

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

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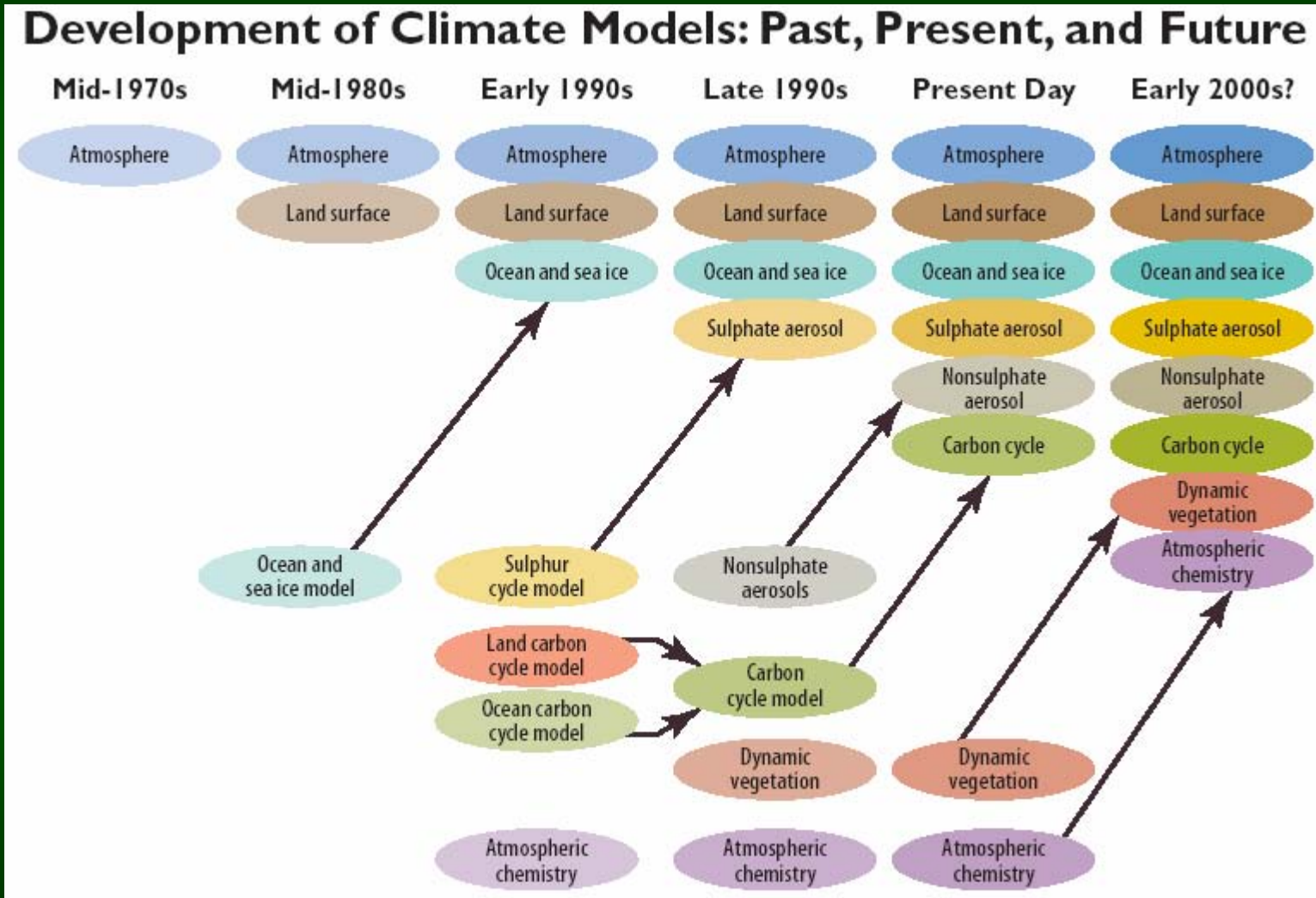
Overview

