Biogenic Carbon Sequestration and Climate Policy: Issues in Using Forests to Offset Greenhouse Gas Emissions

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Molly Macauley
Senior Fellow and Research Director
Resources for the Future
macauley@rff.org

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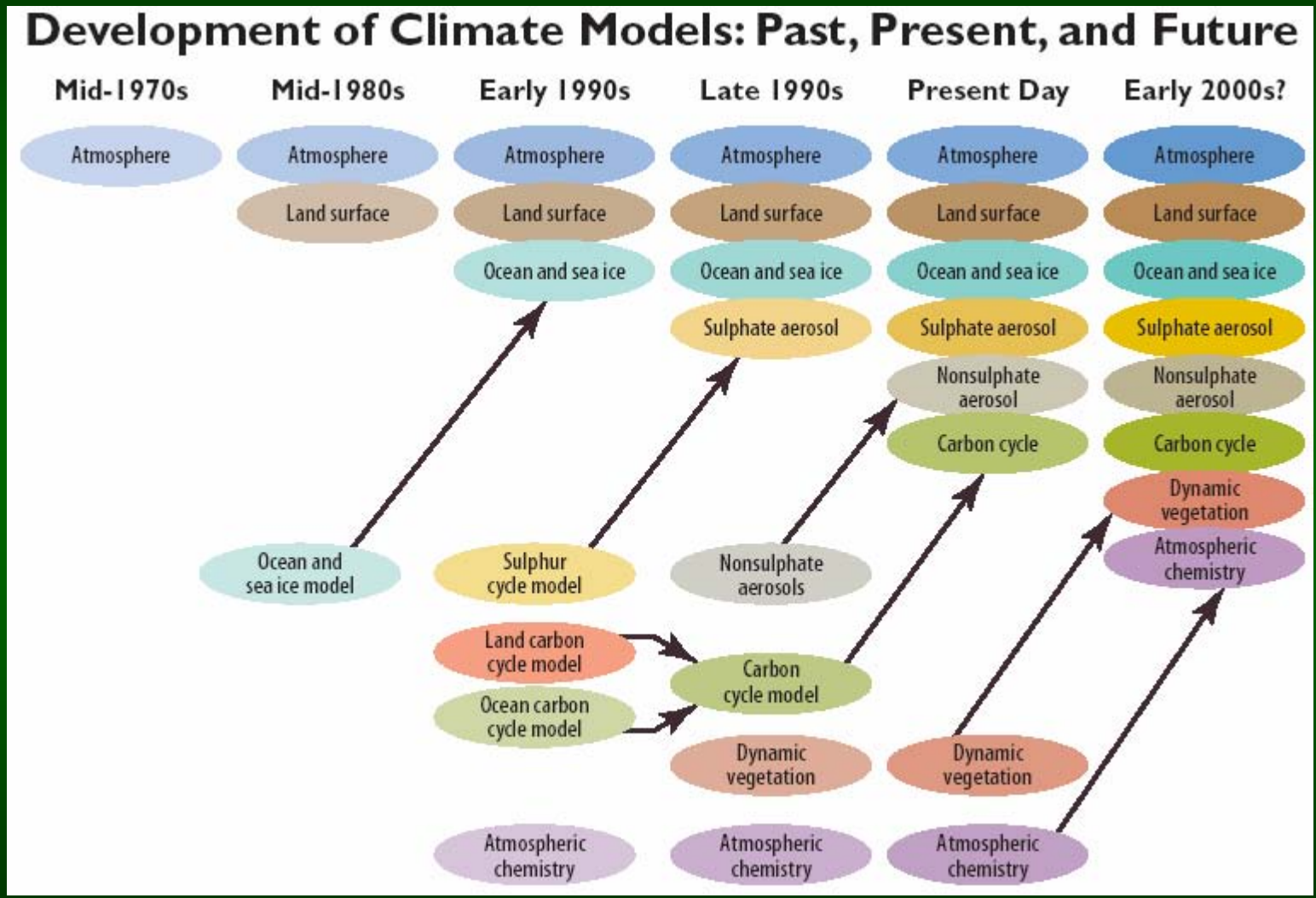
Overview

- Why have forest carbon offsets become prominent in US and international climate policy discussion?
- What do we know about the supply of forest carbon offsets?
- What are proposed legislative, regulatory and other provisions for offsets?
- What are the key issues in including offsets in US policy? In international policy?

