Building Ecosystem Services Conceptual Models for Federal Decision Making

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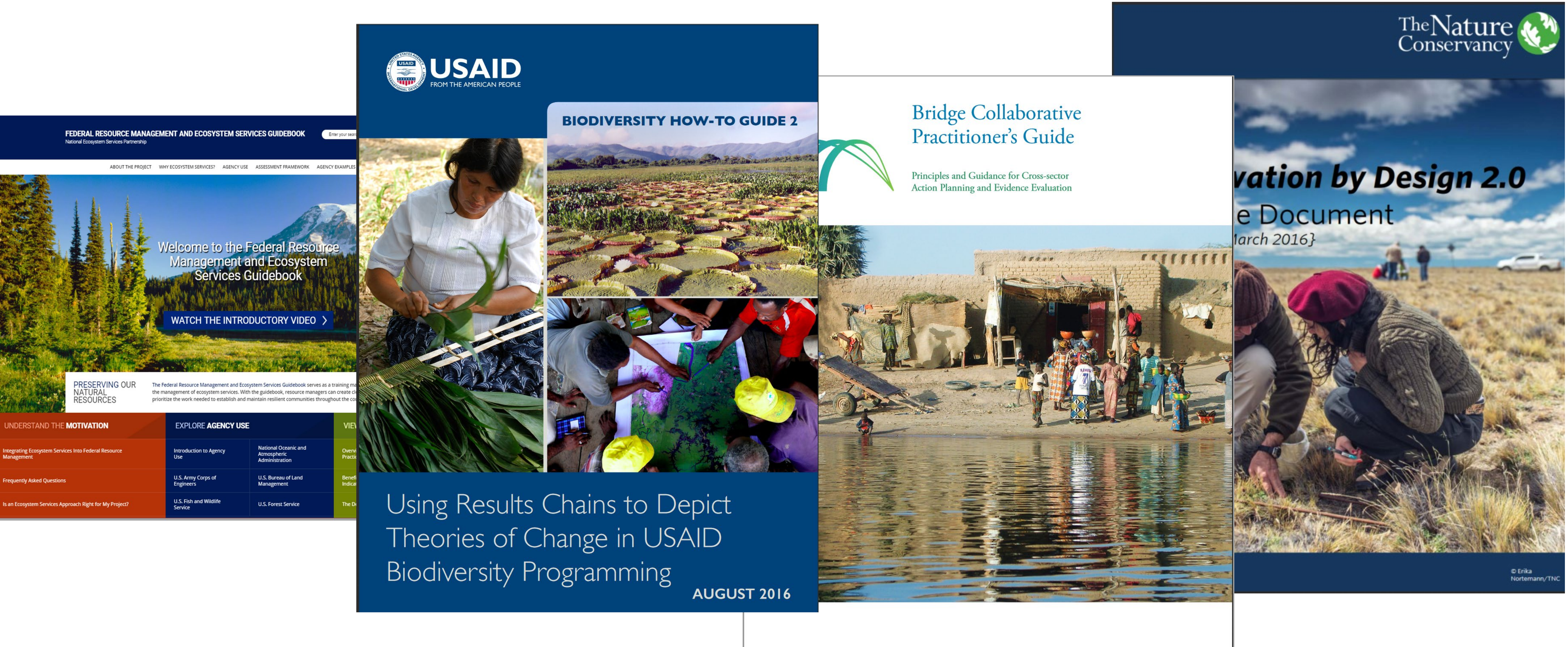
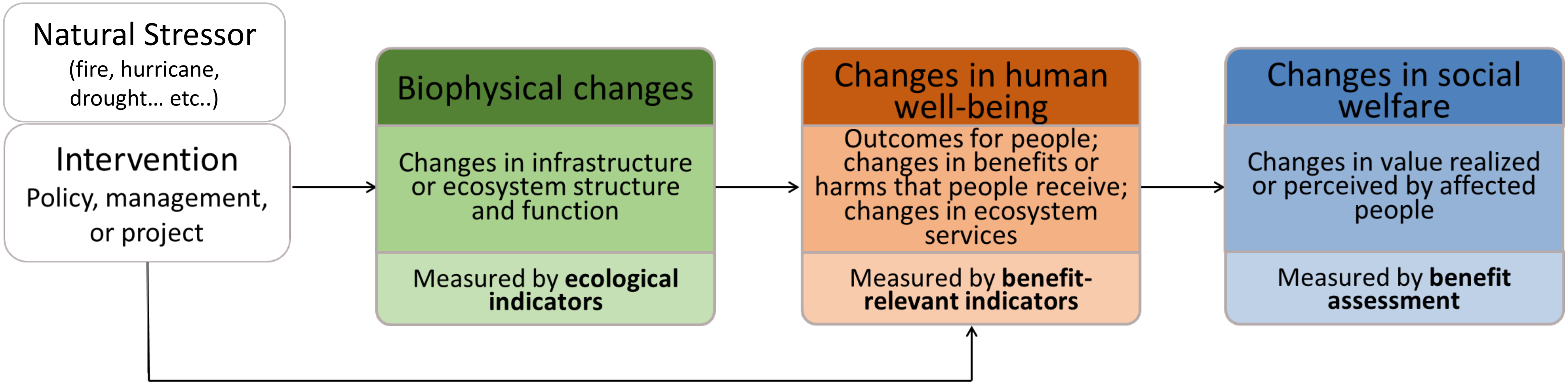
Conceptual Models: Used by many organizations



What is an Ecosystem Services Conceptual Model?