- 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

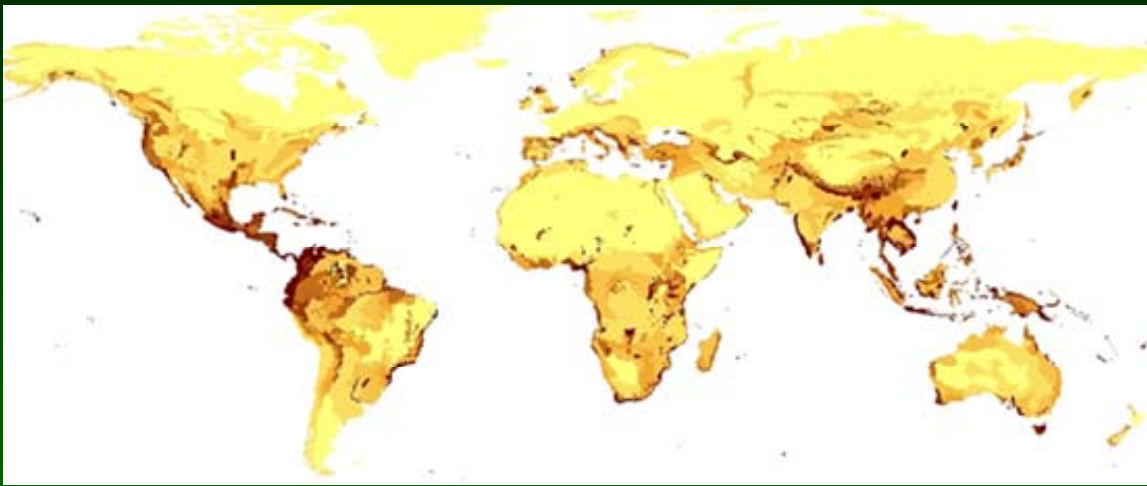


Why policy intervention?

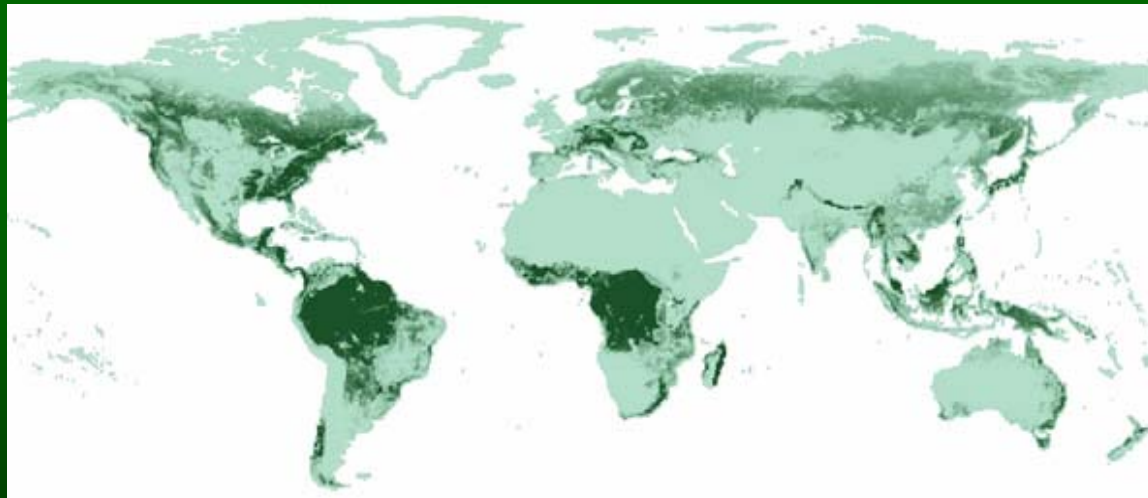
- May be a lower cost means of managing climate; some experts suggest significantly lower
- May have co-benefits (forests/habitat preservation/watershed protection or energy source such as landfill methane markets)
- May serve other purposes (political goals, other social objectives such as resource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



