Development of a quantification methodology for greenhouse-gas benefits associated with riparian forest restoration and conservation

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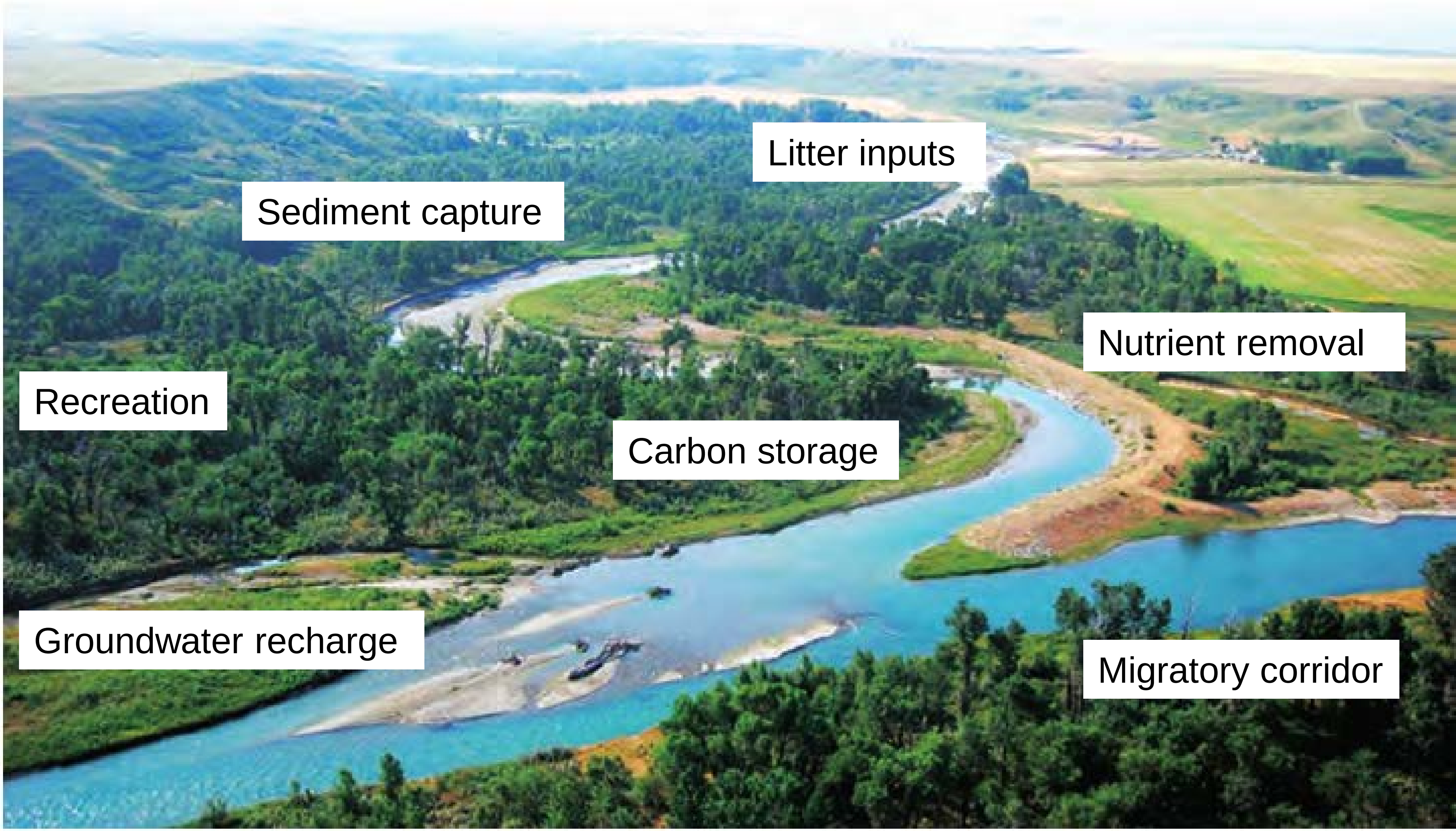
We're all about 'multiple benefits'…



…until we start looking for payment schemes.

Though other **payments for ecosystem services (PES)** exist, in the U.S., the most highly developed programs are for carbon.