Types of Conceptual Models

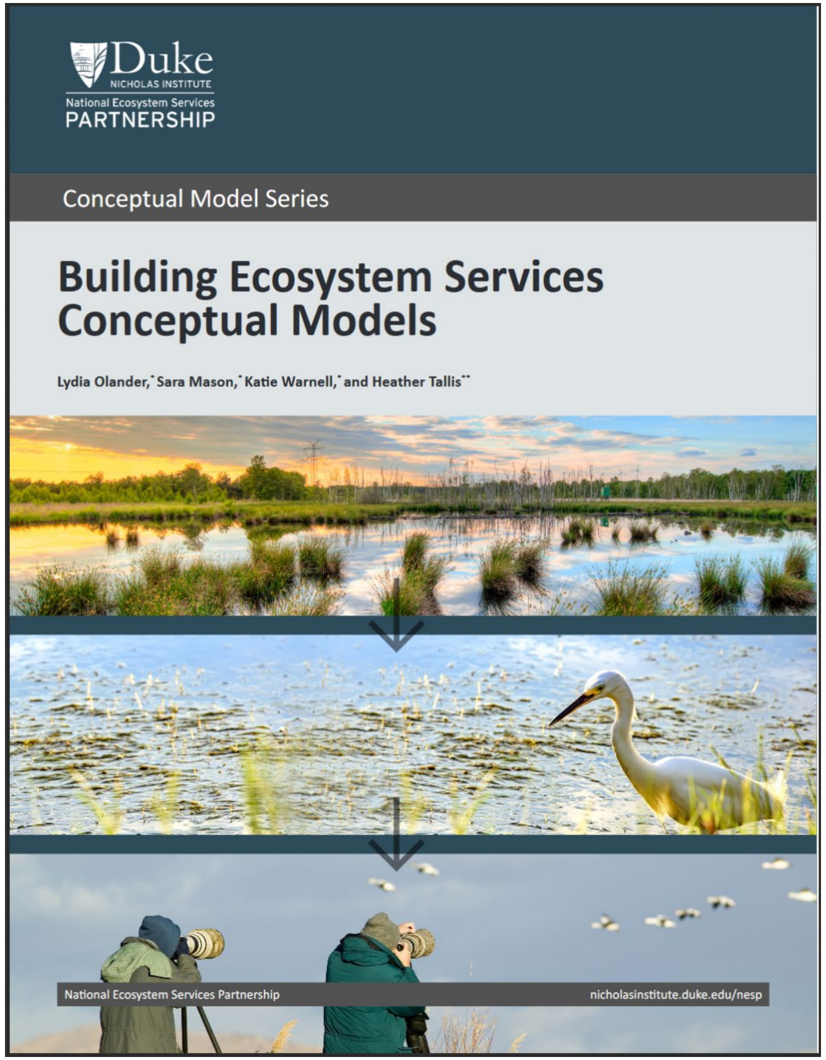
Types of Models	Characteristics	What it takes to make them
Exploratory	Preliminary, incomplete, unspecified	Quick initial sketch. Takes a few hours to a day, ideally with some input from experts, managers, and stakeholders or knowledge of the issues.
General	Complete, vetted, captures changes in generalized categories that represent a habitat or intervention type. (A parent model)	Few weeks to get sufficient expert/stakeholder input
Specified	Complete, vetted, captures specific outcomes (including species, recreational activities, etc…) that are specific to place and decision context (mostly likely to be used in decisions and to have quantifiable indicators associated)	Requires input from (or at a minimum knowledge of the priorities for a) wide range of stakeholders and beneficiaries as well as input from managers and experts.

Building evidence based ESCMs

1) Start with an exploratory or general model
2) Specify the model for your context
3) Clarify model assumptions
4) Build an evidence library
5) Assess the evidence
6) Map the strength of evidence

Add-ons:

