest-related N sources?

We aggregated metrics into single index of water provision service

Integrates regulation of quantity and quality regulation over time

Weighting scheme based on:

Survey of beneficiaries (local population near watershed)
Management priorities
Regulatory and policy options
FEST.net users



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Transient decreases in ES, but watersheds appear to recover





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Land Use Impacts on Water Provision Services

-10



year since harvest

0

10

20

Stakeholder surveys to provide weights for composite ES indices, GLZ distributions 4. How important are the following benefits of forests TO YOU AND YOUR FAMILY? In choosing your answers, consider the benefits you receive from both public and private forests, not just forests that you personally own.

Select one answer for each row.

	Not Important At All (1)	Not Important (2)	Somewhat Important (3)	Important (4)	Very Important (5)	Extremely Important (6)
To enjoy beauty or scenery	0	•	\circ	•	•	\circ
To protect nature or biological diversity	0	0	0	0	0	0
To provide clean drinking water	0	•	\circ	•	•	\circ
To protect against flooding or drought	0	0	0	0	0	0
To protect or improve wildlife habitat	•	•	•	•	•	0
For spiritual or religious purposes	0	0	0	0	0	0
For historical or cultural legacy	•	\circ	\circ	•	•	\circ
For firewood (and other uses of wood for energy)	0	0	0	0	0	0

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Fine-scale temporal responses to extreme events (e.g., storms)

Hampshire: 8/29/2011 1-Day Observed Precipitation at 8/29/2011 1200 UTC - Created 8/31/11 23:30 UTC

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Application of FEST to assess social and economic impacts of the acidification and potential recovery of forests and waters in the Adirondack Park, NY

Summary

▶ FEST is a systems-based, data-driven approach to quantifying ecosystem services (ES) and their societal benefits

Focused on the regulating services, their provision over time, and their responses to multiple drivers of change

Capable of estimating probability of future service provision as climate, land use, and deposition change

► Healthy forests → healthy water → healthy communities

► Working forests may provide healthy water too...

... but land use change may impair water regulation services

Thanks. Questions?

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- Turkey Lakes: Fred Beall
- Frontier Spatial LLC
- ▶OpenGeo, Project R

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🔫 Hubbard Brook Research Foundati