Forest carbon sequestration in context: Physical means of providing alternatives to reductions in greenhouse gas emissions

- Biosequestration
  - Forest management
  - Soil management
  - Some agricultural practices
- Fugitive gases
  - Landfill and coal-bed methane
- Energy systems
  - Renewable energy deployment
- Industrial gases (hydroflourocarbons, perflourocarbons, sulfur hexaflouride – if not covered under "regulated GHGs")

A note on the physical relevance



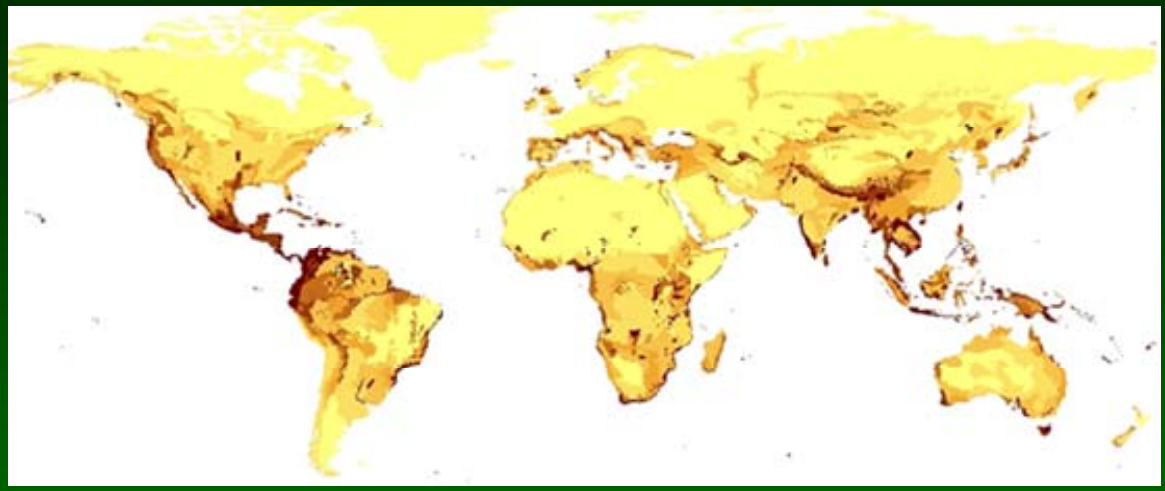
Source: IPCC, repr Fig 1, CCSP SAP 3.1

Why policy intervention?

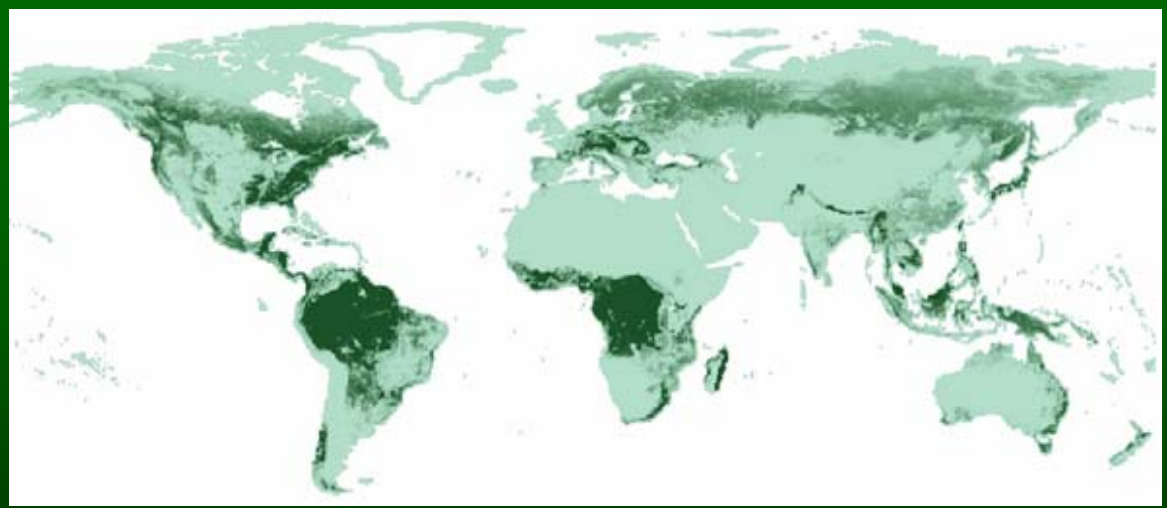
- May be a lower cost means of managing climate; some experts suggest significantly lower
- May have co-benefits (forests/habitat preservation/watershed protection or energy source such as landfill methane markets)
- May serve other purposes (political goals, other social objectives such as resource management for poverty reduction in developing countries)

What do we know about the supply of forest offsets?

- Highly dependent on land use and changes in land use
  - Physical quantities including baseline measures and periodic changes
  - Natural influences (e.g., fires, drought, flooding, pests)
  - Economic influences (e.g., wood products market*, logging and timber, fuelwood, agriculture) *carbon stored
  - Ecosystem services and "co-benefits" (e.g., watershed protection, biodiversity)
  - Policy influences (e.g., mandates to produce biofuels)
- Desirability of good measurement *simply* for the science of forest carbon in the global carbon cycle