- Developing common indicators
- Building a predictive model

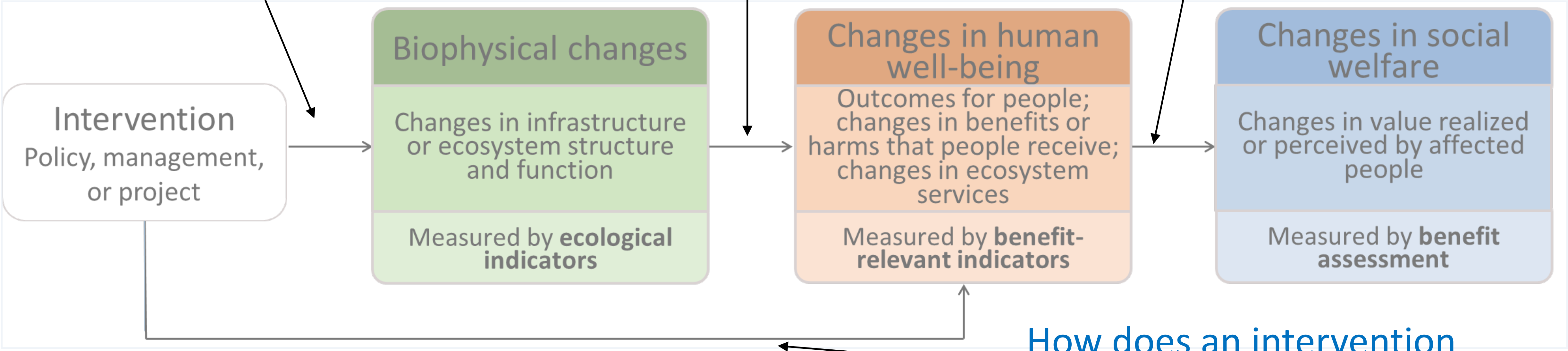


1. Four questions can help start the model building process

1.How does an intervention affect biophysical and ecological conditions?

2.How do changes in these conditions lead to changes in the delivery of ecosystem services to people who are using them, affected by them or appreciating them?

3.How do the changes in delivery of services affect the benefits or costs to individuals or groups?



How does an intervention directly affect people?

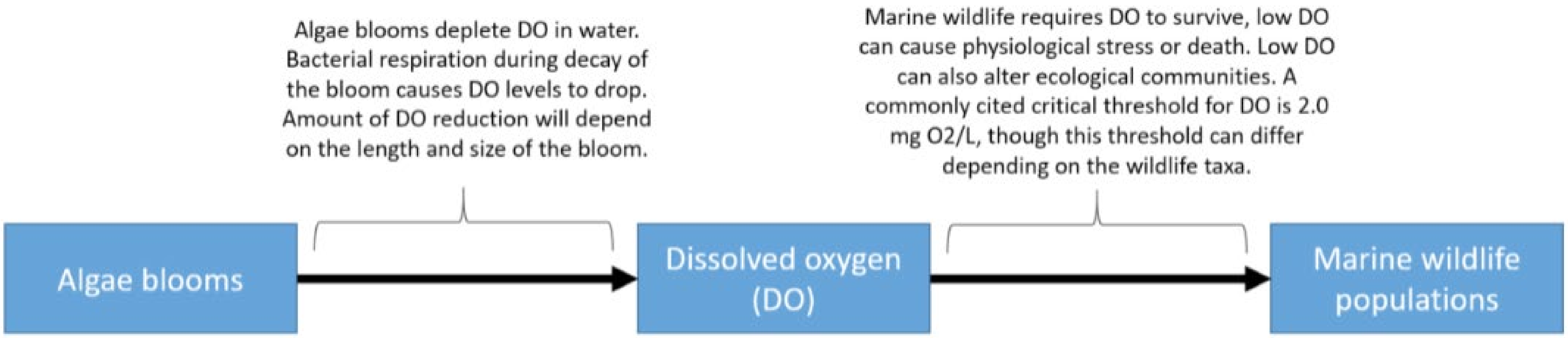
2. Specifying the models

Table 5. Illustrative questions to elicit specified outcomes and endpoints for a conceptual model for salt marsh restoration in San Francisco Bay

Ecosystem service/ social outcome	Details
Health impacts (water quality)	Health impacts could include illness from exposure to contaminated water by swimming or drinking. **Are these impacts important or relevant in San Francisco? Which contaminants introduce the greatest health risks? Are SF populations more vulnerable to certain contaminant risks because of other prevalent health conditions?**
Health impacts (dietary)	Health impacts could include nutritional changes based on changing fish/ shellfish populations and availability. **Which groups of people rely on fish/shellfish from SF Bay? What portion of their protein or micronutrient needs are met by local fish/shellfish? Do SF residents depending on wild local fish/ shellfish have access to dietary alternatives with similar nutritional qualities?**
Existence	Existence value represents the value that people place on the existence of elements of the ecosystem—for example, the marsh itself or specific species that use the marsh as habitat. Often endangered, threatened, or charismatic species have high existence value. **Which population's existence values do people care about capturing (local SF bay residents, U.S. residents, global residents)? Which species are most valued by the focal population? Which marsh characteristics are most valued?**

3.Articulating assumptions

Figure 5. Example of articulating model assumptions



4. Evidence Library

- Description of the relationship
- Summary of the evidence
- Confidence in the assumption given available evidence
- List of other factors that may result in variation (location, timing, external drivers, and so on)
- List of sources

