Accounting for Permanence and Leakage in Terrestrial Carbon Sequestration Programs

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Funding and Collaborators

- **Funding:** US EPA, Climate Change Division
- **Collaborators**:
  - RTI: Brent Sohngen*, Martin Ross, Laurel Clayton
  - Texas A&M: Bruce McCarl, Dhazn Gillig, Heng-chi Lee
  - EPA: Ken Andrasko, Ben DeAngelo

** and Ohio State University*

What is Permanence?

- **<u>Permanence:</u>** Time over which sequestered carbon is removed from the atmosphere.
  - If its forever, its "permanent"
  - Typically assumed that an emission reduction is permanent, and sequestered carbon is not

    Q: What is the value of temporary storage?

What is Leakage?

- **<u>Leakage:</u>** Emissions that occur outside the project boundaries ***as a result*** *of* the project activities themselves
- It is caused by the **shifting of emitting activity** elsewhere in response to reductions (sequestration) in the project area
  - Spatial
  - Temporal
  - Sectoral

Why do we care about permanence and leakage?

- They **erode the GHG benefits** of a project over time (permanence) and space (leakage)
- Can be **difficult to measure**
- **Difficult to enforce** due to incomplete contracts
- Potential to **undermine a project-based** offset system

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Accounting for Permanence

* Clarification about "Permanence"

- Some refer to the permanence issue in 3 parts

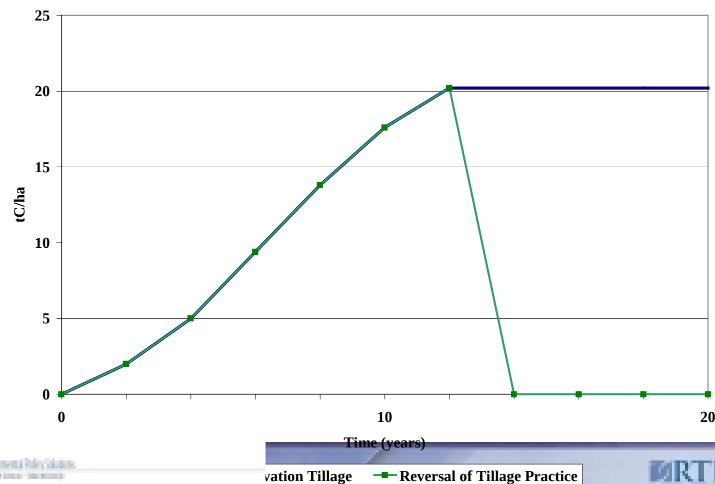
1. Terrestrial sinks saturating at a new equilibrium,
2. Reversal thru accidental or intentional release of carbon
3. Residual liability at end of finite contract life

- I will refer only to items 2 and 3 in this presentation

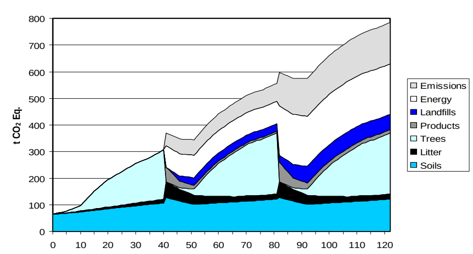
Reversibility

- Soil carbon storage is **volatile**
  - Can **easily be released in the future** if practice is discontinued or natural disturbance occurs
  - **Practices need to be maintained** to avoid release, or **appropriate accounting** for reversal is necessary

Soil carbon reversal: reversion to conventional tillage



Even More Complicated: Timber Harvesting, Releases, and Carbon Stored in Products



Data Source: Bi

Contractual Issues

- **Liability** for carbon replacement
  - Throughout the contract
  - At the end of the contract
- **Limited duration** contracts

Alternative Accounting Rules for Carbon Reversal

	Comprehensive ("Pay as you Go")	*Ex Ante* Discounting/Annuity	Temporary Crediting/Leasing
Description	Balances debits and credits as they occur over time. Can be based on "stock change" or average storage during time period.	Attempts to account for the possibility of loss by reducing the amount of credit in the first place based on the expectation of reversal.	Balances debits and credits for finite periods with provisions for future reversal.
Environmental Rigor	Achieves consistency, as long as system is monitored into perpetuity.	Credits may not equal debits for any particular project. Ex ante discounting may lead to an under- or over-debiting of ex post reversal.	Rigorous. Temporary credit must be replaced when it expires.
Feasibility of Implementation	Enhances investment attractiveness by allowing credits to be received as soon as generated. But a perpetual accounting system may not adequately allow for "balancing books" at the end of a finite-life project.	Relatively easy to simply impose discounts on credits, if projection difficulties referenced above can be resolved.	Also enables up front payments. Can handle book balancing at end of project.
Transaction costs	Measurement, monitoring, and verification (MMV) into perpetuity.	No MMV necessary. Credits reduced by formula, not observed change in carbon.	MMV each period + contract renewal costs. Renting or leasing credits may lead to an increase in contracting costs (Dutschke, 2002).