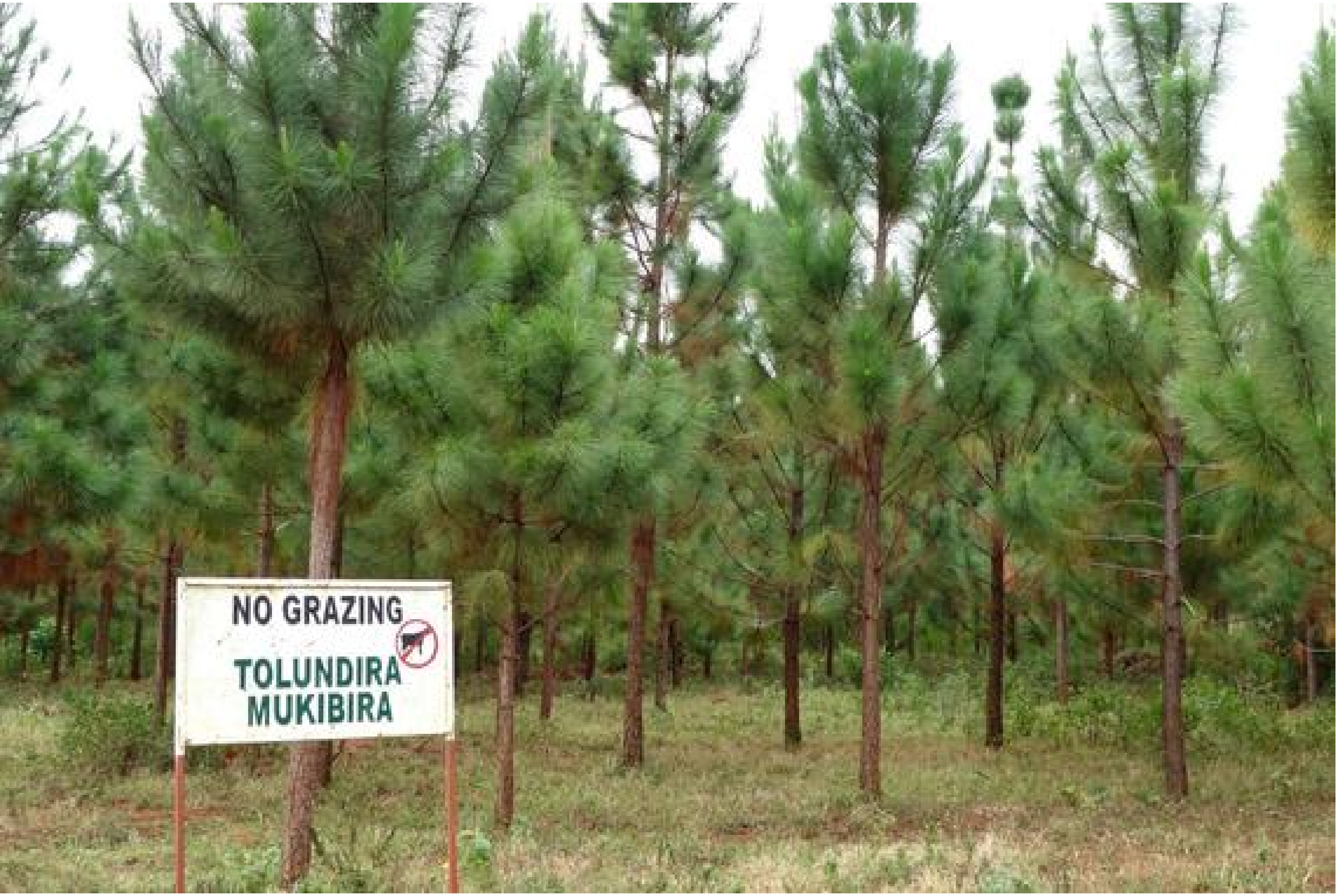
California Environmental Protection Agency

Air Resources Board

RGGI Inc.

Graphic: Alex Eben Meyer, *NY Times*

A key question that arises is, do carbon markets encourage the wrong kind of conservation?



