Ecosystem Services:
Paths and Challenges for Quantification and Valuation

Summit on Realizing the Circular Carbon Economy

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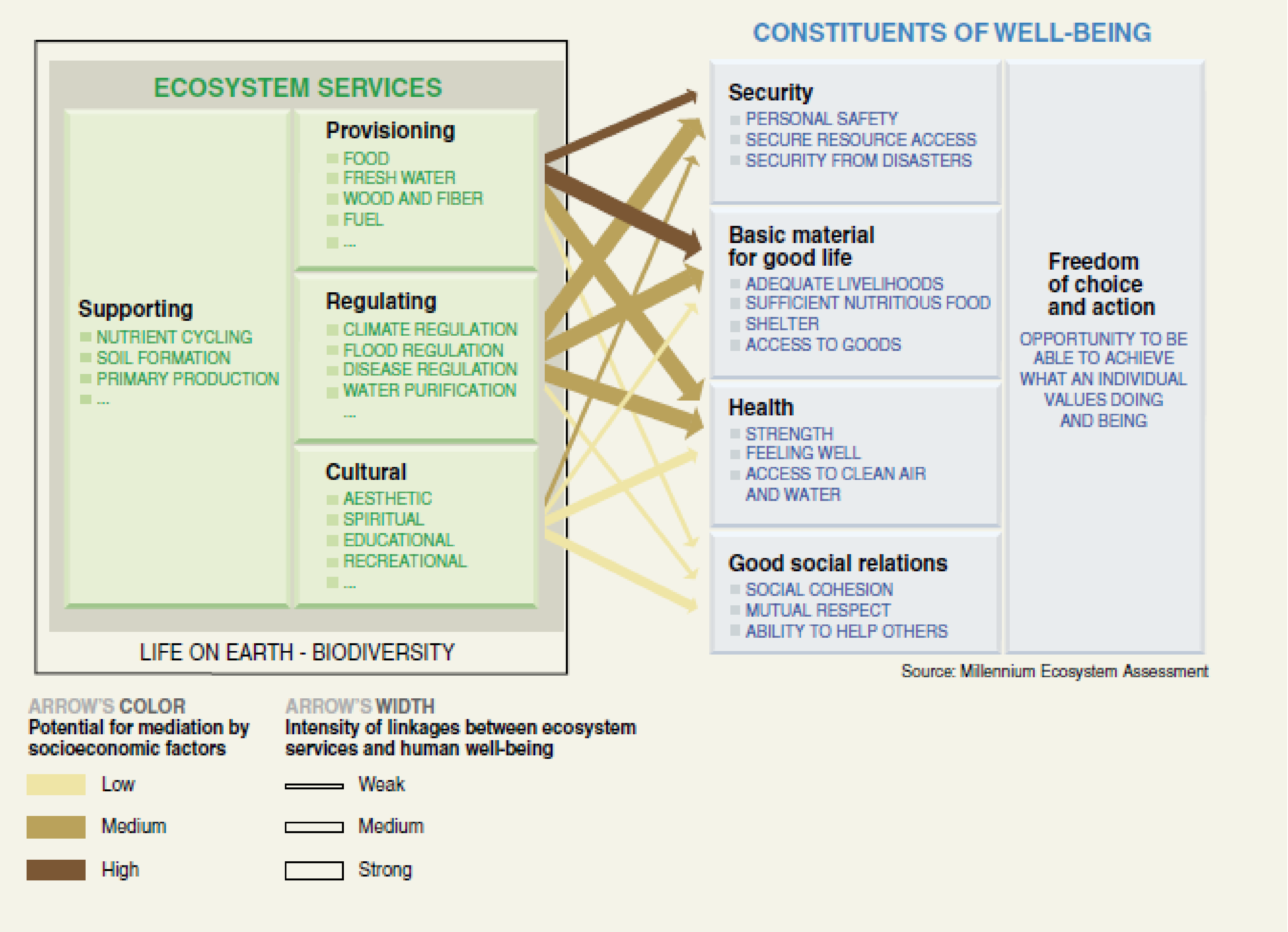
Ecosystem Services

The benefits received by people from ecosystems

(Millennium Ecosystem Assessment, 2005)



A multistep approach

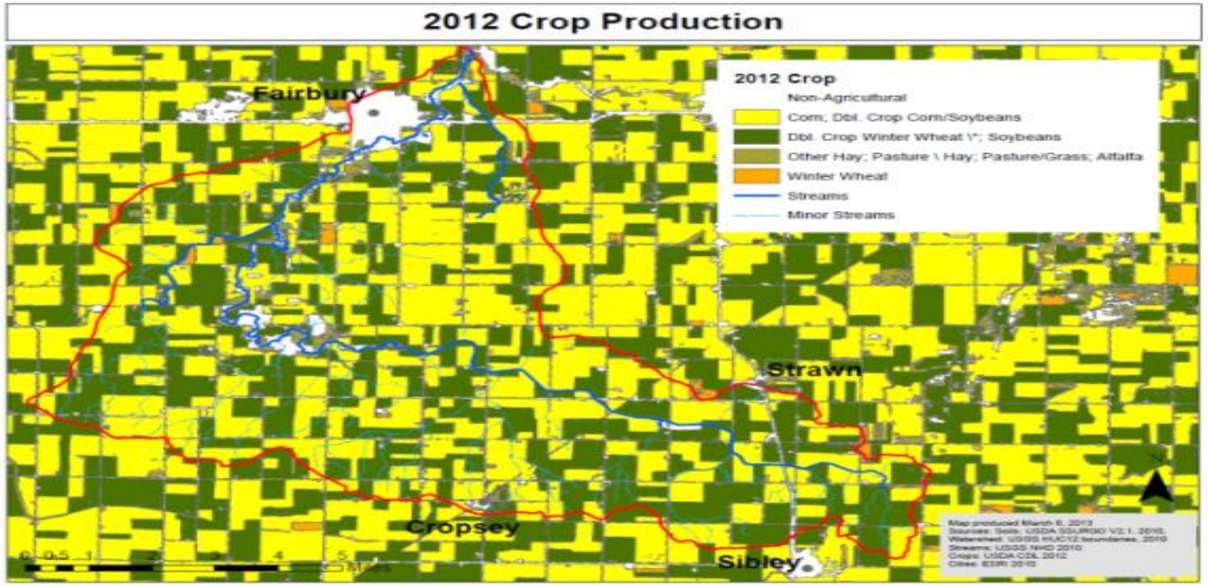
- Identification of the ES goals
- Quantification
- Valuation
- (policy, regulatory, or voluntary action)
- Payment framework