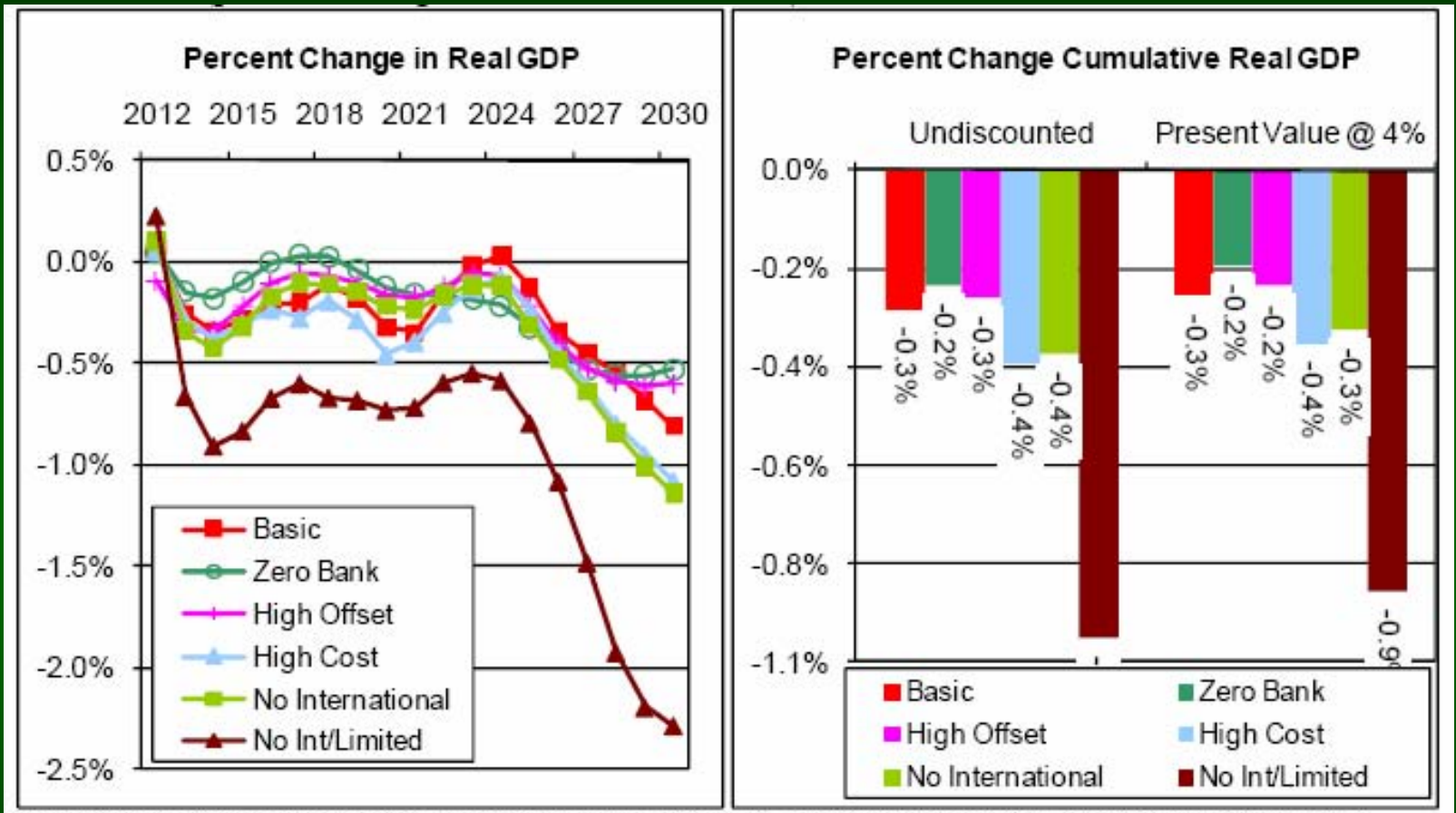
Species richness (number of mammal species per km2, by ecological region, using IUCN data)



Estimated above ground carbon (tons of carbon/ha)

Source: Siikamaki 2009

Cost effectiveness: projected changes in GDP



Source: National Energy Modeling System runs, STIMULUS.D041409A, HR2454CAP.D072909A, HR2454NOBNK.D072909A, HR2454HIOFF.D072909A, HR2454HC.D072909A, HR2454NOINT.D072909A, and HR2454NIBIV.D072909A.

- **Cumulative change in GDP ranges from -0.2% ($432 billion in 2000 dollars) to -0.9% ($1,897 billion in 2000 dollars)**

Source: EIA, 2009

Forest offsets -- the economic case, cont'd

- ***EPA (2009)***
  - "Without international offsets, the allowance price would increase 89% relative to the core scenario."
- ***EPA (2009) and EIA (2009)***
  - Forest offsets represent 90% of offsets

What are complications?

- **Measurement**
- **Additionality (what actions would happen anyway?)**
- **Permanence (here today but gone tomorrow?)**
- **Leakage (here today but somewhere else tomorrow?)**
- **Reporting (consistent, global, frequent)**
- **Data for international and domestic scope of actions**
  - ***CBO (2009); GAO (2008); Forte and Ramseur (2008)***
    - Offsets need to be additional, quantifiable, permanent, and credited to account for "relocation" of activities ("leakage")
- **Can measurement be cost-effective (so as not to exceed the value of the commodity)**

Measurement

- What amount of total anthropogenic emissions is attributable to deforestation and forest degradation? Current scientific understanding is from 7% to 30% (Houghton and Goetz 2008 – GLS on ICESat; PALSAR on ALOS; DESDynI and BIOMASS; Denman 2007)
- Uncertainty in estimates of the contribution of deforestation are "up to 50%" (van der Werf et al 2009)
- The ranges in estimates are largely attributable to limitations in forest measurements (not the denominator, fossil fuel emissions)
- The estimates of forest carbon sequestration also vary; typically derived by allometric equation based on forest area and volume, sometimes biomass (but it's also usually allometric)
- Data limitations impede capacity to incorporate role of land and use of land in climate modeling (Energy Modeling Forum 2008)