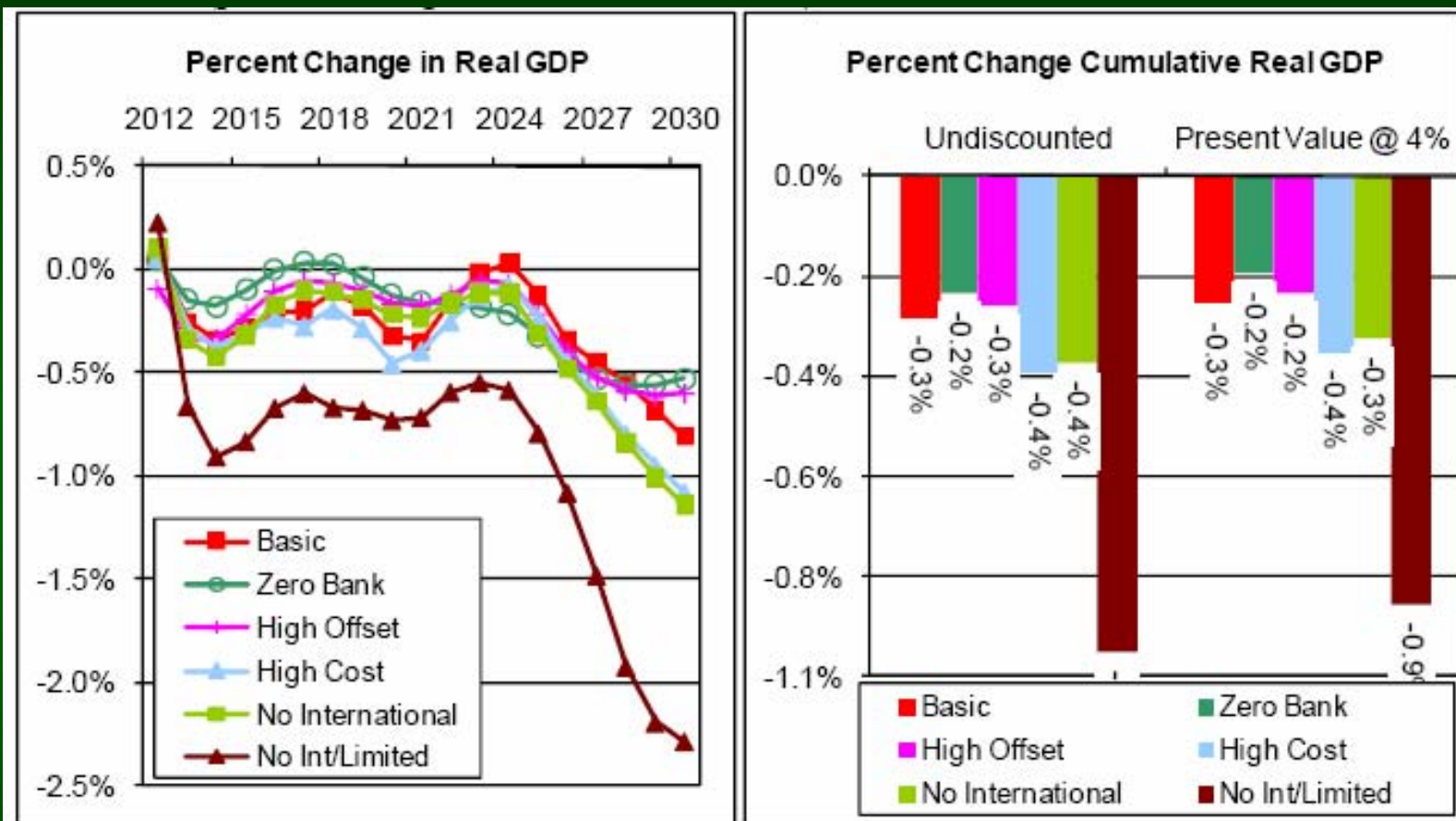
Species richness (number of mammal species per km², by ecological region, using IUCN data)



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)