Table 6. Illustrative evidence library entry describing the link between solar energy development and water use for solar energy installation on Bureau of Land Management lands

Evidence element	Example from solar energy development conceptual model
Link ID	10a: Solar energy development >> Water use
Description of relationship	Photovoltaic solar plants consume 11–226 gallons of water per MWh of electricity produced. This consumption includes water used to manufacture photovoltaic panels and for dust suppression during construction.
Summary of evidence	One meta-analysis harmonized lifecycle water consumption estimates for photovoltaic power plants and found the water consumption values listed above. It included 23 estimates of upstream (raw materials, manufacturing, construction, and transportation) and downstream (decommissioning) water consumption for crystalline silicon panels and 9 estimates of water consumption during operation.
Strength of evidence	Fair: The meta-analysis of water consumption by solar energy facilities was constrained by the number of studies available, and the included water consumption estimates ranged over an order of magnitude. This analysis did not account for site-specific factors including climate that may influence water consumption.
Other factors	The amount of water required for manufacturing photovoltaic panels varies by specific panel technology; for example, cadmium telluride panels require less water to produce than crystalline silicon panels.
Sources	Meldrum, J., S. Nettles-Anderson, G. Heath, and J. Macknick. 2013. "Life Cycle Water Use for Electricity Generation: A Review and Harmonization of Literature Estimates." *Environmental Research Letters* 8. stacks.iop.org/ERL/8/015031. Sinha, P. 2013. "Life Cycle Materials and Water Management for CdTe Photovoltaics." *Solar Energy Materials and Solar Cells* 119: 271–275. https://doi.org/10.1016/j.solmat.2013.08.022.

5. Evidence Assessment Matrix

	Criteria			
Confidence level	**Types of evidence**	**Consistency of results**	**Methods**	**Applicability**
High	Multiple	Direction and magnitude of effects are consistent across sources, types of evidence, and contexts	Well documented and accepted	High
Moderate	Several	Some consistency	Some documentation, not fully accepted	Some
Fair	A few	Limited consistency	Limited documentation, emerging methods	Limited
Low	Limited, extrapolations	Inconsistent	Poor documentation or untested	Limited to none
None	None	Not applicable	Not applicable	Not applicable

Source: Adapted from Bridge Collaborative strength of evidence template.