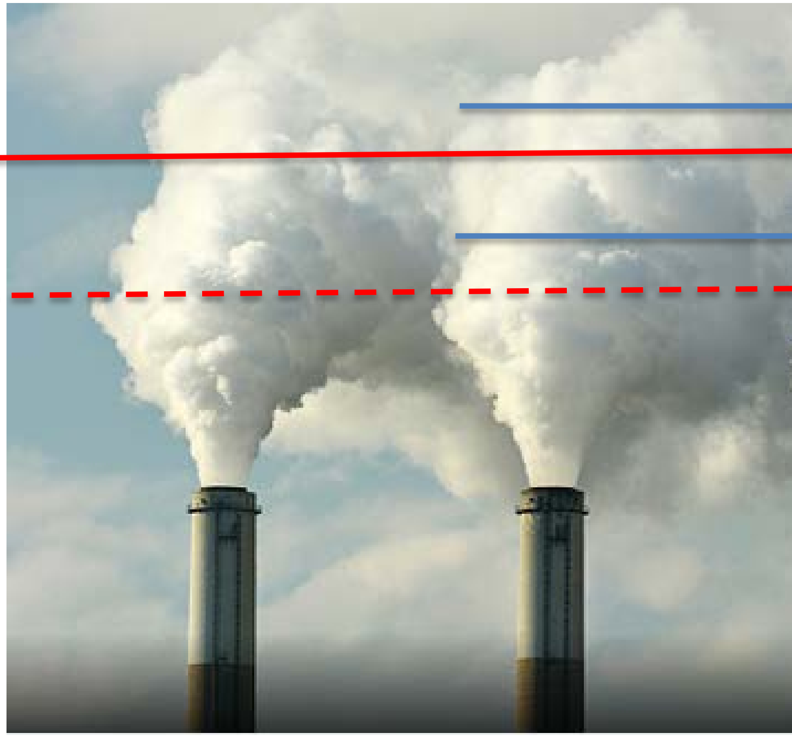
Lindenmayer et al. (2012) warned against **“bio-perversity”**—perverse outcomes from a narrow focus on carbon—such as exotic invasion, clearing of native vegetation for tree plantations, changes to fire and hydrologic regimes, etc.

In developing a method for quantifying the GHG benefits of riparian conservation, we faced 2 parallel problems:

Lack of published data suitable for predicting C accumulation in riparian stands over time

Avoidance of perverse outcomes: loss of other benefits due to maximizing the C benefit

Some background: cap-and-trade in California



Company C

Emitter A buys some allowances at auction from the state;
Emitter B must get below the cap by buying market-value credits as well as state auction allowances;
Company C generates credits for Emitter B in an unrelated industry

Allowances

State sets reserve price

Public money

(GGRF, Greenhouse Gas Reduction Fund; aka Climate Investments)

Offsets

Other industries voluntarily undertake activities that earn saleable credits

Private money

Offsets programs have strict requirements to assure the state that ton-for-ton, excess emissions *by regulated parties* are being offset with real reductions by *non-regulated parties*.

Additionality
Reforestation cannot be mandated by another law or regulation

Permanence
Land must be protected by easement or the credits paid back

Leakage
Penalty for stopping a viable agricultural activity

Risk of reversal
Credits paid to insure against fire, flood, other disasters

Confidence deduction
Loss of credits if project's benefits are uncertain or variable

3rd-party verification
Expense of hiring a professional forester to verify tree growth

With revenues from allowances, state agencies pay *up front* for projects that will result in *future* emissions reductions.

~~Additionality~~

Permanence (optional)

~~Leakage~~

Risk of reversal (flexible)

~~Confidence deduction~~

~~3rd-party verification~~

Flexible approach to verification

What about the public funds?

CALIFORNIA CLIMATE INVESTMENTS

CALIFORNIA CONSERVATION

In order to disburse GGRF money to riparian restoration, the state needs a quantification methodology (QM)

Equation 2: Biomass carbon loss due to vegetation clearing in site preparation

$$\boldsymbol{Cbiomass_{loss}} = \sum_i \left[(CA_i \times FL_i) - (CB_i \times CA_i \times e^{(-PL \div 19.8)}) \right]$$

where

$\boldsymbol{Cbiomass_{loss}}$= biomass carbon lost from site over project life due to initial clearing for restoration activities, in metric tons CO2e;

