Insights from Agricultural GHG Offset studies that might Influence IAM Modeling

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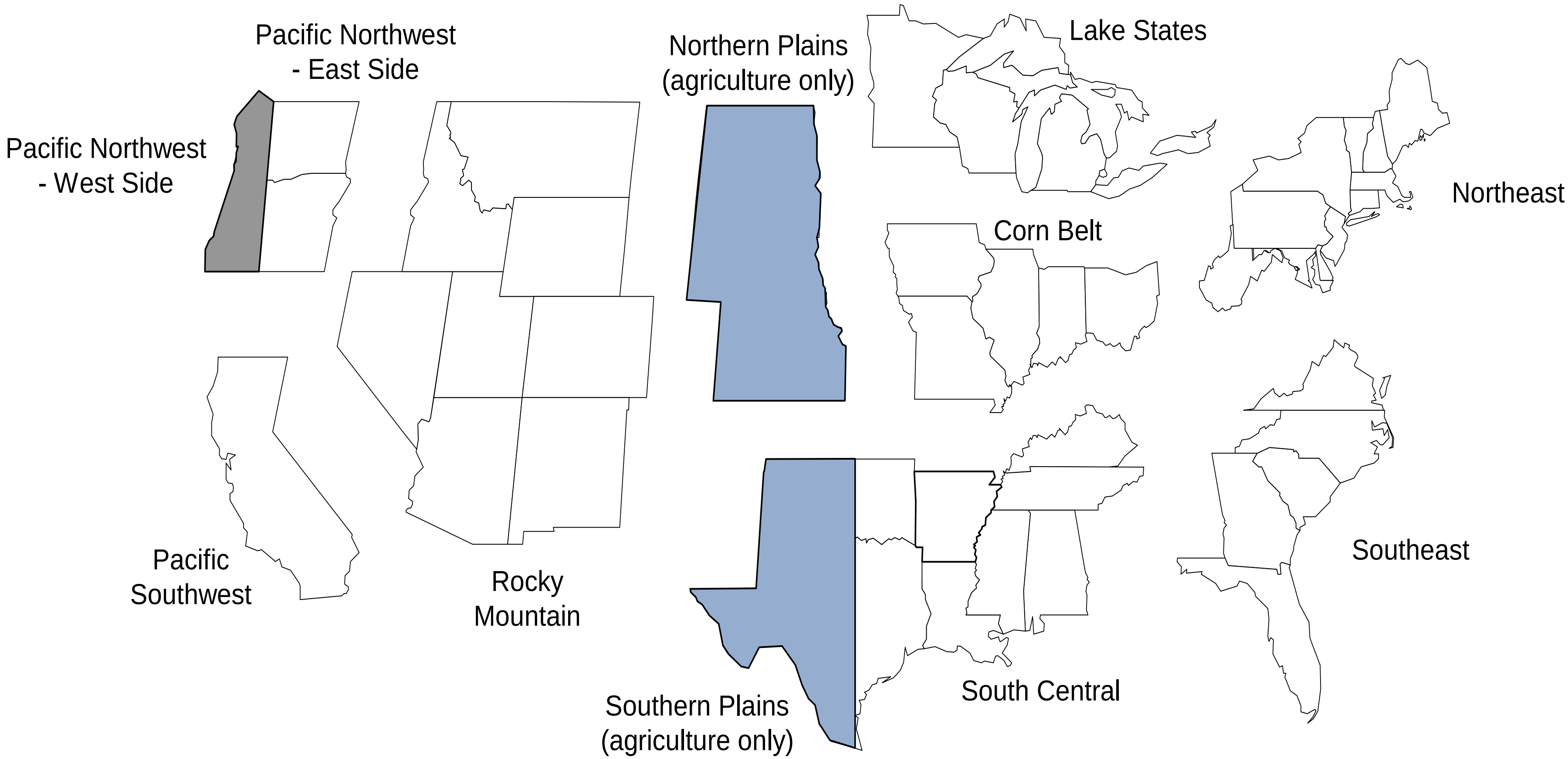
Paper/Study Objectives

- Discuss insights from aggregate studies done on ag and forestry that could influence IAM work
- Address fungibility
- Reveal some information on project direction

FASOMGHG land

Regions In Forestry



How is land currently characterized by bio-physical models and IAMs?