6. Strength of Evidence Map

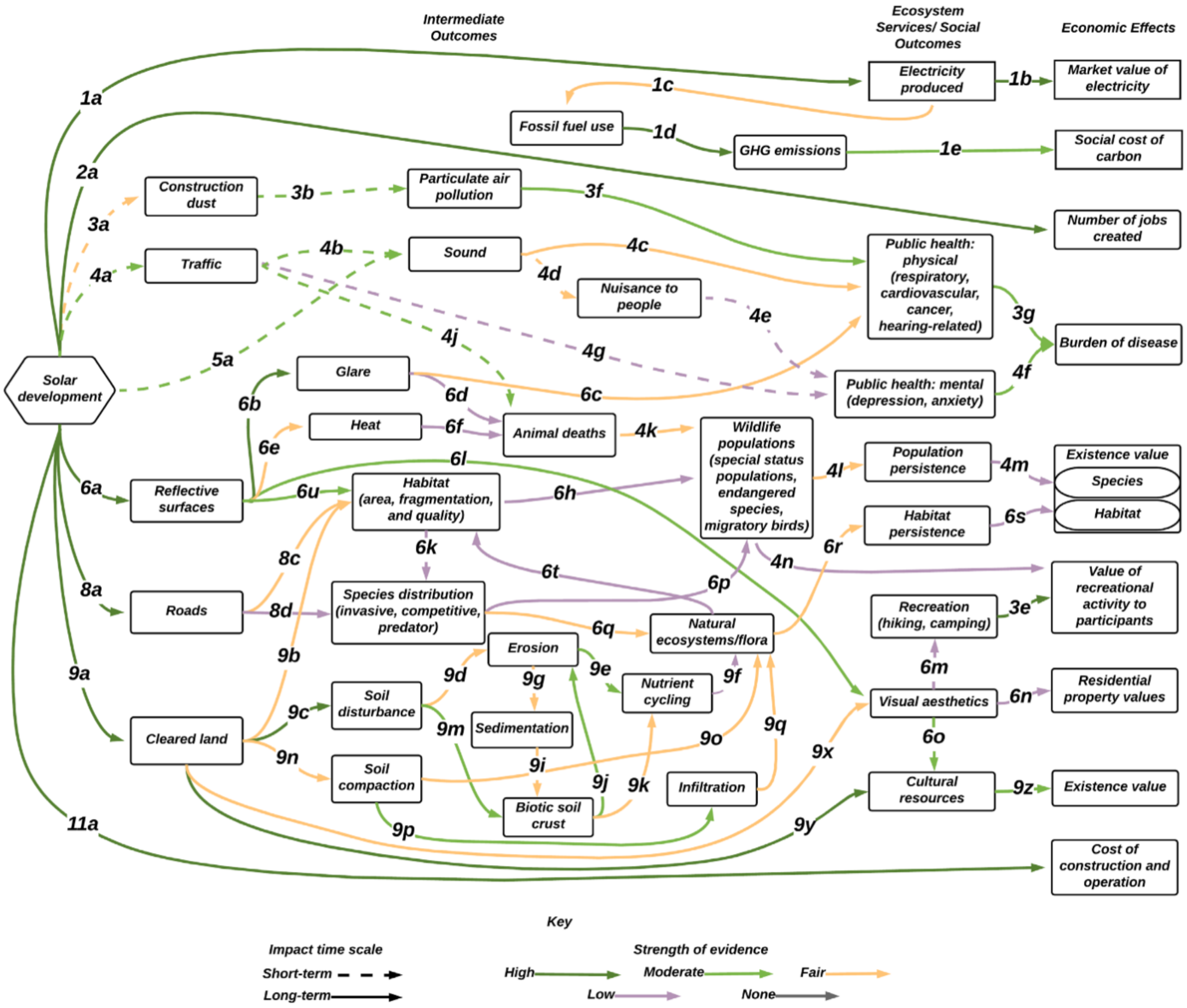
GREEN – high

YELLOW - Fair

PURPLE – Low or None

-----> Short-term

⟶ Long-term



Indicators

Ecosystem services or social benefit	Indicator (benefit-relevant or monetary)
Health impacts	Numbers of households exposed to water-borne disease Number of hospitalizations resulting from forest fire smoke each year
Commercial fishing	Increase in commercial fishing revenues ($) Avoided number of days of shellfish bed closures (acre/day)
Recreation	Numbers of anglers visiting Distance people are willing to travel to recreate ($)
Existence	Willingness to pay for the existence of certain species or habitat ($) Number of books, art, or literature tied to a specific species or place
Flooding	Likelihood of flooding each year (likelihood/number of properties) Days of disruption due the closure of critical services
Education/research	Number of people participating in educational events Use of related science by other people

Time and Expertise Required

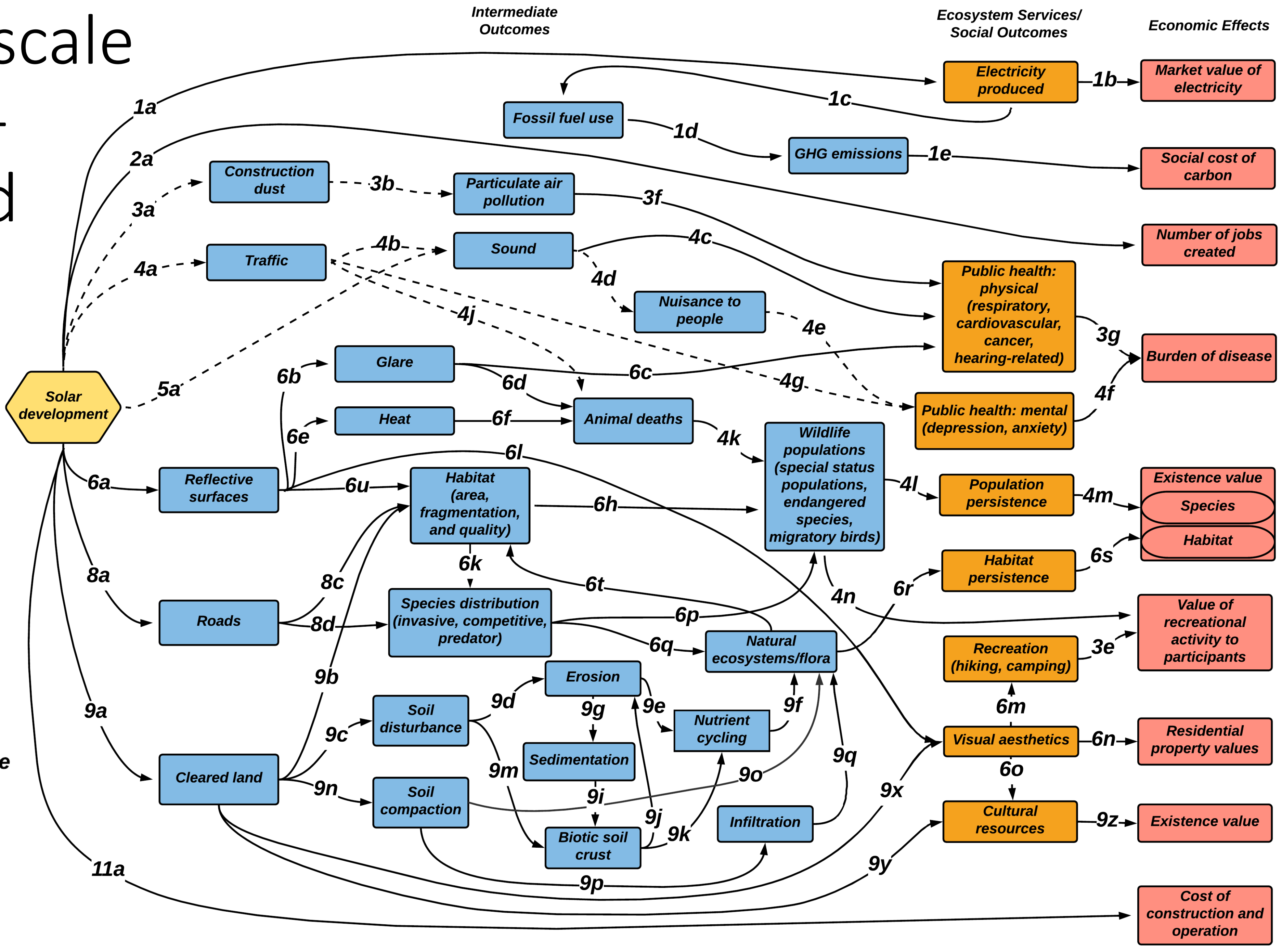
Task	Time	Expertise
Exploratory Model	**1 hour to 1 day**	Familiarity with ES and conceptual models
Refined Model (general or specified)	**1 to 2 weeks** for articulation of assumptions and expert review	Same as above
Identifying socio-economic indicators/metrics	Part of **initial 1 hr – 1 day** session	
Assessing indicator/metric feasibility	**0.5-6 months full time**	Familiarity with socio-economic measures and local monitoring
Initial evidence library and evidence assessment	**6 weeks full time** for new one **3 weeks or fewer** for adapting	Experience with literature review and gathering expert input, understanding of ecosystems, and ecosystem services