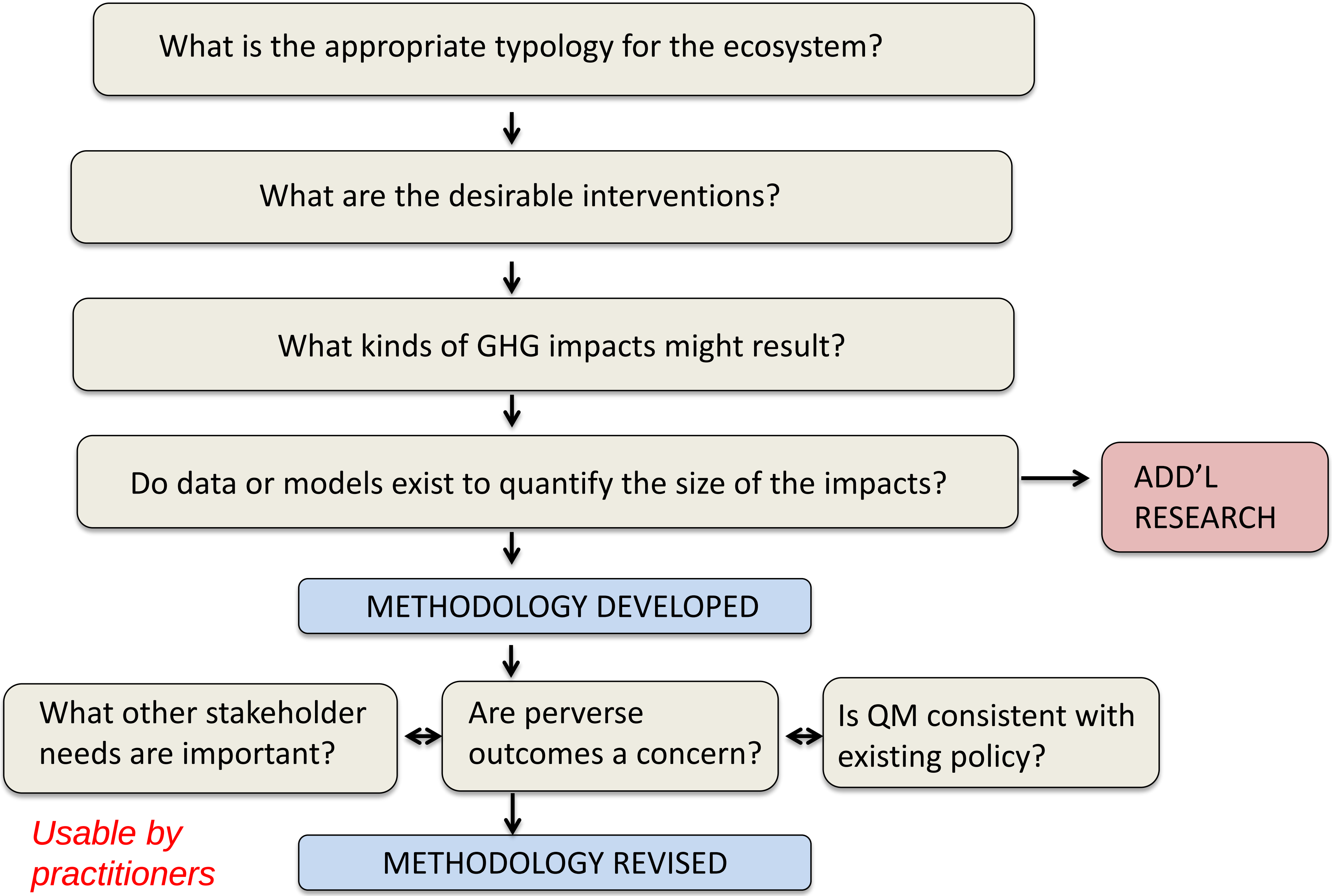
CA_i = Area in acres of cleared area *i*;

FL_i = carbon estimate for land cover type in cleared area *i*, from Table 1, in metric tons CO2e/acre[17]

CB_i = chipped biomass factor for cleared area *i*, which has a value of 0 if removed biomass is not chipped onsite, or a value of FL_i if biomass is chipped onsite[18]

PL = project life, in years

and 19.8 is a decay factor for forest-floor material.