In US Agriculture

Subreg

Alabama	Arizona	Arkansas	CaliforniN	CaliforniS
Colorado	Conn	Delaware	Florida	Georgia
Idaho	IllinoisN	IllinoisS	IndianaN	IndianaS
IowaW	IowaCent	IowaNE	IowaS	Kansas
Kentucky	Louisiana	Maine	Maryland	Mass
Michigan	Minnesota	Mississipp	Missouri	Montana
Nebraska	Nevada	NewHampshi	NewJersey	NewMexico
NewYork	NorthCarol	NorthDakot	OhioNW	OhioS
OhioNE	Oklahoma	Oregon	Pennsylvan	Rhodeislan
Southcarol	Southdakot	Tennessee	TxHiPlains	TxRolingPl
TxCntBlack	TxEast	TxEdplat	TxCoastBe	TxSouth
TxTranspec	Utah	Vermont	Virginia	Washington
Westvirgin	Wisconsin	Wyoming		

How are land-use and terrestrial GHG mitigation decisions currently modeled

Activity and GHG Coverage

Strategy	Basic Nature	CO2	CH4	N2O
Afforestation	Sequestration	X		
Existing timberland/reforestation	Sequestration	X		
Deforestation	Emission	X		
Biofuel Production	Offset	X	X	X
Crop Mix Alteration	Emiss, Seq	X		X
Crop Fertilization Alteration	Emiss, Seq	X		X
Crop Input Alteration	Emission	X		X
Crop Tillage Alteration	Emission	X		X
Grassland Conversion	Sequestration	X		
Irrigated /Dry land Mix	Emission	X		X
Enteric fermentation	Emission		X	
Livestock Herd Size	Emission		X	X
Livestock System Change	Emission		X	X
Manure Management	Emission		X	X
Rice Acreage	Emission	X	X	X

How should land potential and land-use responses (impacts) to climate change be modeled?

A House of Cards

Climate Scenarios	– GCMs
Crop Simulation	– Crop yields (dry and irr), water use Carbon sequestration
Forest Simulation	– Yields by region, year and species Product fate Carbon sequestration
Hydrologic simulation	– Irrigation water
Livestock sim /experts	– Livestock performance,
Grass simulation	– Livestock pasture usage Animal unit month grazing supply Carbon sequestered
Other studies	– International supply and demand
Regression	– Pesticide usage, Non Ag water use Extreme event effects
Adaptation obs/expert	– Crop mix shift Varieties
GHG Mitigation	– Methane from rice, enteric, manure, others N2O from fertilizer, manure, other sources Biomass yields and processing
Economics	– FASOM sector model

How are land-use and terrestrial GHG mitigation decisions currently modeled

- Constrained Optimization Problem
- Objective Function: Maximize NPV of sum of producers’ and consumers’ surpluses
  - Across Ag and Forest sectors
  - Over time (100 yrs)
  - Including GHG payments
- Constraints
  - Total Production = Total Consumption
  - Tech Input/output relationships hold
  - Land use balances