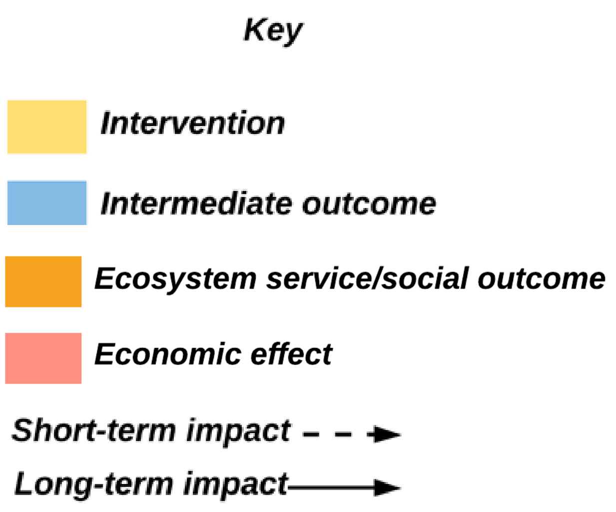
How ESCMs can help with implementation

- Get stakeholders and experts on the same page.
- Provide an intuitive entry point for those new to considering ecosystem services
- Capture priorities and link them to interventions in a transparent and systematic way.
- Make sure there are no critical outcomes/impacts that are missing from consideration.
- Provide an evidence-based qualitative assessment of ecosystem services implications of interventions.
- Provide a common foundation of best available science to reduce time and expertise needed for use and to reduce duplication of effort.
- Identify critical information gaps that generate significant uncertainty for decision makers, and pinpoint crucial research/monitoring needs.
- Identify a subset of socio-economic metrics that best capture important ecosystem service outcomes.
- Provide consistency in services assessed, evidence considered, and metrics selected.
- Provide a consistent and credible foundation for qualitative assessments, quantitative assessments, or monetary or non-monetary valuation where such methods are desired

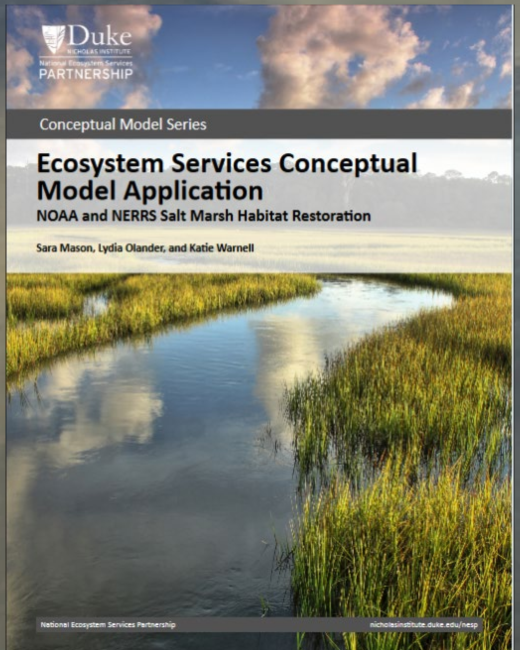
Large Scale Solar Installation for BLM

ESCM: Large-scale solar on BLM-managed land





NOAA and NERRS Salt Marsh Habitat Restoration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Conceptual Model Series