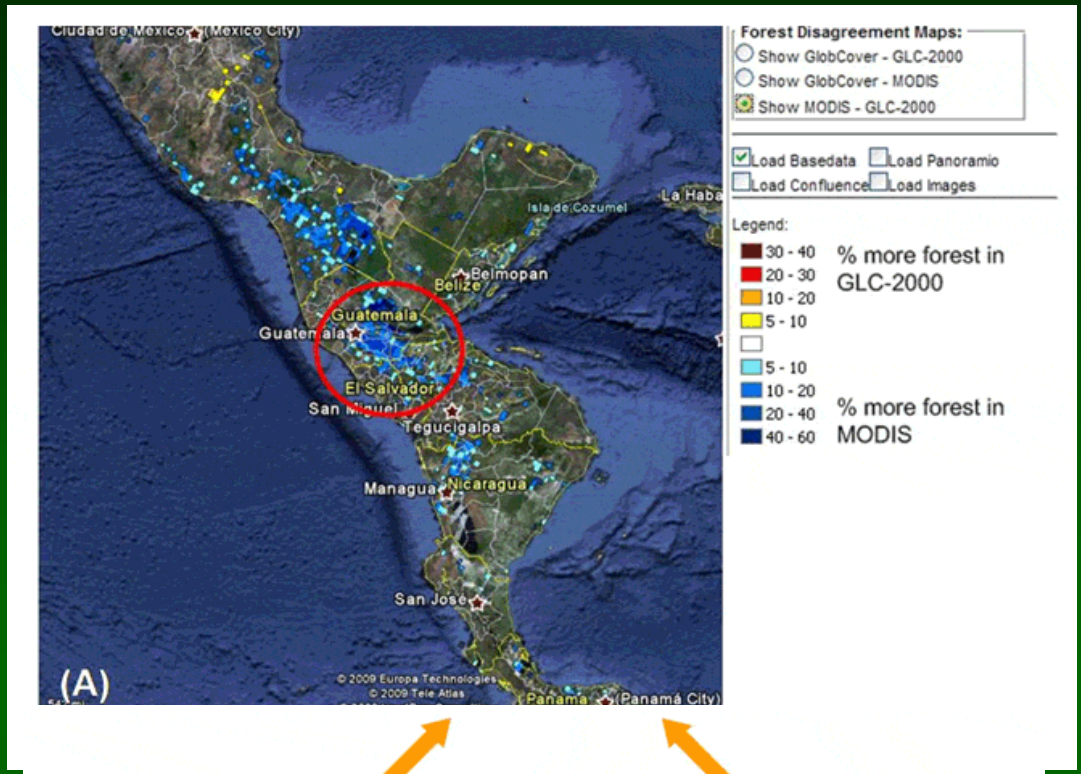
Differences Among Reported Changes in Forest Area (Grainger 2009)			
Country	**Reports by FRA**	**Reports to FRA**	**Country Own Survey**
Costa Rica	Possible reversal	Rise	Uncertain
Guatemala	Decline	Reversal	Uncertain
Honduras	Decline	Decline	Decline
Mexico	Decline	Reversal	Decline
Madagascar	Decline	Reversal	Decline
India	Possible reversal	Rise	Reversal
Nepal	Decline	Reversal	Decline
Vietnam	Reversal	Decline	Reversal

Emissions and Offsets Quantities for Policy Scenarios (mmt) (*EIA 2009*)						
	Basic		High Offsets		No International/ Limited	
	2020	2030	2020	2030	2020	2030
Total covered emissions	5505	4560	5705	5387	4801	4187
Total biogenic sequestration	1217	1838	1465	1771	515	676
Domestic	251	518	160	301	515	676
International	966	1320	1305	1470	0	0
Noncovered gases	35	53	23	44	65	73

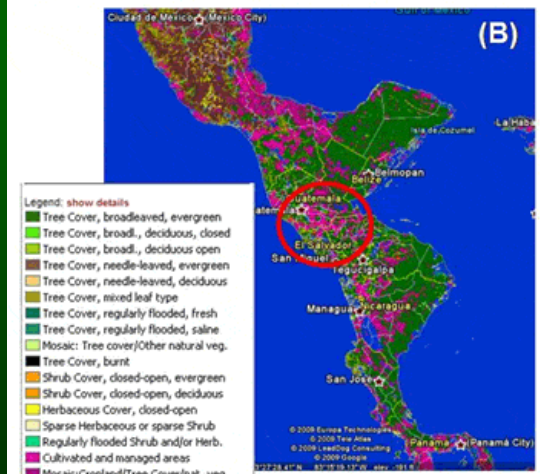
IPCC Tier 1 and Good Practice Measures of Carbon Density