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 |

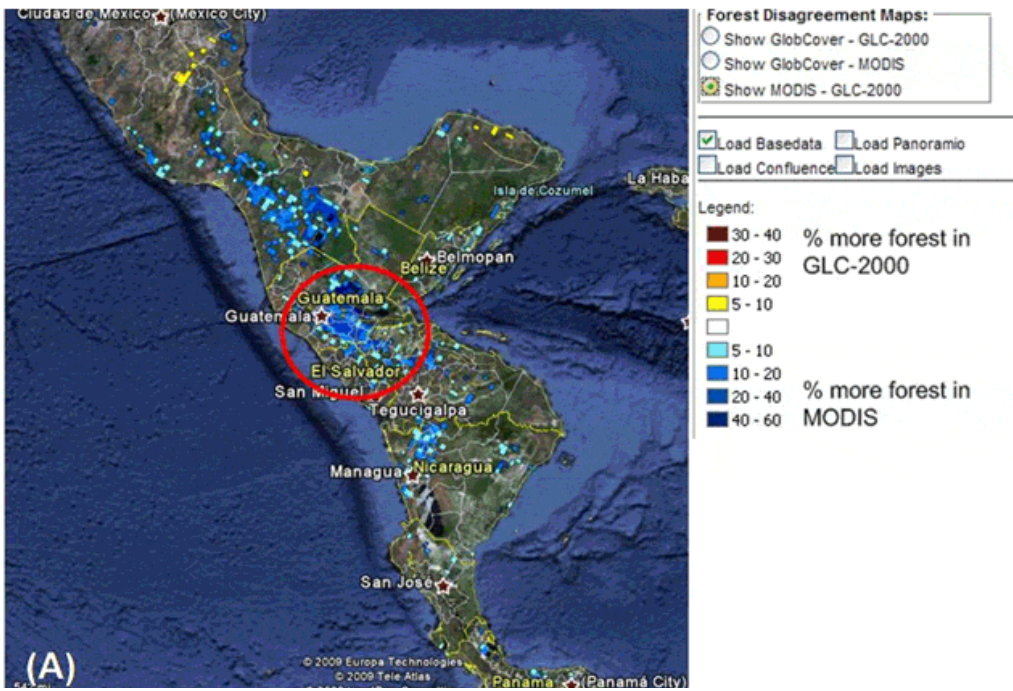
**Emissions and Offsets Quantities for Policy Scenarios
(mmt) (EIA 2009)**

| | 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 |

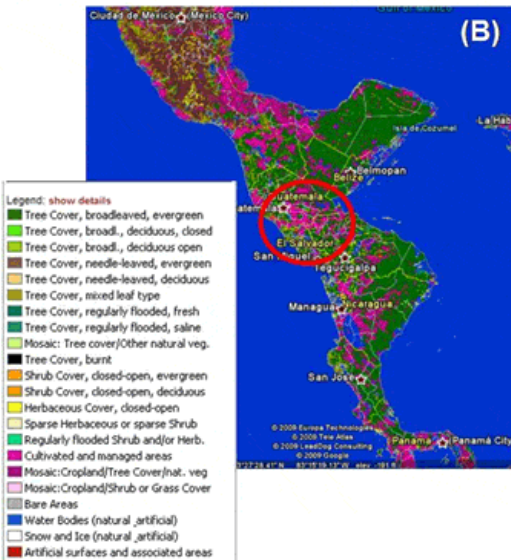
Waggoner 2009 based on Brown et al 2007 Box 4.2



Forest cover from Mexico to Panama: discrepancies between measures

GLC2000

MODIS



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
 - CO₂ 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