Ecosystem Services Conceptual Model Application

NOAA and NERRS Salt Marsh Habitat Restoration

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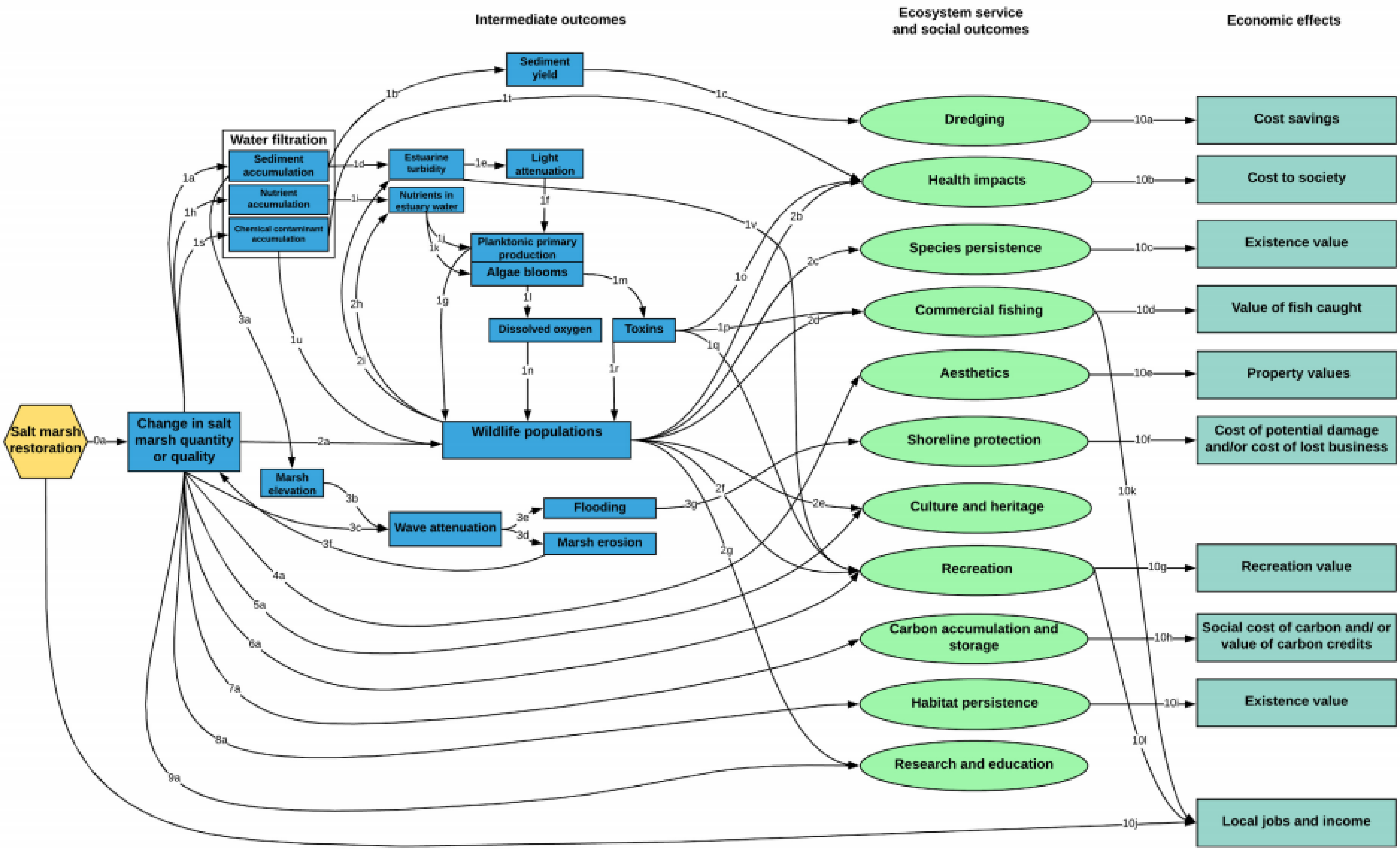
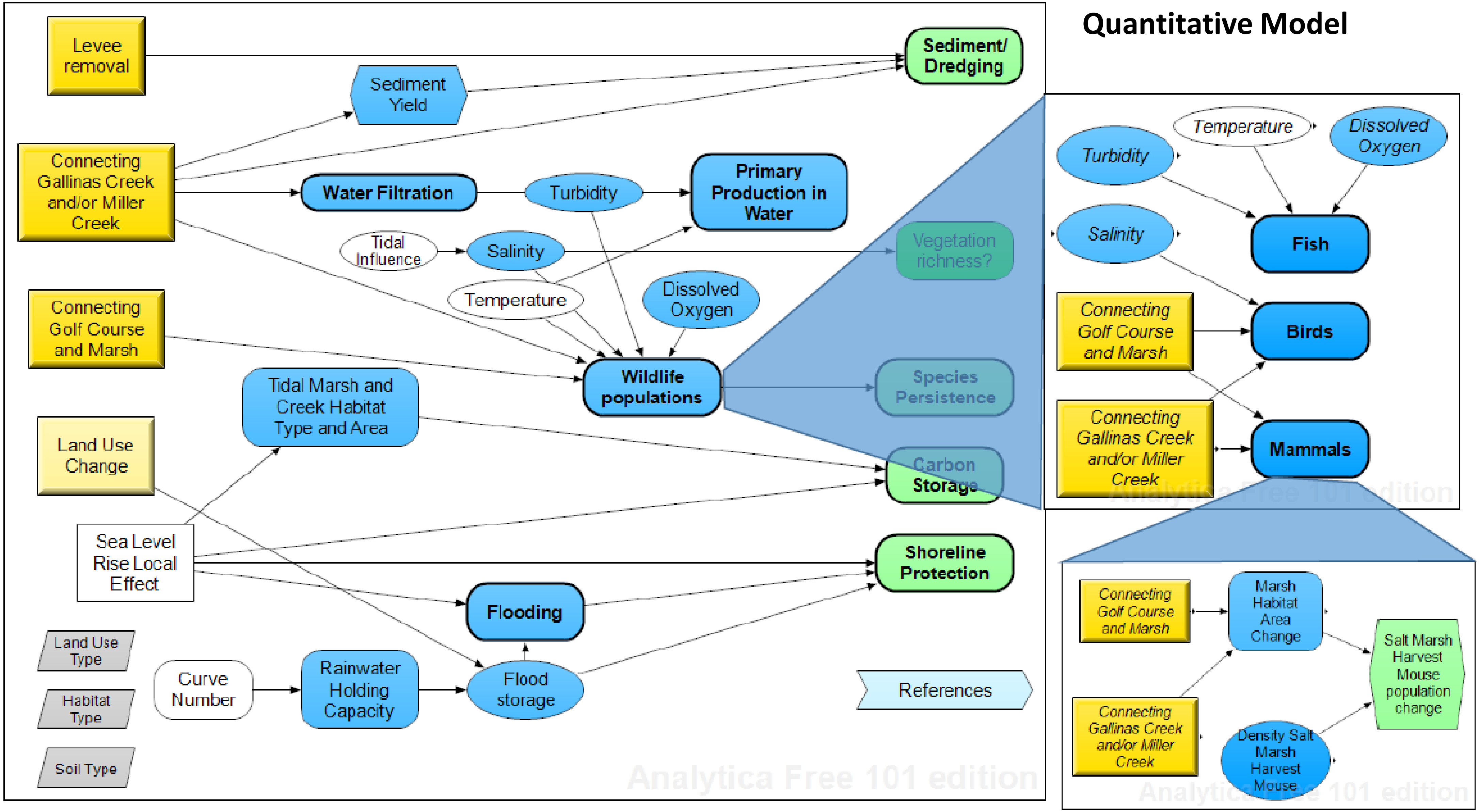
National Ecosystem Services Partnership nicholasinstitute.duke.edu/nesp