Location	IPCC Definition	Tier 1 Default (t C/ha)	Plot Measurements (t C/ha)	Tier 1 as % of Plot Measurements
Brazil	Tropical Rainforest, North and South America	150	218	-31
Mexico	Temperate Mountain Systems, North and South America	65	49	+33
Indonesia	Tropical Rainforest Asia Insular	175	212	-17
Republic of Congo	Tropical rainforest Africa	155	277	-44
Republic of Guinea	Tropical rainforest Africa	155	209	-26
Madagascar	Tropical rainforest Africa	155	148	+5

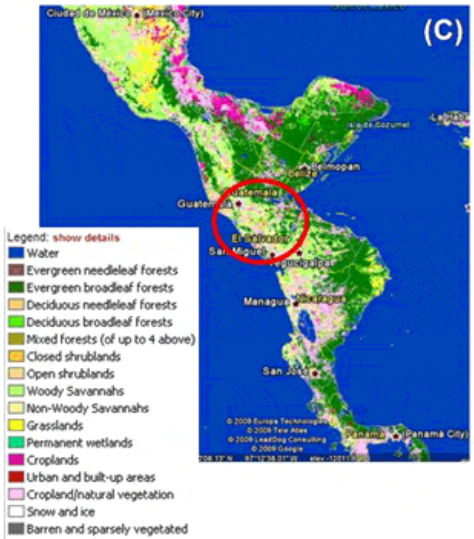
Waggoner 2009 based on Brown et al 2007 Box 4.2



GLC2000



MODIS



Forest cover from Mexico to Panama: discrepancies between measures

Sources: Geo-WIKI, 2009; Waggoner, 2009

Additionality, Permanence, and Leakage

- Additionality: what actions would happen anyway? (Define change with respect to a baseline)
- Permanence: here today but gone tomorrow? (changes in the quantity and quality, both opportunity cost of forests and wildfire, drought, pest infestation)
- Leakage: here today but somewhere else tomorrow? (A forest stand preserved in one location but removed in another – to detriment of climate management effort)
- Some solutions:
  - Rental of the offset
  - Role of baseline and land dynamics data; baseline default may be Landsat archived data (FAO 2011 FRA effort)
  - Requirement for periodic monitoring within "context" of land use, probably ideal if space-derived information

Reporting

- Global: rather than project by project; also consistent, periodic, updated, science-based, in Earth system context
- National: inventory of national sources: US as signatory to the 1992 UNFCCC; US EPA coordinates annual US reporting obligations in the "US National Greenhouse Gas Inventory"
  - Data from DoE (fossil energy), USDA (land-based emissions and sequestration), DoD (aircraft and ship operations)
  - State Dept submits inventory to UNFCCC
- Wide range of methodologies and data quality
  - 80% of emissions in form of fossil fuels deemed accurately reported to within a few percentage points
  - CO_2 sequestration in soils and forests difficult to measure; large number of sample plots used by Forest Service and USDA but additional (space-based) Earth observations and continued integration of data potentially beneficial (Kruger, 22 April 2009)
- Validators of individual projects in US and internationally
  - Carbon Auditors Ltd., ImageTree, Vision Forestry
  - Use of airborne LIDAR and some spaceborne RADAR
  - Airspace restrictions; expensive per hectare
  - Project level, not a national inventory as per EPA statutory requirement

Sampling errors and confidence intervals (example protocols)

- **Inventory of US Greenhouse Gas Emissions and Sinks (UNFCCC requirement; US EPA implements)**
  - **http://www.epa.gov/climatechange/emissions/downloads09/LULUCF.pdf**
- **General and Technical Guidelines for the Voluntary GHG Reporting (1605(b): Forestry Appendix)**
  - **http://www.usda.gov/oce/global_change/Forestryappendix.pdf**
- **IPCC National GHG Inventory for AFOLU**
  - **http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html**
- **EPA Climate Leaders Reforestation/Afforestation Methodology**
  - **http://www.epa.gov/climateleaders/resources/optional-module.html**
- **Chicago Climate Exchange Project Guidelines: Forestry**
  - **http://www.chicagoclimateex.com/docs/offsets/CCX_Forestry_Sequestration_Protocol_Final.pdf**