Source: Murray et al 2006

$p_{max} = p_0\left[1-(1+\beta)^n(1+\alpha)^{-n}\right]$

Temporary Crediting

- Scenario
  - Credit generated in Year 0 for temporary storage
  - All credits must be repaid in n years
- Value of a temporary credit (derived from Keeler, 2005)
  - $P_{max} = P_0[1- (1+B)^n (1+a)^{-n}]$
- *Parameters*
  - *P_0 is GHG price paid in Year 0*
  - *B is price growth rate*
  - *a is time discount rate*

Temporary Credit Values

Current Credit Price	Price Growth Rate	Discount Rate	Value of Temporary Credit (length of project in years)			Ratio of Value to Carbon Price		
			10	20	30	10	20	30
$25	5%	5%	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
$25	4%	5%	$2.28	$4.35	$6.24	9%	17%	25%
$25	3%	5%	$4.37	$7.98	$10.96	17%	32%	44%
$25	2%	5%	$6.29	$11.00	$14.52	25%	44%	58%
$25	1%	5%	$8.05	$13.50	$17.20	32%	54%	69%

Source: Murray et al 2006, derived from Keeler, 2005

Extenuating Factors

- Carbon could be resold/renegotiated at the end of the contract, rather than just assumed valueless.
  - Eliminates "artificial" impermanence
- Net value of temporary storage will be further diminished if the landowner has to engage in maintenance costs to keep the carbon from becoming impermanent (McCarl, in press)

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Accounting for Leakage

* Important Point about Leakage

- Leakage is only a problem if the "leaked" (shifted) emissions fall outside some accounting framework,
  - E.g., from a capped or monitored sector or region to an uncapped/unmonitored sector/region
  - From a monitored project to an unmonitored activity
- Otherwise, its captured in the accounting and does not undermine net emissions reduction

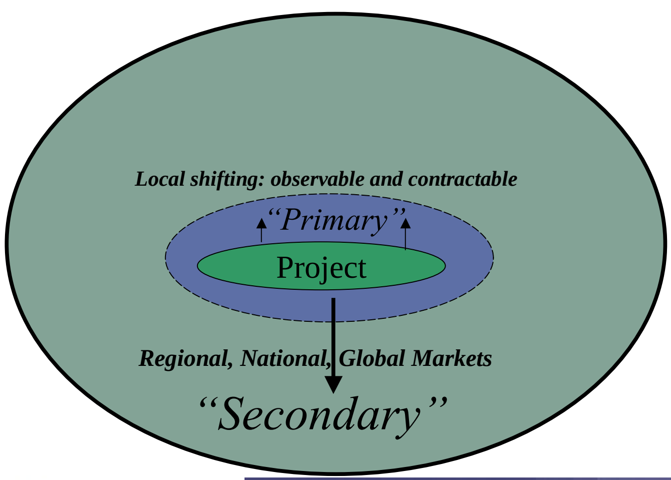
Leakage as an issue in forestry and agriculture projects

- **Induced by economic forces**: Supply/demand supplanted by the project is met elsewhere
  - Formal markets
  - Other institutional arrangements
- Leakage is **not unique to forest and ag projects**
- But, **features of forestry and agriculture** make them somewhat susceptible to leakage
  - Fixed land base: Land use change has spillover effects
  - Commodity markets are often broad in scope (regional, national, global)

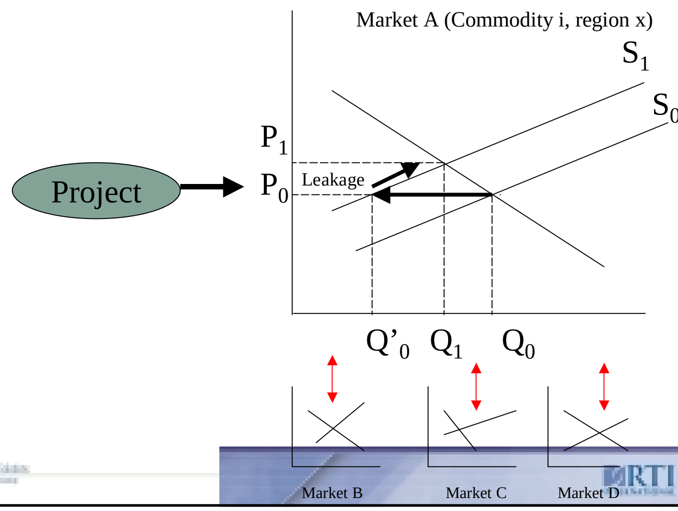
Myths and Reality

- ***Myth:*** *Leakage only happens when projects are big enough to affect the market price*
- ***Reality:*** *Leakage can happen any time that a project involves the exchange of goods and services, subject to the laws of supply and demand.*
- ***In fact, leakage is proportionately larger for small projects than for large projects or policies***