Usable by practitioners

Desirable interventions

Avoided conversion
Natural regeneration
Active restoration

The basic restoration formula:

Carbon stock gains due to forest growth minus losses due to clearing (e.g. invasive veg) - Emissions from motorized equipment used in site preparation +/- Emissions from land-use change (increased wetland area, less agriculture)

= Emissions reductions

Problem 1: calculating C stocks over time

The basic restoration formula:

Carbon stock gains due to forest growth minus losses due to clearing (e.g. invasive veg)

–

Emissions from motorized equipment used in site preparation

+/-

Emissions from land-use change (increased wetland area, less agriculture)

Problem 2: avoiding perverse outcomes

=

Emissions reductions

CREEC

Carbon in Riparian Ecosystems Estimator for California

Estimator About Contact

Regeneration What type of restoration is this project? | Regeneration Type

Region Where is the project located? | Select a Location

Site Preparation What is the intensity of soil disturbance of the site? | Select a Site Prep

Unknown

Land Use How is the land used? | Select a Land Use

Unknown

Estimator About Contact

Regeneration What type of restoration is this project? — Regeneration Type

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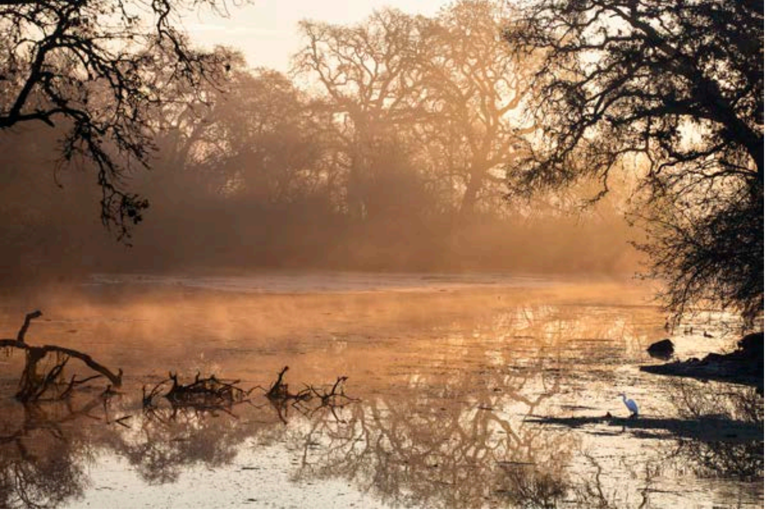
CREEC chooses a riparian forest vegetation community based on climate zone and species composition--BIOMASS

CREEC then selects levels of soil disturbance based on prior land use and the intensity of site preparation--SOIL

BIOMASS + SOIL combo yields a look-up table

Age	Tree Carbon	Down Dead Carbon	Forest Floor Carbon	Understory Carbon	Non-Soil Carbon Accum	Soil Carbon Stock	Soil Carbon Accum	Total: Soil + Non-Soil Carbon Accum
0	0	0	0	0	0	50.4	0.00	0
5	3.89	0.18	3.74	6.87	14.67	51.4	1.02	15.69
10	19.87	0.87	6.96	4.84	32.54	52.2	1.85	34.38
15	43.97	1.86	9.76	4.09	59.69	52.9	2.53	62.21
20	70.08	2.89	12.22	3.71	88.9	53.4	3.08	91.98
25	94.28	3.79	14.4	3.5	115.97	53.9	3.54	119.51
30	114.86	4.53	16.34	3.36	139.09	54.3	3.91	143.01
35	131.46	5.1	18.08	3.28	157.92	54.6	4.22	162.14
40	144.4	5.53	19.65	3.22	172.8	54.8	4.47	177.27
45	154.26	5.84	21.07	3.18	184.35	55.0	4.67	189.03
50	161.66	6.07	22.37	3.15	193.25	55.2	4.84	198.09
60	171.19	6.34	24.64	3.12	205.3	55.4	5.09	210.39
70	176.32	6.48	26.57	3.11	212.47	55.6	5.26	217.73
80	179.03	6.55	28.23	3.1	216.91	55.7	5.37	222.28
90	180.46	6.59	29.66	3.1	219.81	55.8	5.45	225.25
100	181.21	6.6	30.93	3.1	221.83	55.9	5.50	227.33