EPA GHG measurement protocols

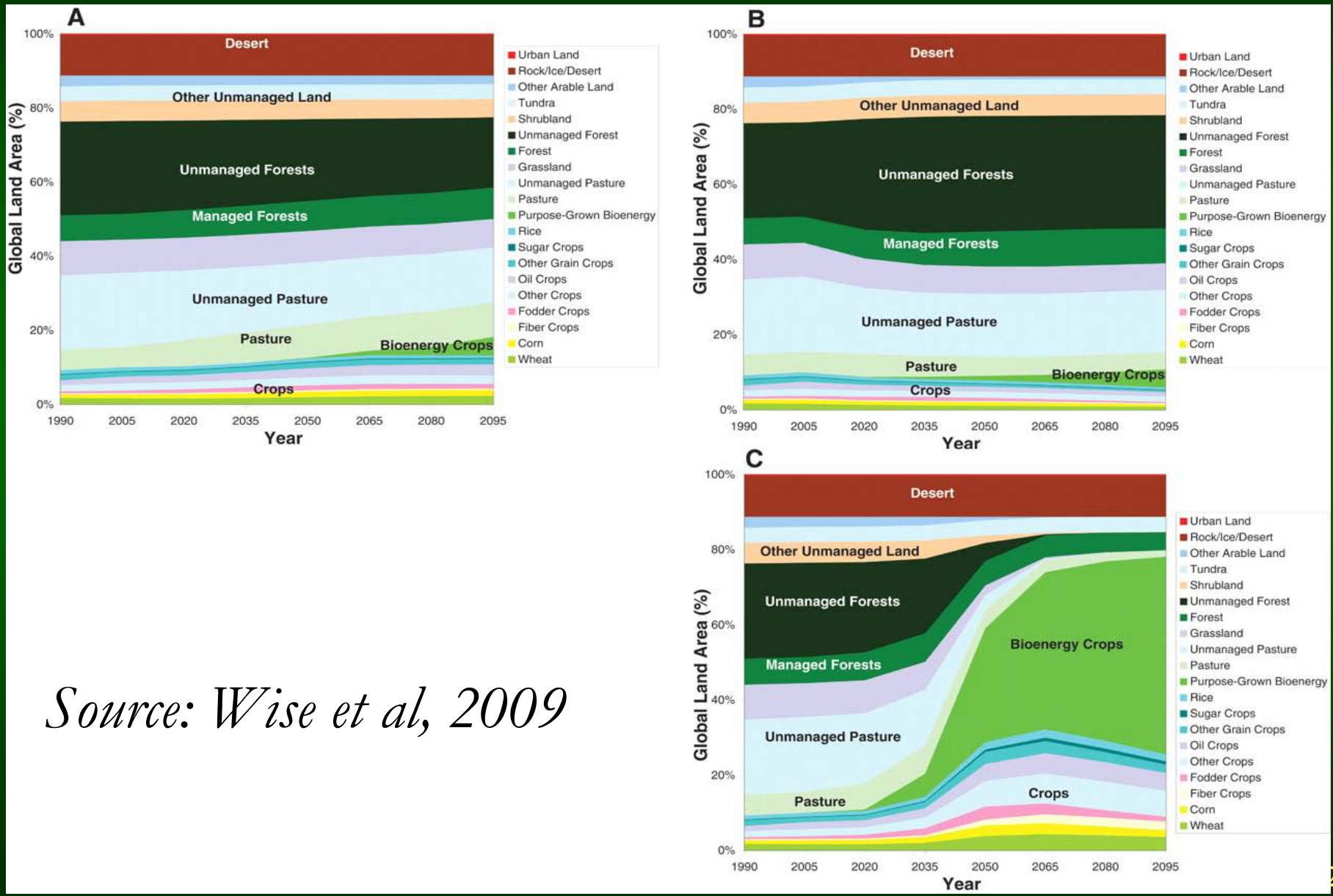
Source	Standard type	Users	Level of Accuracy/Precision (metrics are source-specific)
Inventory of Greenhouse Gas Emissions and Sinks: 1990–2007: Land Use, Land Use Change, and Forestry (pg. 7-19) http://www.epa.gov/climatechange/emissions/downloads09/LULUCF.pdf	Government data collection and additional inventories	Policymakers, scientists	In 2007, 910.1 Tg CO_2e fluxed from forest lands in the US with an uncertainty range of +/- 19%.
EPA Climate Leaders Reforestation/Afforestation Methodology (pg. 12) http://www.epa.gov/climateleaders/resources/optional-module.html	Government-sponsored voluntary GHG offset reporting protocol	Policymakers, scientists, offset suppliers, offset purchasers	+/- 10% precision of estimated CO_2 sequestration at 95% confidence level.

Policy in play

- American Power Act (Kerry-Lieberman) (*also HR 2454, S. 1733*)
- Energy Independence and Security Act of 2007 (Section 712)
- Clean Air Act of 1990 and amendments
- Required reporting (EPA *US National Greenhouse Gas Inventory* under UNFCCC)
- Voluntary efforts (*e.g.,* RGGI, WCI, CCX, CDM)
- International negotiations and pledges (e.g., FY11 Budget for International Climate Change Financing (Copenhagen Accord); Advance Version Negotiating Text for UNFCCC Bonn Meetings (June))

- **American Power Act: limit on total offsets; divided between domestic and international with provision to increase international if domestic ceiling not reached; USDA oversight of domestic forestry and offsets; separate integrity advisory committees for domestic and international offsets. No set-aside of allocations for international projects for reducing emissions from deforestation and degradation (REDD).**
- **Clean Air Act: "Not readily compatible with international offsets in a GHG context," "statutory restrictions that require, at best, creative and legally questionable reinterpretation in order to be compatible with international offsets…" (Richardson 2010).**
- **FY11 budget for international climate change financing: Depts of State and Treasury and US AID provide assistance of $347 M to reduce GHG emissions by increasing biogenic carbon sequestration (of total of $1.4 billion)**