Intermediate outcomes
Ecosystem service and social outcomes
Economic effects
Salt marsh restoration
Change in salt marsh quantity or quality
Water filtration
Sediment accumulation
Nutrient accumulation
Chemical contaminant accumulation
Sediment yield
Estuarine turbidity
Light attenuation
Nutrients in estuary water
Planktonic primary production
Algae blooms
Dissolved oxygen
Toxins
Wildlife populations
Marsh elevation
Wave attenuation
Flooding
Marsh erosion
Dredging
Health impacts
Species persistence
Commercial fishing
Aesthetics
Shoreline protection
Culture and heritage
Recreation
Carbon accumulation and storage
Habitat persistence
Research and education
Cost savings
Cost to society
Existence value
Value of fish caught
Property values
Cost of potential damage and/or cost of lost business
Recreation value
Social cost of carbon and/ or value of carbon credits
Existence value
Local jobs and income

General Model Adaptability

Quantitative Model



New Applications of ESCMs

Gulf of Mexico (RESTORE, NRDA, States)	General Models & Common Metrics	Oyster reef restoration & TBD
NOAA National Estuary Research Reserves	Common Metrics & Predictive Model Library and Communications	Oyster reef restoration & Mangrove restoration
Department of Defense	Bayesian Predictive Model	ES provided by military bases; How base management changes ES provision
US Forest Service	General Models & Predictive Model and Data Library	How forest management activities affect ES provision

Take Home Messages

- Given a constrained set of ways in which managers manipulate the natural environment and a fixed number of effects such management can have on the environment and people, it seems possible to establish a reference set of evidence-based conceptual models that become a go-to resource.
- These reference models could provide efficiency and consistency in application.
- The development of such a repository would help transition ecosystem services consideration from an interesting concept to an actionable approach to natural resource management.

Questions?

ESCM series https://nicholasinstitute.duke.edu/conceptual-model-series

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If you are interested in joining the NESP e-mail list, please e-mail ***nesp@duke.edu***.

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