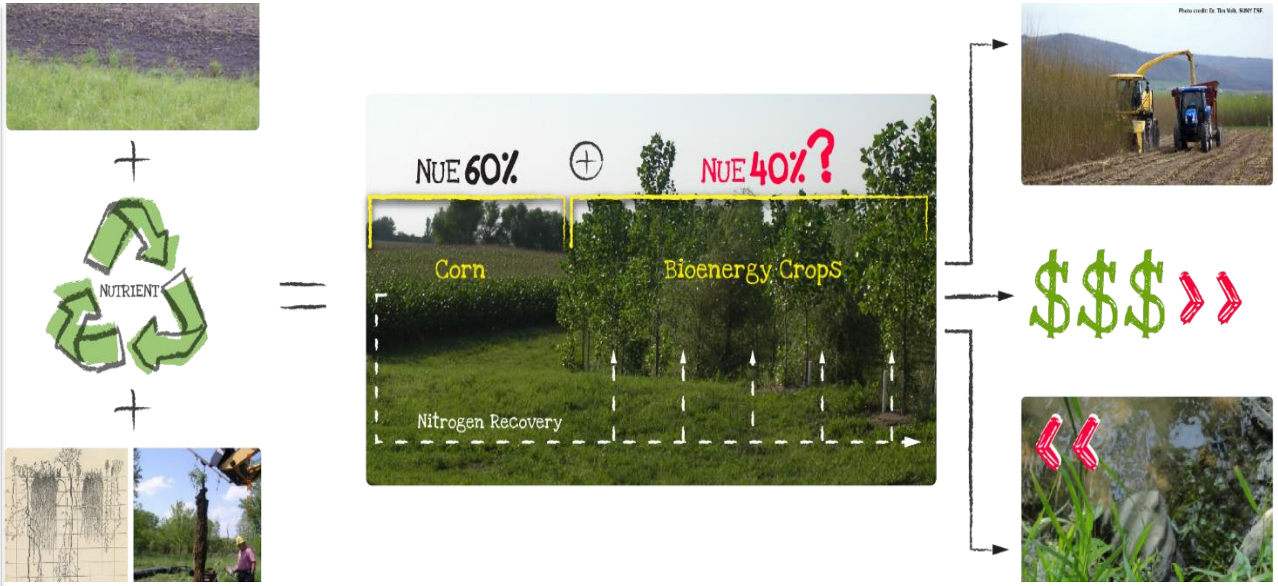
Decision making frameworks

- *Cost –benefit analysis*
- Environmental Impact assessment
- Programmatic Environmental impact assessment
- Lifecycle analysis
- Risk assessment
- Techno-economic analysis
- Multi-criteria analysis

Evaluating damage | Preventing damage | Enhancing natural capital and human wellbeing

Landscape design vs BAU – meeting societal goals and the circular economy





Business As Usual (BAU) focused on one *provisioning* service

- yields, profit.

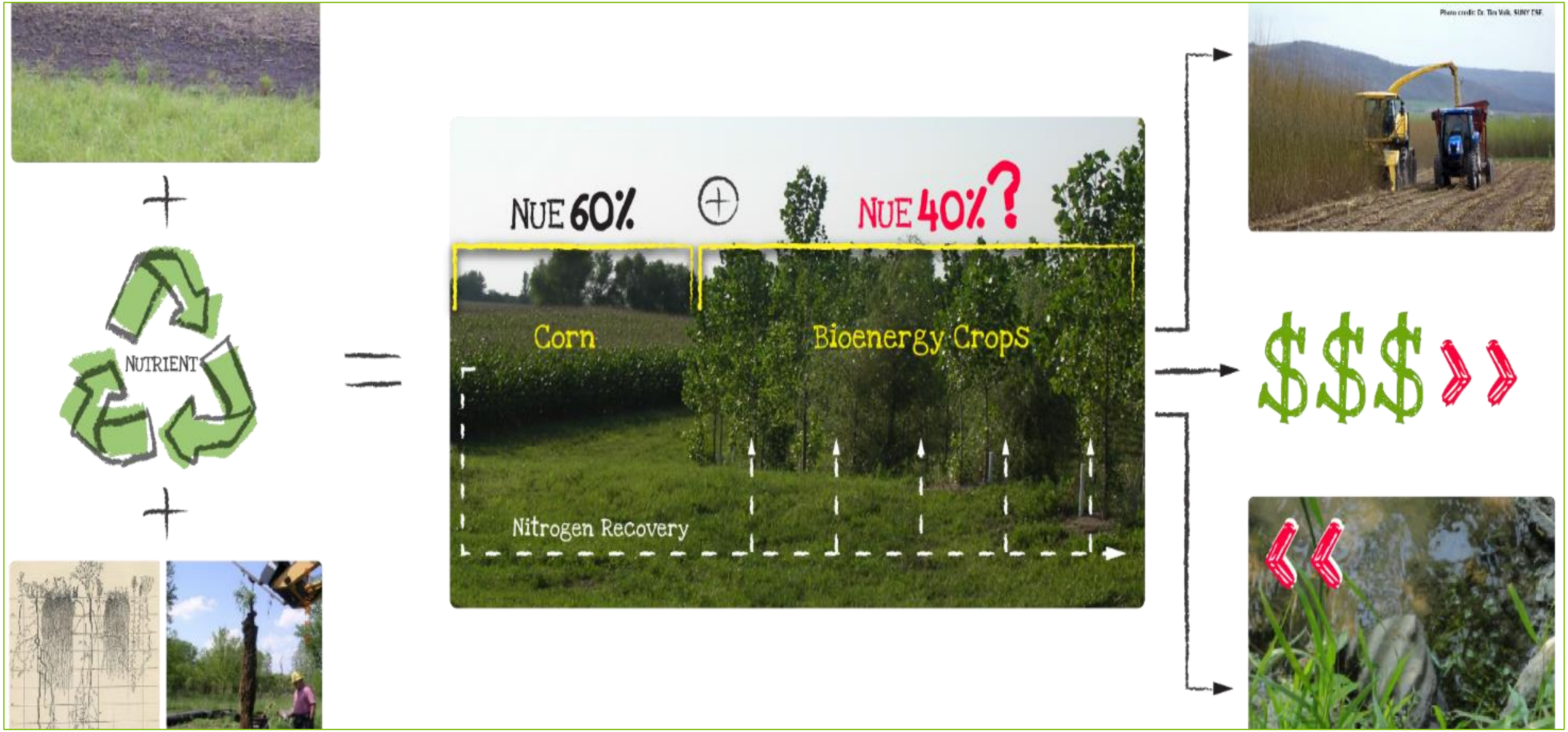
Regulating services not factored in the economics, called externalities

Conceptual focus is how to mitigate the impacts retroactively

Landscape Design focused on providing:

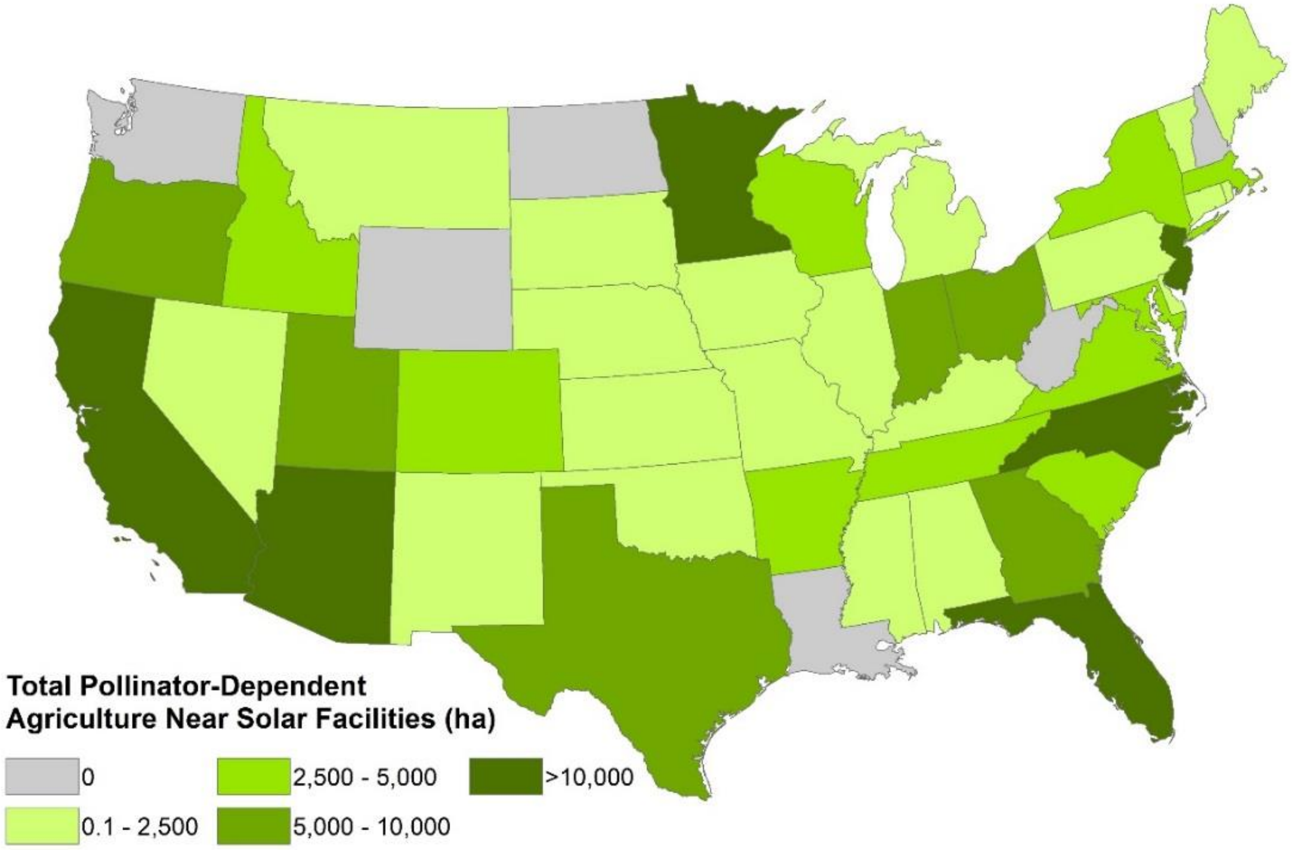
- *Provisioning services* – optimize yields of food, feed, fiber, bioenergy, bioproducts
- *Regulating services*: water quality, habitat, C sequestration, GHG reduction, flood control, etc. are part of the design
- Economic models accounts for both
- Conceptual model focuses beyond mitigating impacts, on “how to design” so that all services are incorporated and desirable externalities are obtained