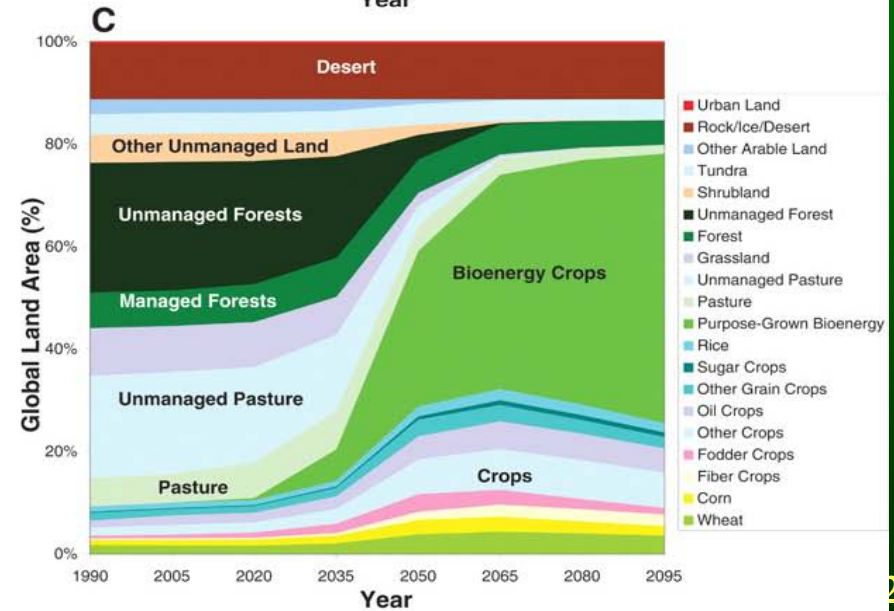
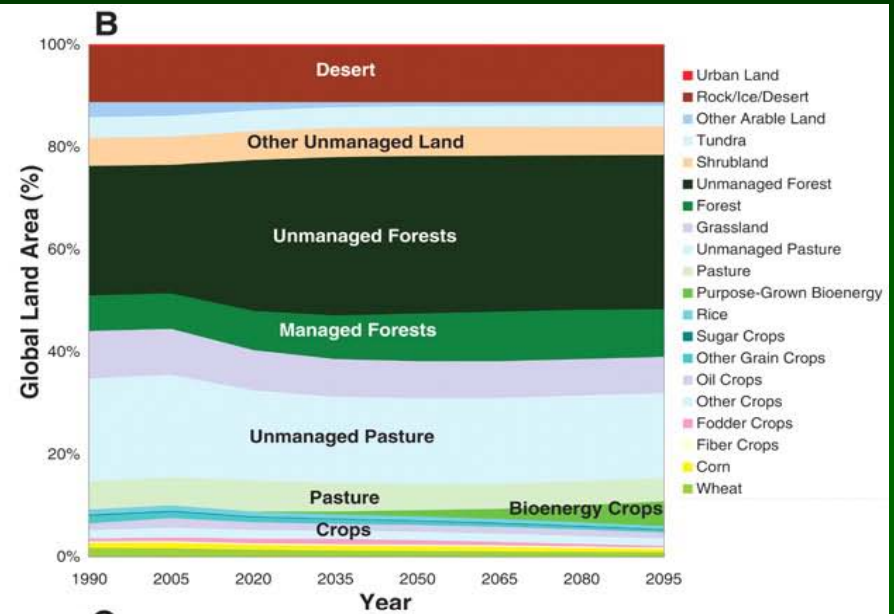
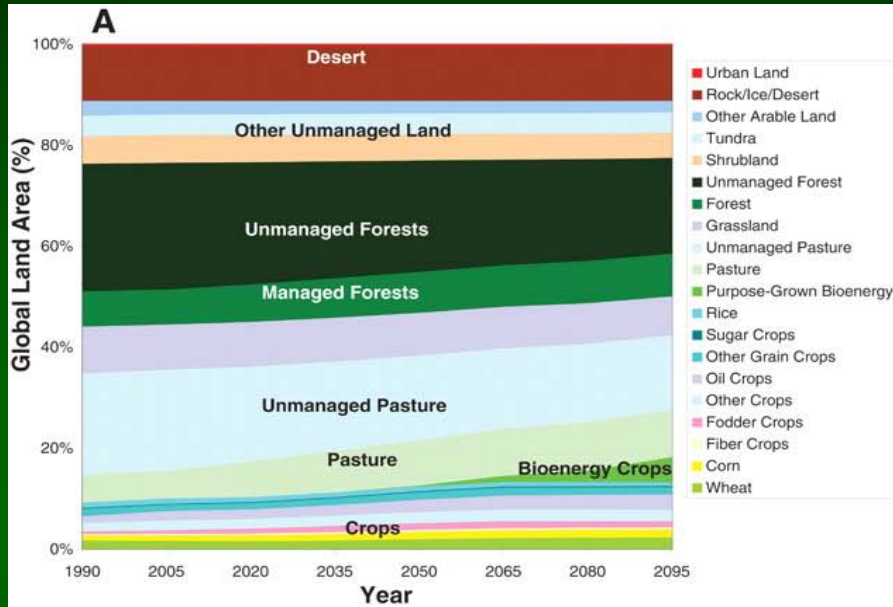
| Source | Standard type | Users | Level of Accuracy/Precision (metrics are source-specific) |
|---|--|---|--|
| Inventory of Greenhouse Gas Emissions and Sinks: 1990–2007: Land Use, Land Use Change, and Forestry (pg. 7-19) http://www.epa.gov/climatechange/emissions/downloads09/LULUCF.pdf | Government data collection and additional inventories | Policymakers, scientists | In 2007, 910.1 