Global land use under different policies



Source: Wise et al, 2009

Summary

- Physical and economic importance of offsets
- Existing data on how many trees, where, and how much carbon stored are poor
- Policy and institutional design problematic
  - Mixed private and public good (nationally sovereign resources provide globally useful carbon sequestration)
  - Existing information asymmetries rational
- Technology available but not fully deployed (no instrument(s) "optimized" for forest observations or for additionality, permanence, leakage)
- Pay to play possible but only if carbon is valued through (strong) marketlike or regulatory forces (and an *ex post* solution to an *ex ante* problem in modeling efforts)
- Demands for climate science may strengthen desirability of expenditures for better data on carbon fluxes but little evidence to date

Back up information

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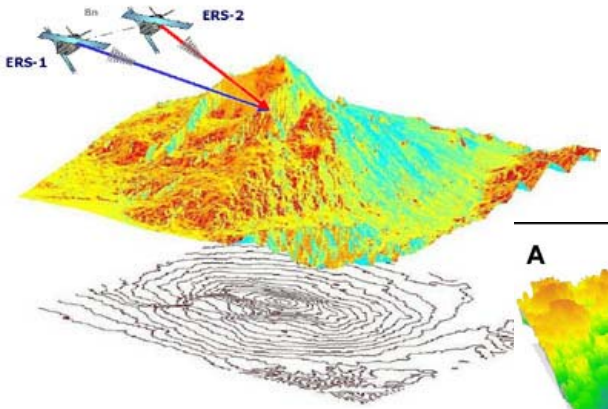
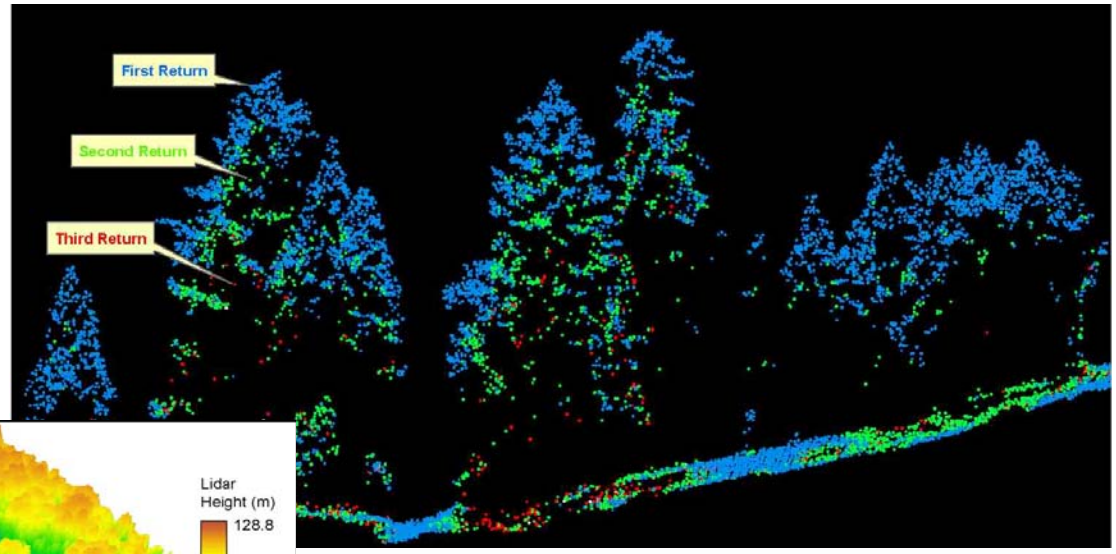
Context Dependency (Earth as a system): Biofuels and land use implications of the Energy Independence and Security Act of 2007

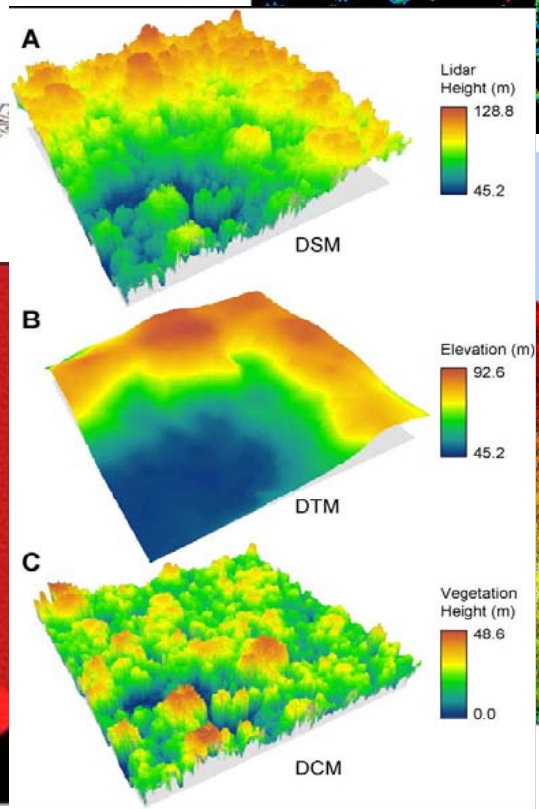
- **Subsidies and mandates to increase use of liquid biofuels for domestic transportation**
  - **Requires gradual increase by US fuel producers; 36 billion gallons by 2022 including 16 billion gallons of cellulosic biofuels**
  - **Provides $1.04/gallon subsidy to cellulosic biofuels; corn ethanol subsidy reduced from $0.51 to $0.45/gallon**
- **Resulting near-term effects**
  - **About 70% of the US 2005 wood harvest required to meet target**
  - **US and world prices for raw wood about 15% higher in 2015 and 20% higher in 2020**
  - **US imports of wood-based products increase to over $4 billion**