On the circular carbon economy and nitrogen



Improving the Environmental Compatibility of Utility-Scale Solar Development (SETO)

- From environmental impact assessment to improving natural capital
- Stacking ecosystem services through vegetation management at solar facilities
  - –Renewable energy
  - –Pollinator habitat

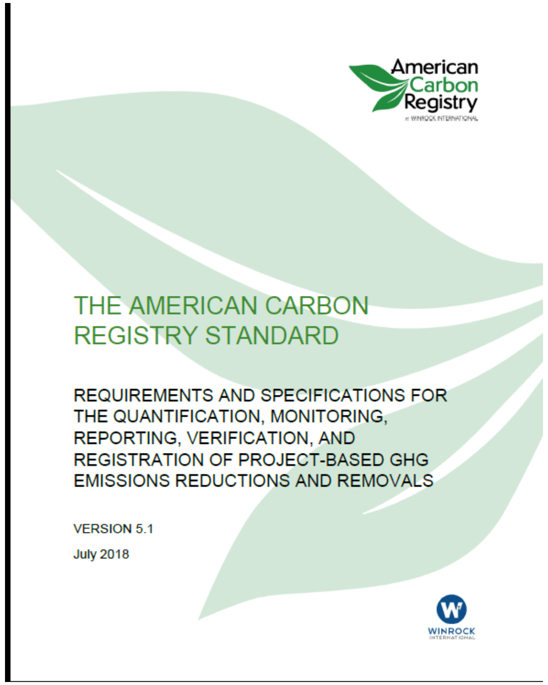


Over 3,500 km^2 pollinator-dependent agriculture in the vicinity of utility-scale solar facilities across the U.S., underscoring the potential beneficial implications of solar-pollinator habitat for agricultural production.

Walston et al., 2018 DOI: 10.1021/acs.est.8b00020

How are Ecosystem Services quantified?

- Defined in standards
  - American Carbon registry
  - Climate Action Reserve
  - Verra/Verified carbon Standards
  - Others
- Generally incorporating IPCC methods (AFOLU)
- Field scale research
- New technology, remote sensing
- Modeling – Century, DNDC, InVest suite, other models
- Available data banks (EcoINFORMA, BISON, EnviroAtlas….)
- Scientifically defensible evidence
- Inspections


American Carbon Registry

THE AMERICAN CARBON REGISTRY STANDARD

REQUIREMENTS AND SPECIFICATIONS FOR THE QUANTIFICATION, MONITORING, REPORTING, VERIFICATION, AND REGISTRATION OF PROJECT-BASED GHG EMISSIONS REDUCTIONS AND REMOVALS

VERSION 5.1

July 2018

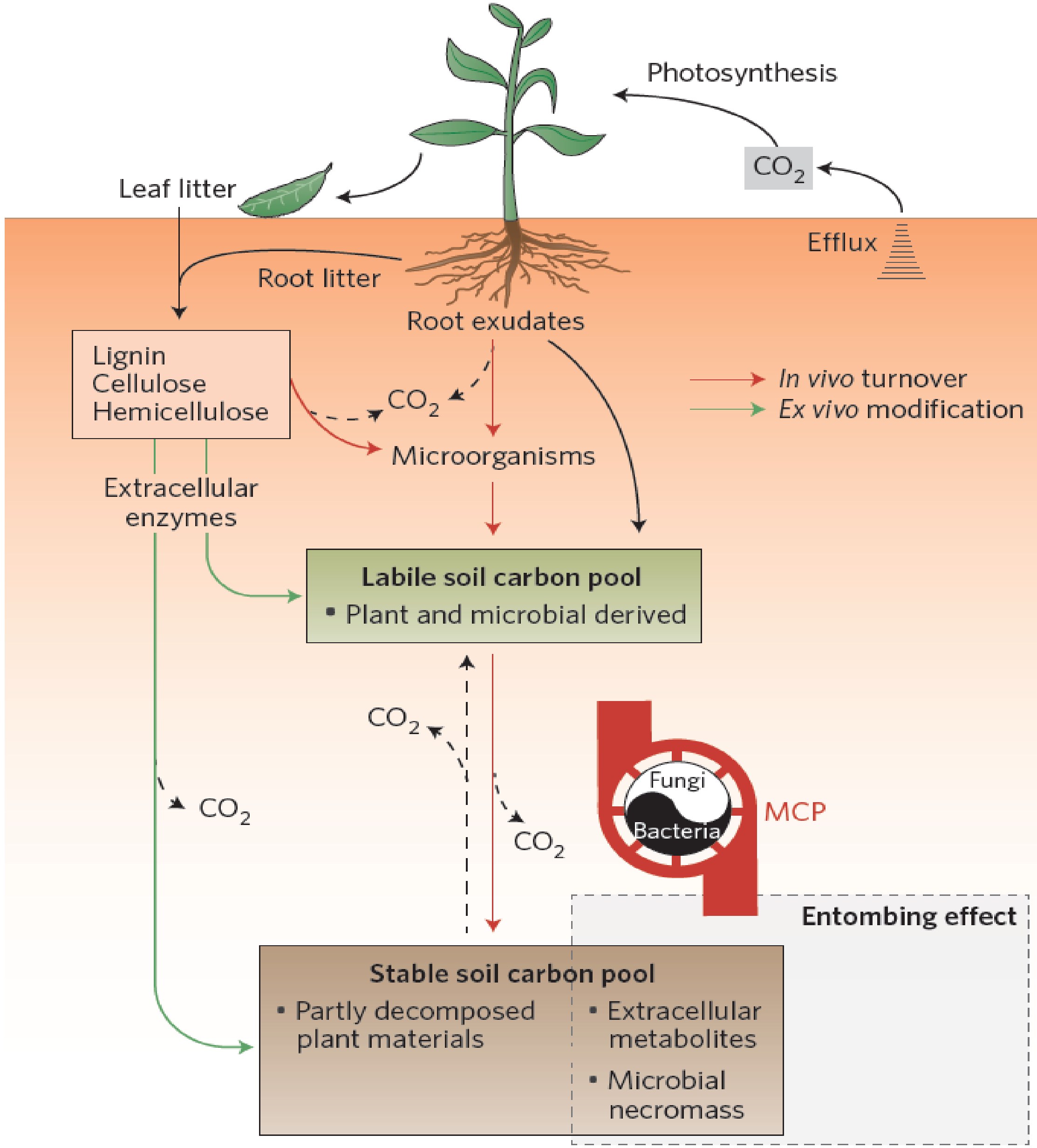
WINROCK

https://www.c-agg.org/voluntary-ghg-registries/

The complexity of the carbon cycle

- Labile vs stabile C
- Timescales for release – the problem with accounting accruals that occur over long timeframes
- What counts for sequestration/storage?