Tg CO ₂ e 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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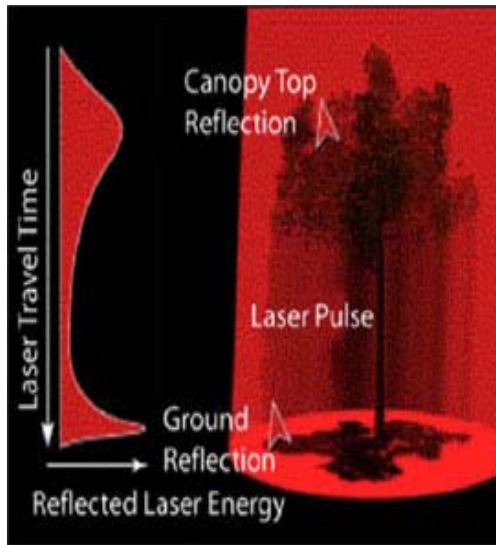
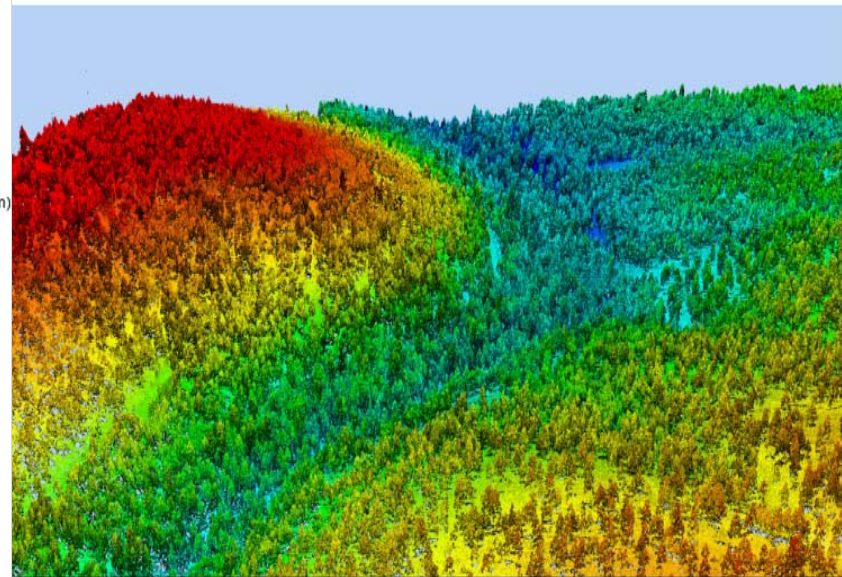
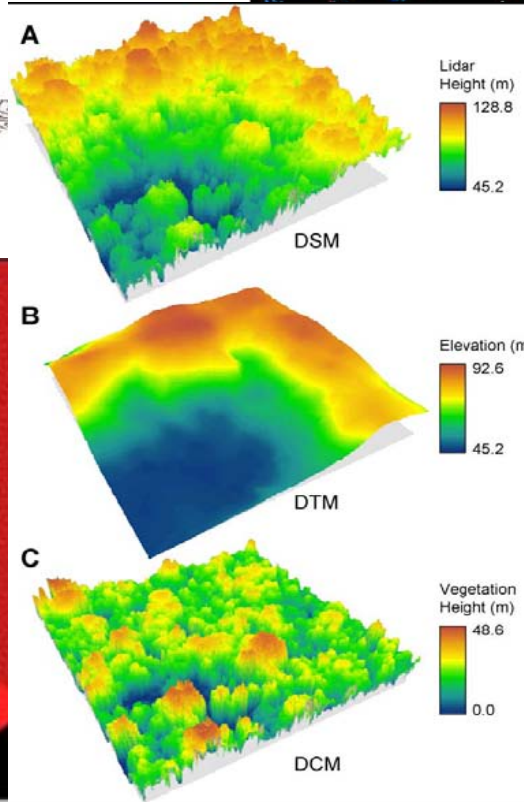
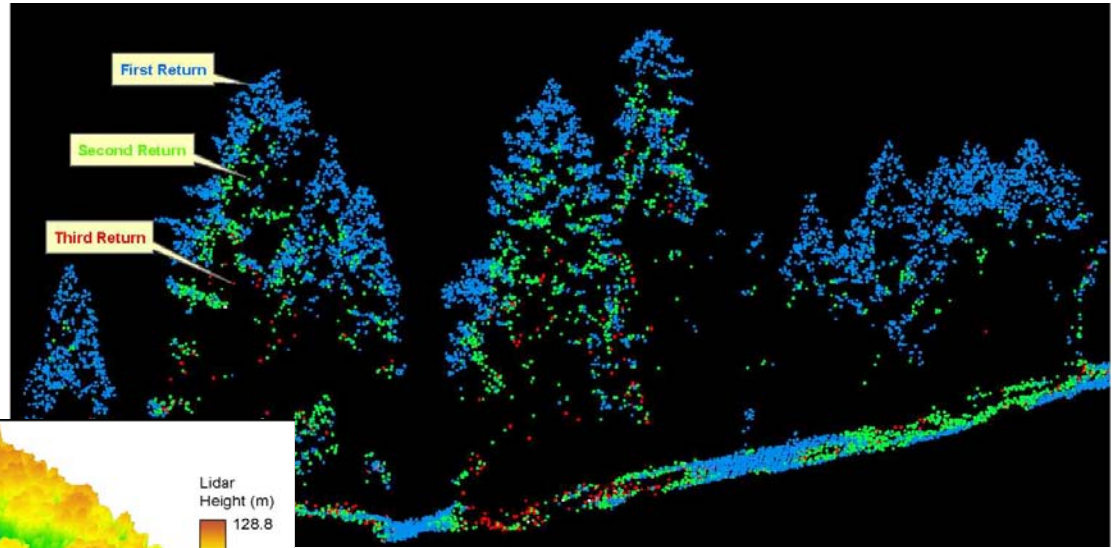
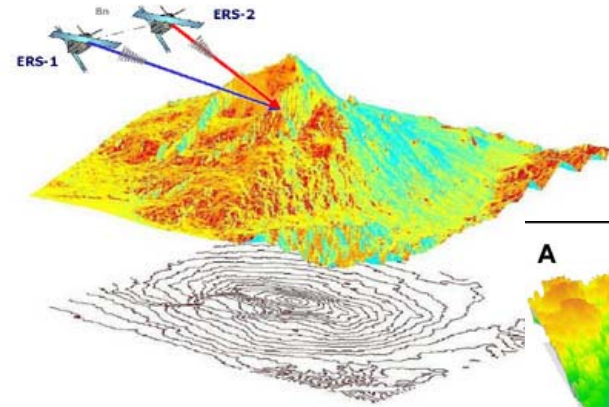
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Context Dependency (Earth as a system): Biofuels and land use implications of the Energy Independence and Security Act of 2007

- **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

We can do even better - is it worth it?



Public/private data \$465/km²; restrictions on overflight

Availability of Data for Global Comparability

| <u>Attribute</u> | Area | Volume | Biomass | Carbon | <u>Frequency</u> <u>Leakage,</u> <u>Permanence</u> | Baseline | Quality (Protocol) |
|---|------|--------|--------------|--------|--|----------|-----------------------|
| <u>Source*</u> | | | | | | | |
| 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