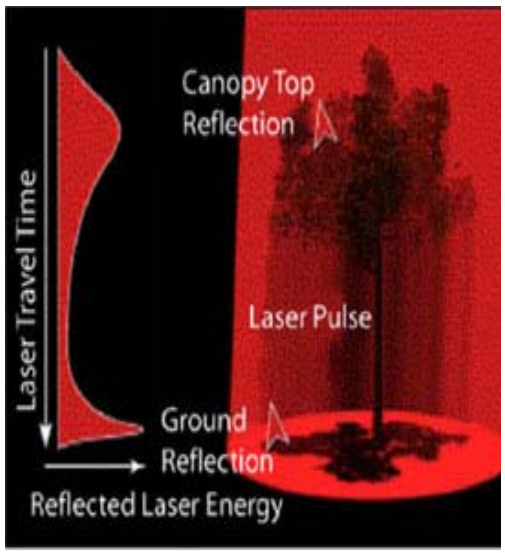
Source: Sedjo and Sohngen 2009

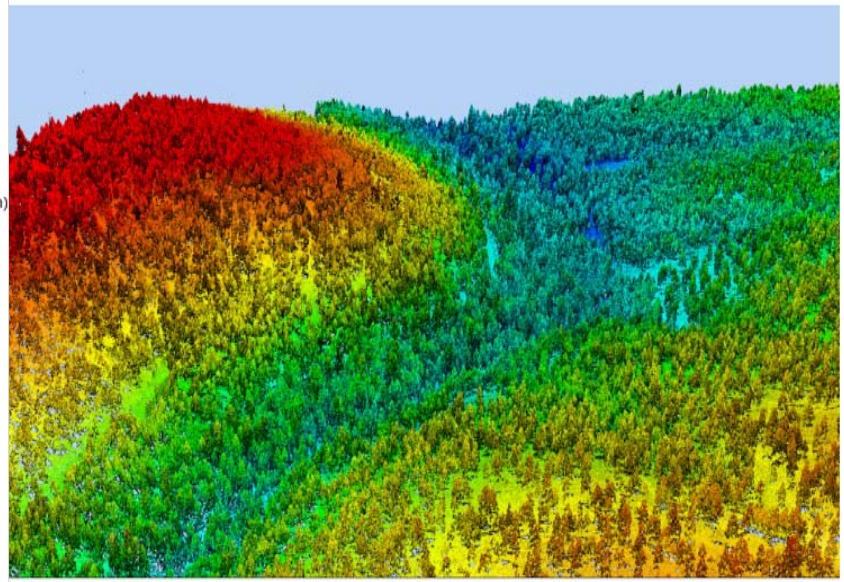
We can do even better - is it worth it?











Public/private data $465/km^2; restrictions on overflight

Fagan and DeFries, ImageTree

Availability of Data for Global Comparability

Attribute **Source***	**Area**	**Volume**	**Biomass**	**Carbon**	**Frequency Leakage, Permanence**	**Baseline**	**Quality (Protocol)**
Aerial instruments		x	x	x			x
Satellite instruments	x	2015?	Very limited		x	x**	
Institution							
UN FAO FRA	x	x				x	
GOFC GOLD	x	x	x	x			
National inventories	x	x					
GEO FCT				x		x	Maybe
Projects (science, philanthropic)	x	x	x	x			By project
Commercial validators	x	x	x	x			By project

*All need field confirmation ("ground truthing")
**Assumes historic satellite data

Expected Improvements in Data Quality for Forest Measures and Monitoring (Fagan and DeFries 2009)					
Variable	Instruments**	Quality		km^2 ($ 2009)	Wall/Wall (billions $2009)
		Current	Expected ~2015		
Area	High resolution optical, radar	65% to 80%	~ 90%	~ $25	~ $ 3
Volume	Radar, lidar	80%	~ 95%	~ $465	~ $ 67
Biomass	P-band	?	?	?	?
Carbon	Allometric				

Note: Estimated "cost" *very roughly* approximated for annual inventory due to data limits. See discussion in Fagan and DeFries. **Ground truthing additionally needed.

HR 2454 and S. 1733: Provisions for Offsets

- Sec. 722(d)(1)(A) - IN GENERAL.—Covered entities collectively may, in accordance with this paragraph, use offset credits to demonstrate compliance for up to a maximum of 2 billion tons of greenhouse gas emissions annually. The ability to demonstrate compliance with offset credits shall be divided pro rata among covered entities by allowing each covered entity to satisfy a percentage of the number of allowances required to be held under subsection (b) to demonstrate compliance by holding 1 domestic offset credit or 1.25 international offset credits in lieu of an emission allowance, except as provided in subparagraph (D).
- Offset language similar, though some differences in volume of domestic and international offsets allowed
- Title VII, Part D and Title V cover specific offset provisions