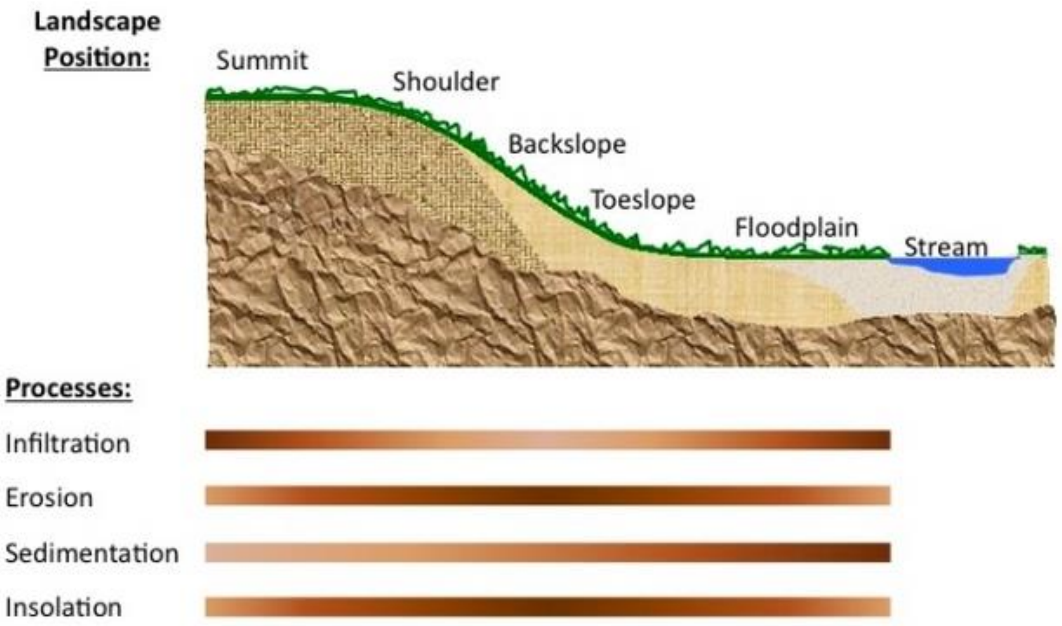
Figure 1 | Schematic diagram of microbial metabolic processes involved in C cycling in terrestrial ecosystems. Primary production inputs to soils occur through two pathways—*in vivo* turnover and *ex vivo* modification—that jointly explain soil C dynamics driven by microbial catabolism and/or anabolism before entering the stable soil C pool. Even though the relative importance of *in vivo* turnover (red lines) and *ex vivo* modification (green lines) vary with different environmental scenarios, we argue that the majority of C that is persistent in soils occurs through coupling of the soil microbial carbon pump (MCP; associated with the *in vivo* turnover pathway) to stabilization via the entombing effect. The soil MCP is a conceptual object to demonstrate the fact that microbial necromass and metabolites can be the precursors for persistent soil C, which particularly highlights the importance of microbial anabolism in soil C storage. The *yin–yang* symbol is used to create a sense of movement and illustrate that the movement is driven, but driven differently, by both bacteria and fungi with different trophic lifestyles.



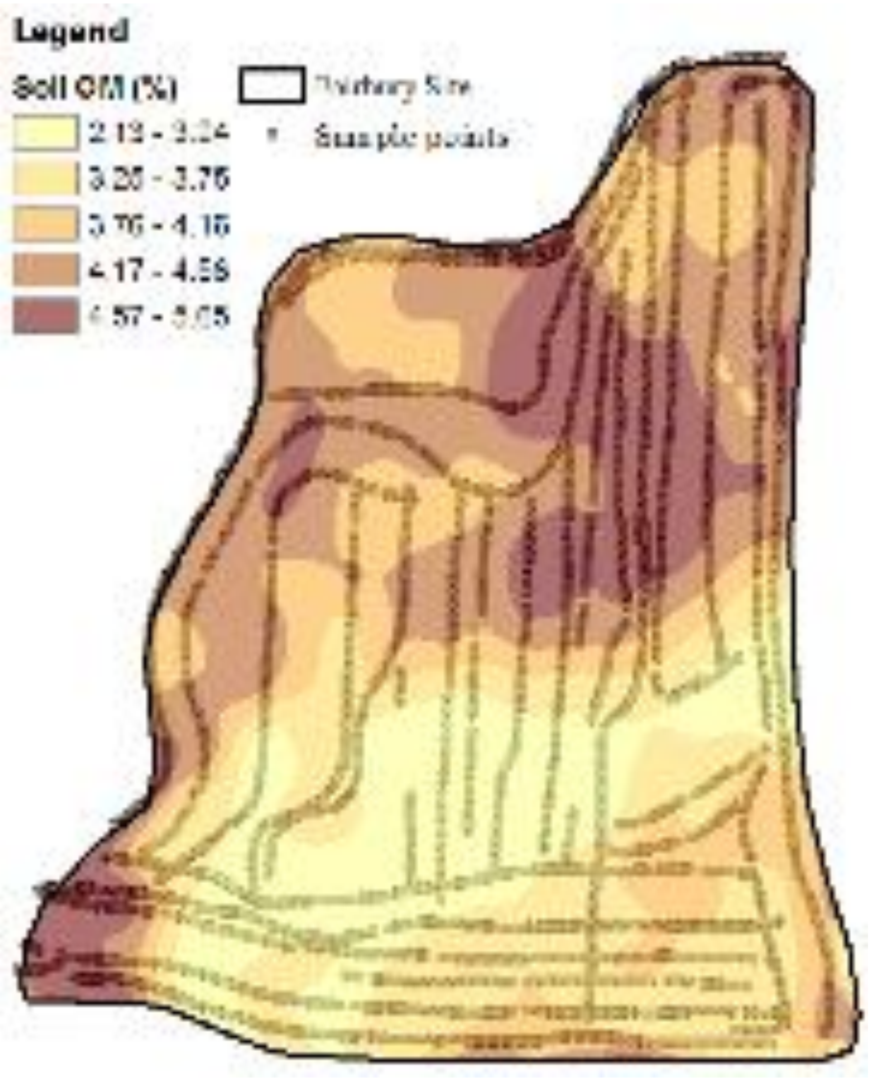
Liang, Schimel and Jastrow, Nature Microbiology 2017

Quantifying C storage as an ecosystem service

- Temporal horizons
- Practices and the uncertainty of their performance
- Spatial resolution – not all land is created equal
- Conventions on depth