CREEC

behind the scenes

Inputs: individual tree measurements on many forest plots of different ages and species mixes

Pros: based on real forests known to exist; for modeled data, uses methods from US GHG official reporting
Cons: hard to find data (aged plots with full census of species, diameters)

25,000 tree diameters $\xrightarrow[\text{equations}]{\text{Allometric}}$ **Total biomass in 632 forest stands**

↓

Linear regressions to determine which stand attributes are important to biomass

↓

Age
% willow
% oak
% cottonwood
% shrub

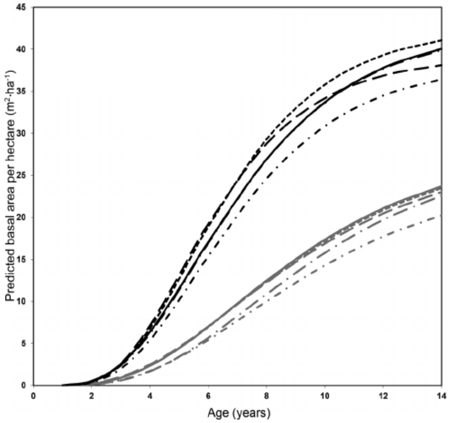
→ Use these attributes to group together stands into “forest types,” e.g. Valley Oak Riparian Forest

↓

Statistically fit 3-parameter Chapman-Richards growth curves to all groupings

$$Biomass = a\left(1 - e^{-b(age)}\right)^{c}$$

Live and standing dead biomass predicted from the growth curve



+ forest floor

$$\frac{f1\times(age)}{f2+(age)}$$

+ downed dead

$$DD = r \times livetreeC$$

+ understory

$$U = livetreeC \times e^{c_1-(c_2\times\ln(livetreeC))}$$

…using literature values for coefficients f_1, f_2, r, c_1, c_2

Soil carbon is modeled assuming that prior land use and site preparation deplete soil C, which recovers over time to a mean value for the region & forest type:

$$soilC = meansoilC \times (p + (1 - p) \times (1 - e^{-\left(\frac{age}{50}\right)^2}))$$

…where p is estimated from literature values for depletion of soil carbon by grazing, tillage, site preparation, etc.

The basic formula:

Carbon stock gains due to forest growth minus losses due to clearing (e.g. invasive veg) **–** Emissions from motorized equipment used in site preparation **+/-** Emissions from land-use change (increased wetland area, less agriculture)

= Emissions reductions

CREEC only produces carbon stock figures; all the other equation components rely on standard values or models from other protocols

What about Problem 2, perverse outcomes?

Arundo-infested stream corridor

What about Problem 2, perverse outcomes?

Arundo-infested stream corridor

Lots of recommendations, but THE important one is:
DOC should not tie funding to the size of the C benefit.

DOC advisory document

Best practices

- Fencing out livestock
- Planting saplings, not seeds
- Use of tube shelters at planting
- IPM approach to weed control
- Minimum of 3 years irrigation
- 70% survivorship required in contract

"Extra credit"

- Planning for climate resilience
- Connectivity with existing habitat
- Pollen, nectar, & fruit in understory
- Enhancements for listed species
- Greater structural complexity
- Community involvement

What has to happen for these funds to be available?

Revise look-up tables for fewer, more ecological vegetation groupings

Propose QM to California Air Resources Board for adoption

Dept of Conservation offers RFP to disburse GGRF funds

Multiple benefits for all!

Thank you!

Funding:
USDA – NIFA 2012-00882 (Matzek)
Santa Clara University College of Arts & Sciences
BECC Strategic Research Area (Nelson)
CA Department of Conservation (Matzek)

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Shawn Warren	Ashley Ciglar	Colleen Fisher
Maile Pujalet	Russell Hutto	Pearce Ropion
Justin Covino	Dana Johnston	
Mat Jordan	Charles Walker	

Project logistics, data-gathering, and advice:

Joe Silveira, USFWS	John Stella, SUNY-ESF
Henry Lomeli, CDFW	David Lewis, UC Cooperative Extension
Charles McClain, CSUC	Dave Wood, CSU Chico
Greg Golet, TNC	Peter Kareiva, UCLA
Bruce Gwynne, DOC	…and many other devoted land stewards