Emissions Shifting as a Spatial Concept



Project Leakage in a Market Context



How to Address Leakage at the Project Level

Action	Primary	Secondary
1. Minimize leakage through project design	Expand contract to include local activity near project boundaries	Select activities that are not likely to have a lot of market leakage
2. Measure what you can't minimize	Extend monitoring to include area proximate to project boundaries Survey of local stakeholders	***Market modeling***

Estimating Leakage through Market Modeling

- Simple comparative statics of individual market equilibria

$$L' = \frac{100 * e * \gamma * C_N}{[e - E * (1 + \gamma * \phi)] \; C_R}$$

Where e, E, γ, Φ, and Ci are market parameters

- Sector models
  - Forest (e.g., Sohngen, Sedjo, Mendelsohn)
  - Forest and Ag (e.g., FASOMGHG)
- CGE models

Leakage Estimates from Market Models

- **International emissions leakage/energy sector**: ~10-20% of targeted reductions are offset by leakage (from the literature)
- **Forest carbon leakage**

Afforestation Program Leakage Estimates by Region (All Quantities Are Percentages)

Region	Leakage Estimate (%)
Northeast	23.2
Lake states	**18.3**
Corn Belt	30.2
Southeast	40.6
South-Central	**42.5**

Source: Murray, McCarl, Lee. 2004. Estimating Leakage from Forest Carbon Sequestration Programs. *Land Econ: 80(1):109-124*

Leakage Estimates from Market Models (II)

- **Forest preservation (avoided deforestation, no harvesting*) – Leakage can be very high**

Region	Leakage %
PNW – East [a]	**8.9**
Northeast [a]	43.1
Lake States [a]	**92.2**
Corn Belt [a]	31.5
South-central [a]	28.8
Bolivia [b]	**2-40%**

a: Murray, McCarl, Lee. 2004. Estimating Leakage from Forest Carbon Sequestration Programs. *Land Econ: 80(1):109-124*

b: Sohngen and Brown. Measuring Leakage from Carbon Projects in Open Economies: A Stop Timber Harvesting Project in Bolivia as a Case Study. *Can. J. For. Res. **34**: 829–839 (2004)*

Comparing forestry and agriculture activities*

Leakage Estimates by Mitigation Activity at a GHG Price of $15/t CO_2 Eq. All quantities are on an annualized basis for the time period 2010–2110.

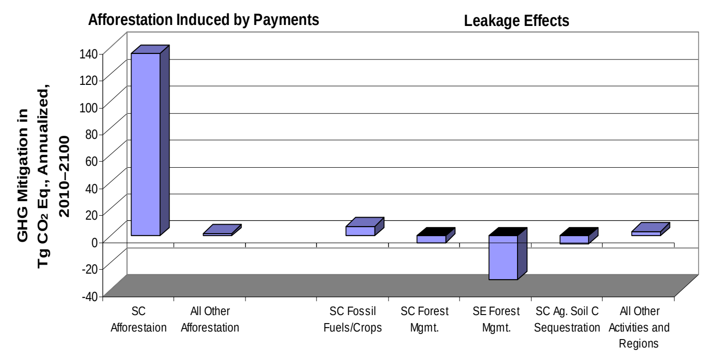
Targeted Mitigation Activities	A GHG Effects of Targeted Payment (Tg. CO_2 Eq.)	B Net GHG Effects of All Activities (Tg. CO_2 Eq.)	C Indirect GHG Effects from Nontargeted Activity[a] (Tg. CO_2 Eq.)	D Leakage Rate[b] (%)
Afforestation	137	104	–33	**24.0**
Agricultural Soil Carbon	154	145	–9	**5.7**
Biofuels	84	83	–1	**0.2**

[a]Indirect effects: C = (B – A).
[b]Leakage rate: D = –(C/A) * 100; rounding occurs in table.
Note: Negative leakage rate in D refers to positive leakage (i.e., additional mitigation outside targeted activity region).

** US EPA, 2005*

Regional dimensions of leakage *

Regional Leakage Flows for Afforestation-Only Payment Scenario: $15/t CO_2 Eq.



US EPA 2005

Conclusions

- A project-based offsets/trading system seeks assurance that the emissions allowance correctly corresponds to the reduction by the project
- For carbon sequestration projects, the main factors that may disrupt this correspondence are
  - Permanence
  - Leakage
  - Additionality

Conclusions (II)

- Permanence discounts range
  - ~0 for long-term projects with stable or declining GHG prices
  - ~100% if stored carbon must be replaced at end of project and GHG prices rise at disct rate
- Likewise leakage estimates have a wide range
  - Low: conservation tillage
  - Moderate: afforestation, land retirement
  - High: forest preservation

Conclusions (III)

- Q: Are high discounts enough to make these investments uneconomic?
  - Depends on the price and on the discounts applied to other offset credits
- Planning: design projects to minimize potential for reversal and leakage
- Centralized efforts needed to harmonize approaches to address and quantify leakage