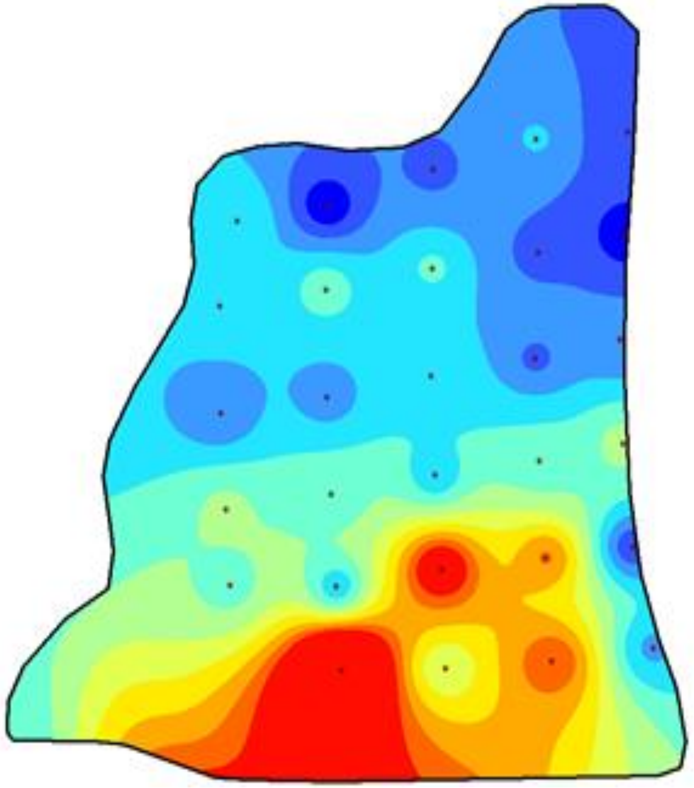


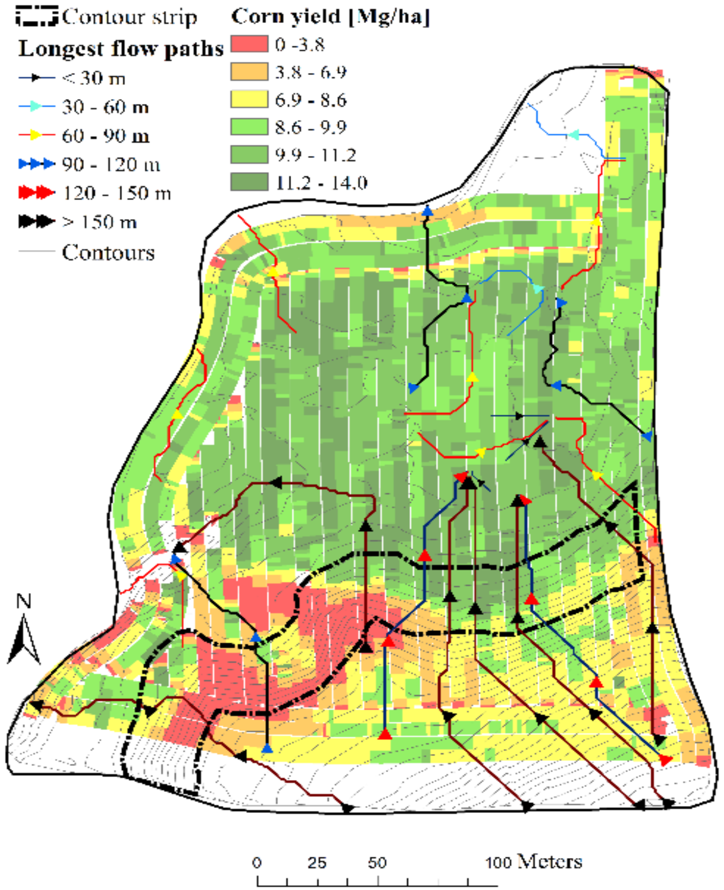
© 2012 Nature Education Photo courtesy of Todd Ontl.



Other Ecosystem Services

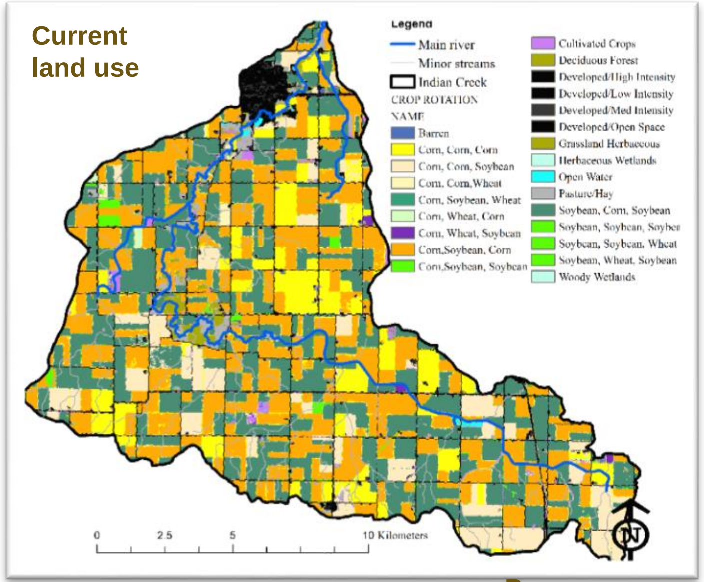
- Water quality
  - Large spatial differences, and the impact of practices in different places
  - Nutrient trading and the Gulf hypoxia
- Oher ecosystem services
  - Pollination
  - Pest control
  - Biodiversity and habitat
  - Hunting and recreation





Watershed design increases ES in marginal land

Current land use



Surface water ponding

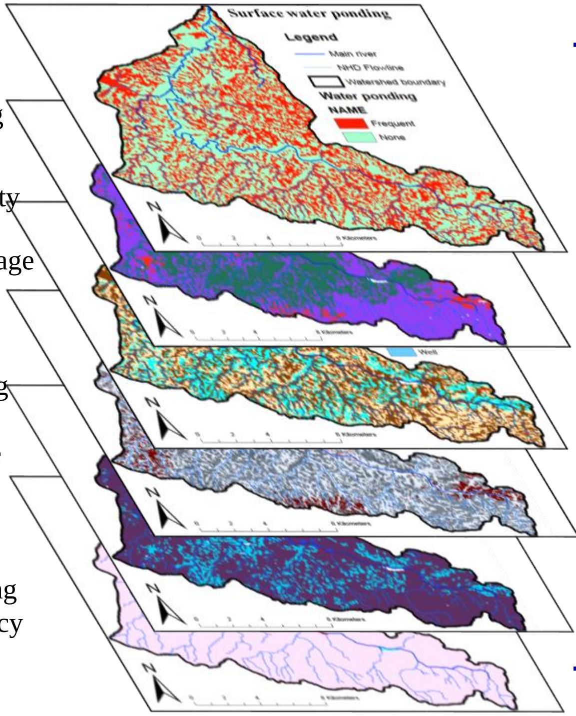
Crop productivity index

Soil drainage

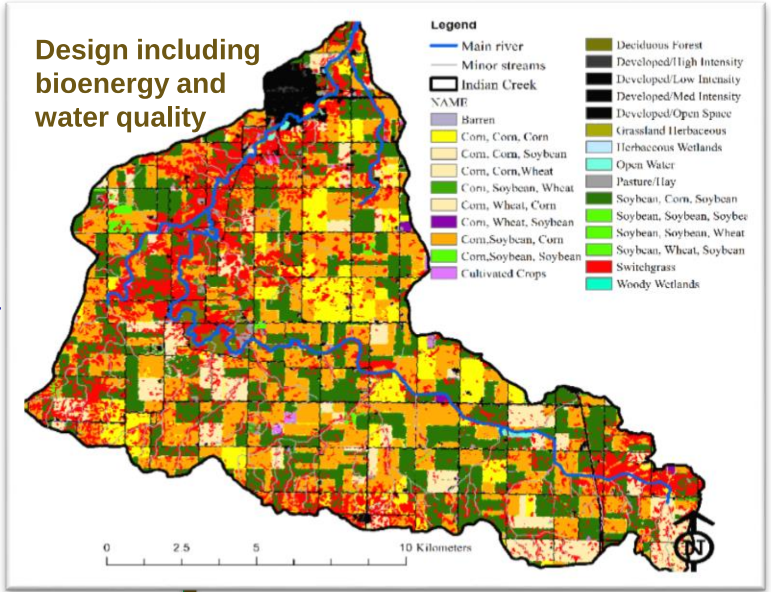
Nitrate leaching

Pesticide leaching

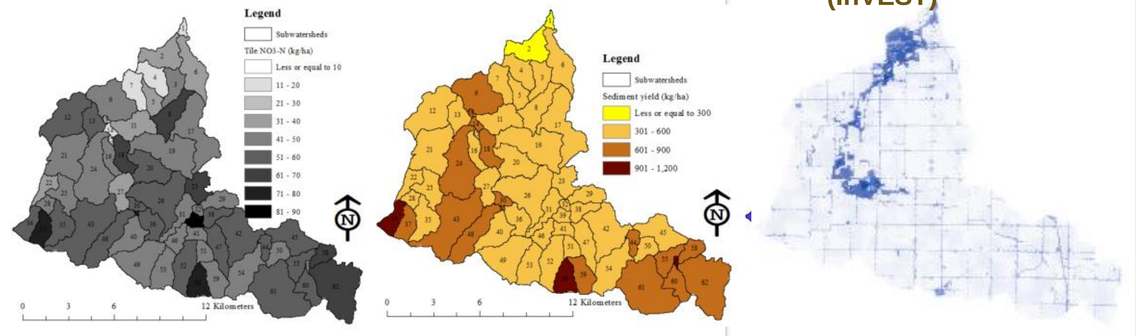
Flooding frequency



Design including bioenergy and water quality



Tile- nitrate leachate | Sediment yield | Pollinator nesting index (InVEST)



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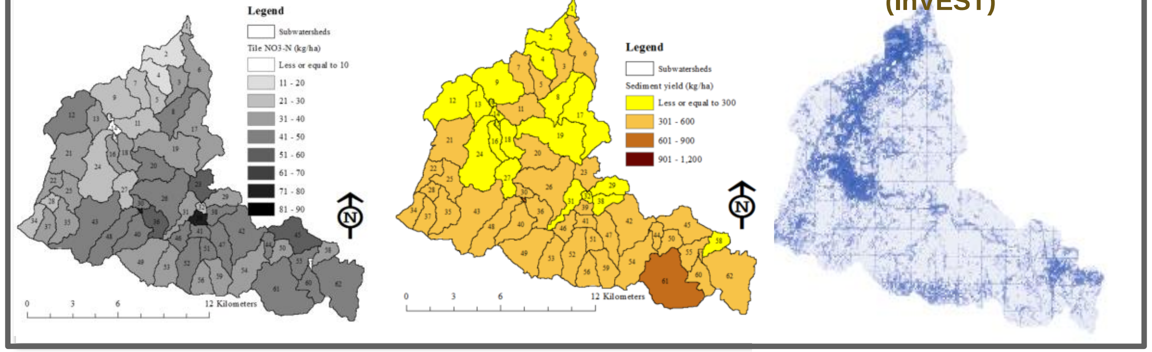
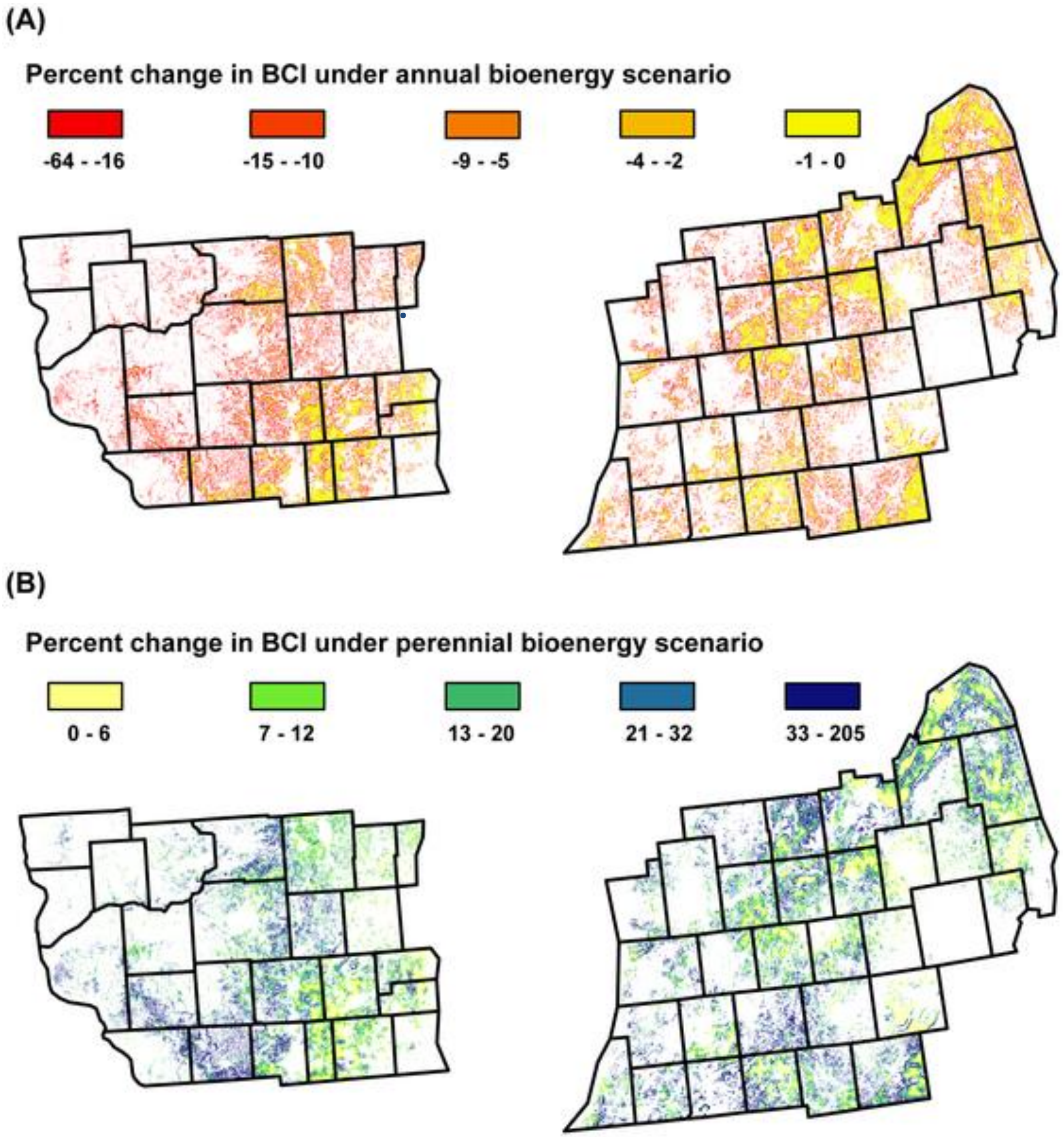


M | SNRE

Ssegane et al., 2016

Pest control



Meehan TD, Werling BP, Landis DA, Gratton C (2012) Pest-Suppression Potential of Midwestern Landscapes under Contrasting Bioenergy Scenarios. PLOS ONE 7(7): e41728. https://doi.org/10.1371/journal.pone.0041728
http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0041728

PLOS ONE

There are tradeoffs

Ecosystem services framework implies system level thinking to maximize benefits

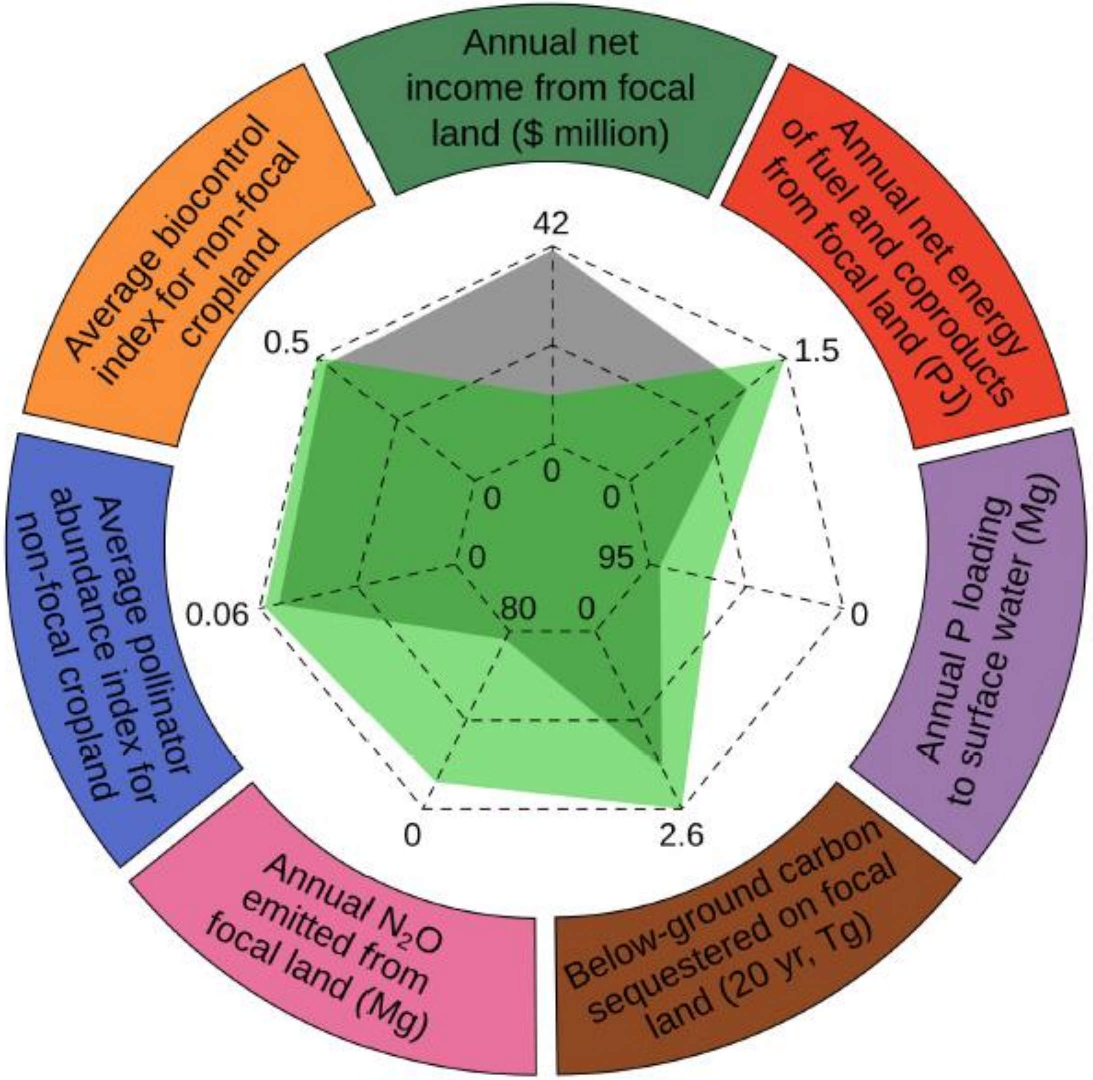


Figure 2. Ecosystem services from focal land. Seven ecosystem services derived from 16,727 hectares of focal land under continuous-corn (gray polygon at center) and perennial-grass (green polygon at center) bioenergy scenarios. Note that axes for phosphorus pollution and nitrous oxide emission are reversed so that the most positive environmental outcomes are consistently furthest from the origin.

doi: 10.1371/journal.pone.0080093.g002

Meehan et al., 2013

PLOS | ONE

Total Economic Value and Ecosystem Valuation

Table 4.1: Valuing ecosystem services through the TEV framework

MA framework		TEV framework			
MA Group	Service	Direct Use	Indirect use	Option value	Non-use value
Provisioning	Includes: food; fibre and fuel; biochemicals, natural medicines, pharmaceuticals; fresh water supply	*		*	
Regulating	Includes: air-quality regulation; climate regulation; water regulation; natural hazard regulation etc.		*	*	
Cultural	Includes: cultural heritage; recreation and tourism; aesthetic values	*		*	*
Supporting	Includes: Primary production; nutrient cycling; soil formation	*Supporting services are valued through the other categories of ecosystem services*			

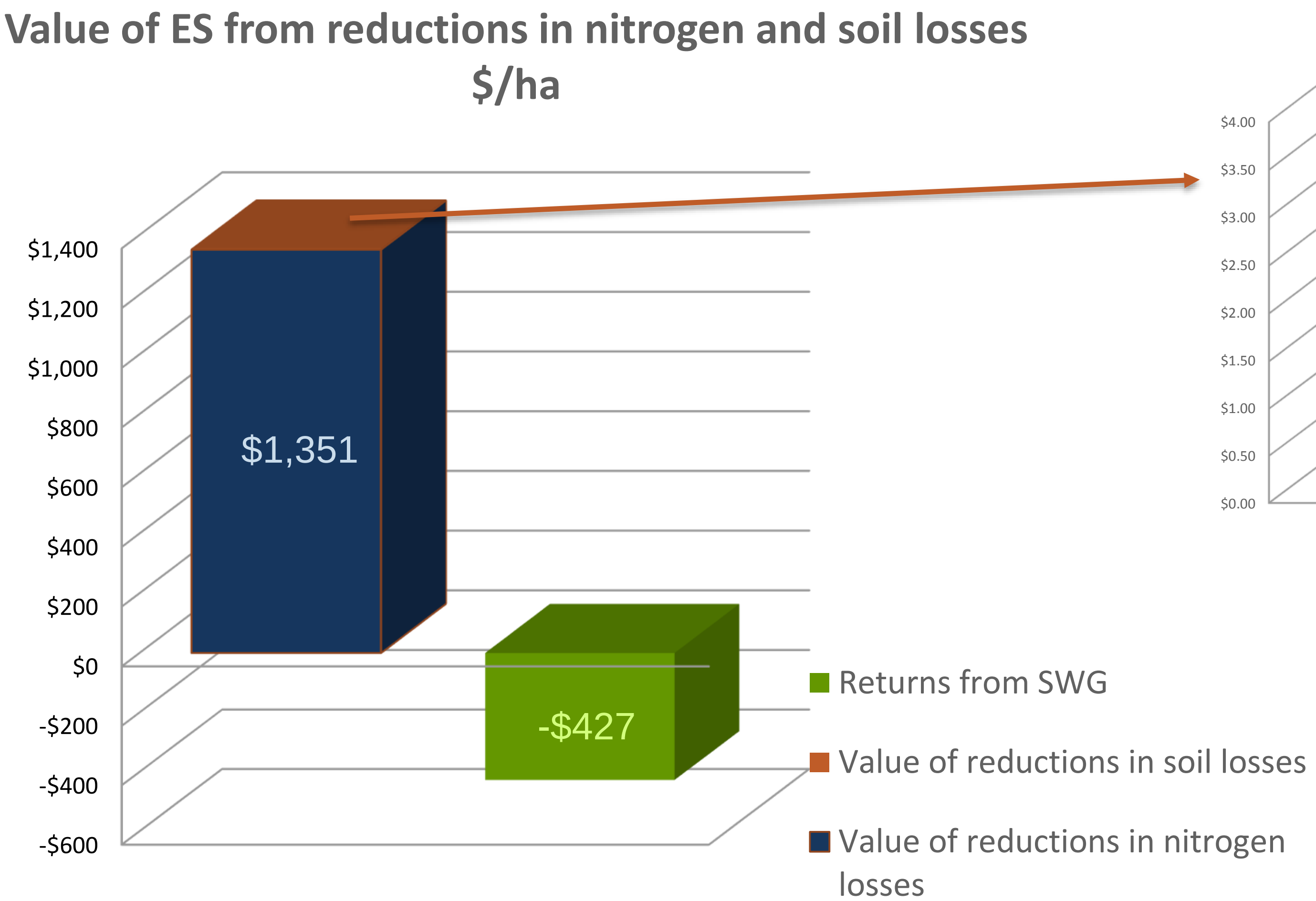
Towards valuation -

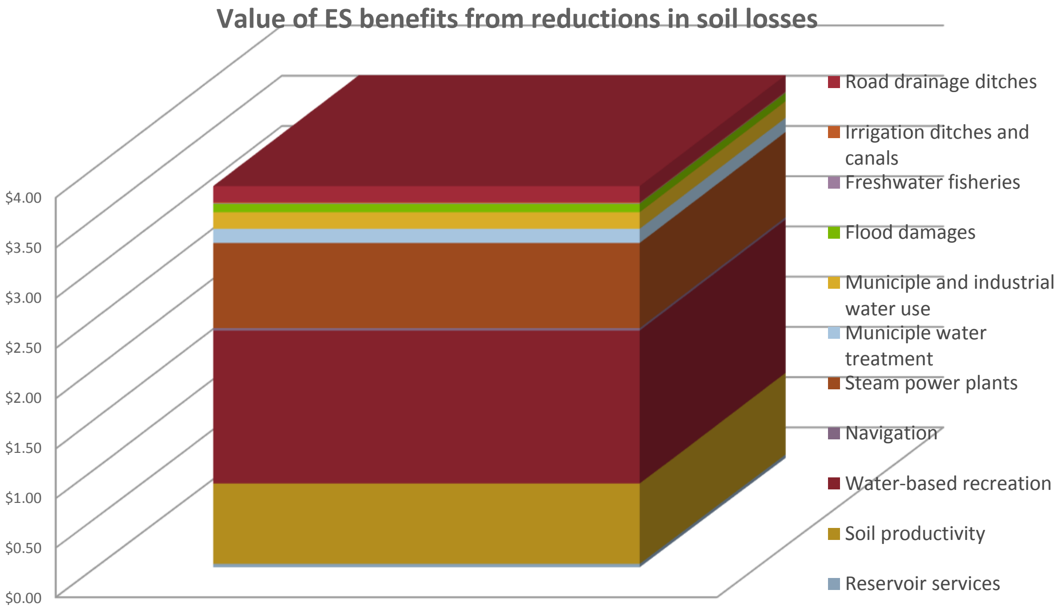
- Valuation is in the context of policy analysis
- Anthropocentric value: contribution to human wellbeing – indirectly to other biota
- Marginal increase in the value of ecosystem services attributed to the new system compared to baseline (as opposed to absolute value)
- Total Economic Value framework
  - Use and non-use value
  - Market and non-market valuation techniques
  - The availability of data and the type of ES determine which method is used.

1.Market price method – can be applied to commodities traded on the market, e.g. oil, corn etc.
2.Productivity method – can be used for ecosystem services that contribute to the production of commodities, e.g. fresh water in an aquaculture pond.
3.Hedonic price method – can be used for ecosystem services that affect the economic value of other commodities, e.g. a forest which increases the value of properties around it.
4.Travel cost method – can measure the value of recreational areas by calculating how much people will pay to travel to and visit those sites.
5.Damage cost avoided, replacement cost and substitute cost methods – can measure the cost of avoided damage to ecosystem services, of replacing or providing substitutes for those services, e.g. the cost of artificial crop pollination in the absence of bees and other pollinating insects.
6.Contingent valuation method – can be used to elicit the value of any ecosystem service based on asking people to choose between ecosystem services.
7.Benefit transfer method – estimates the value of ecosystem services based on an already completed valuation in another place.

http://www.ceeweb.org/work-areas/priority-areas/ecosystem-services/how-to-value-ecosystem-services/

Case study – landscape design for water quality and biomass production

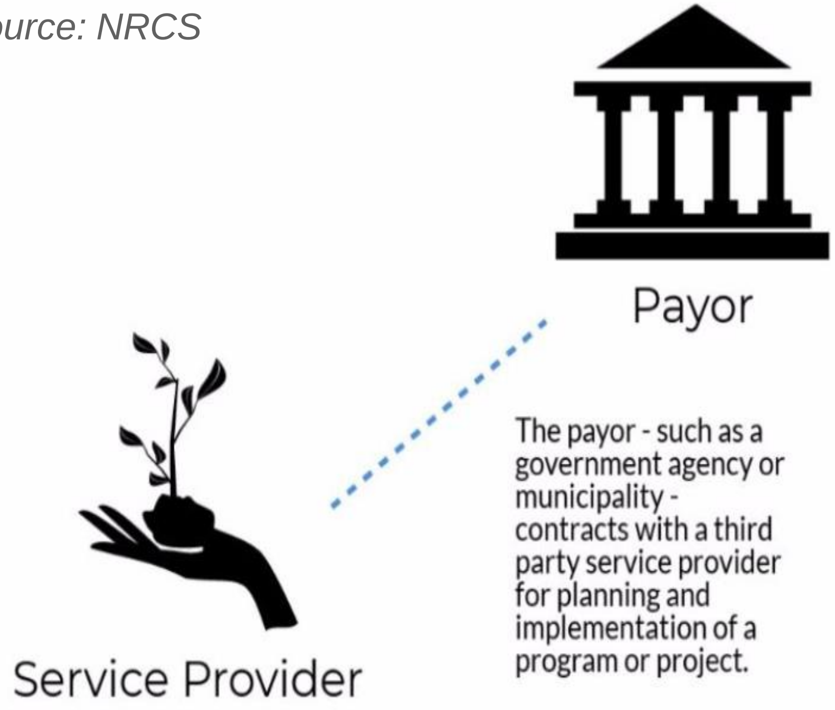




Per hectare, losses from switchgrass production could be more than compensated by the value of the Ecosystem Service provided.

Private- Public mechanisms for Ecosystem Services payment
NRCS - Pay for Success and others

Source: NRCS



- i2 Capital's project, with The Nature Conservancy, Quantified Ventures, and other partners in the Brandywine-Christina watershed (Delaware, Maryland, and Pennsylvania). If successful, private investment will flow to private landowners, with PFS payments coming from downstream beneficiaries such as water utilities and municipalities.
- American Rivers - in partnership with Environmental Defense Fund and other non-profits, agencies, and utilities - created the Central Valley Habitat Exchange. This PFS program connects producers and landowners with public and private conservation buyers, creating a one stop shop for investment, measurement, and habitat credit sales in the Central Valley.
- Ohio River Basin Interstate Water Quality Trading Project (funded by EPRI)
- Fox River Valley Phosphorus Trading Program Fox-Wolf Watershed Alliance, Brown County, Outagamie County Land Conservation Department, the Wisconsin Department of Natural Resources, Great Lakes Commission, and the USDA NRCS.

https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/newsroom/features/?cid=NRCSEPRD1370854

The path forward

- This is what we are here for - avenues for improvement
- Learning from examples, the good AND the bad
- Social science aspects to drive the change
- Research needs to address many unknowns
  - Tipping points and climate change
  - Working on trust and reducing uncertainties
  - Uncertainty analysis / sensitivity analysis
  - Understanding lag times and permanence of ES
  - Cumulative effects and buffering
  - Scales of resolution – are current methods scalable and appropriate for the precision required?