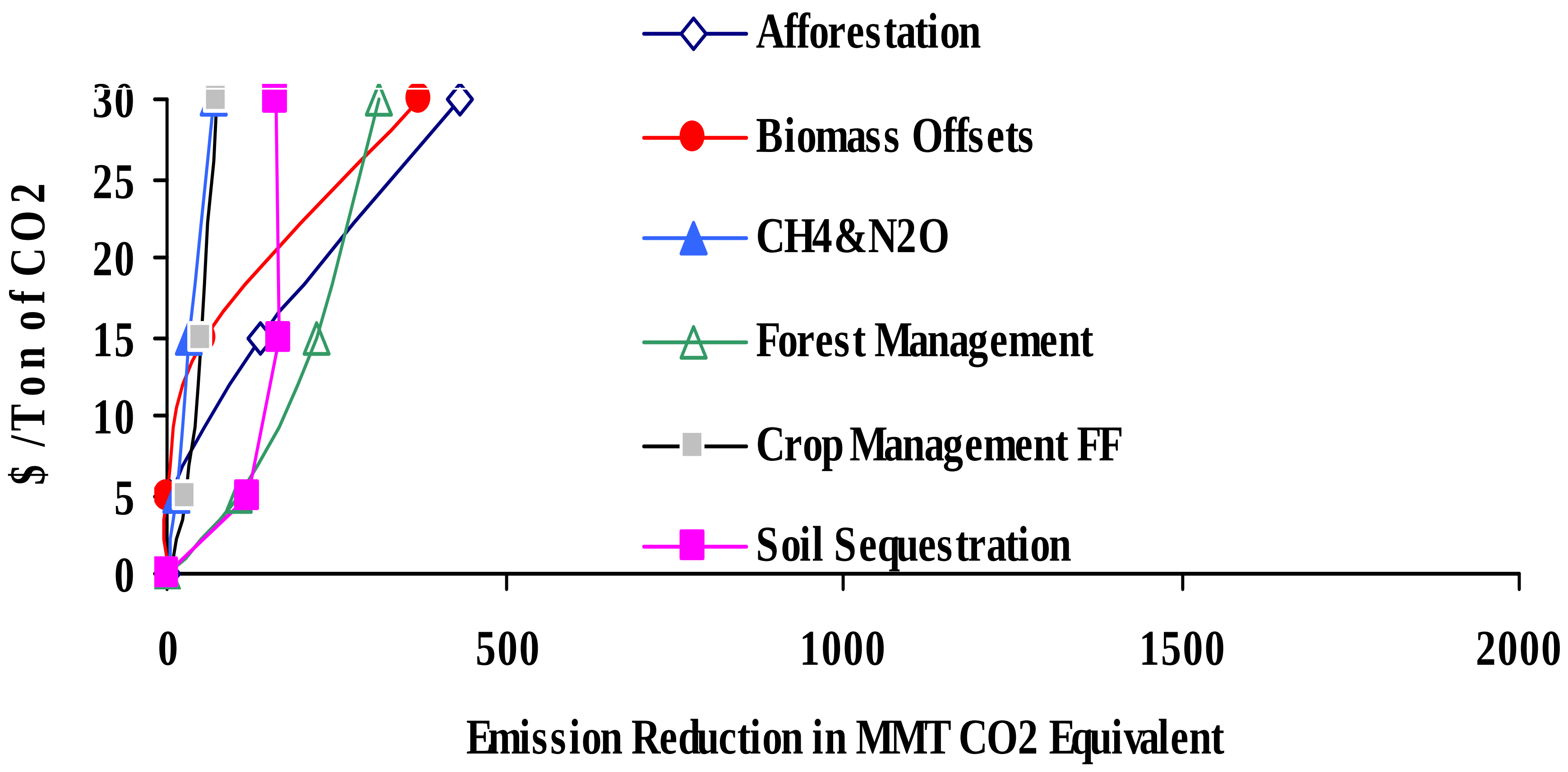
What issues might IAM modelers consider?

Undesirableness of sequestration only modeling
Dynamics
Substitution with traditional production
– short and long run
Regional heterogeneity
Fungibility
Co-benefits
Adapting price expectations
Policy scope and applicability

What issues might IAM modelers consider?

Undesirableness of sequestration only modeling

MMt arising at an offset price giving $/tonne carbon equiv

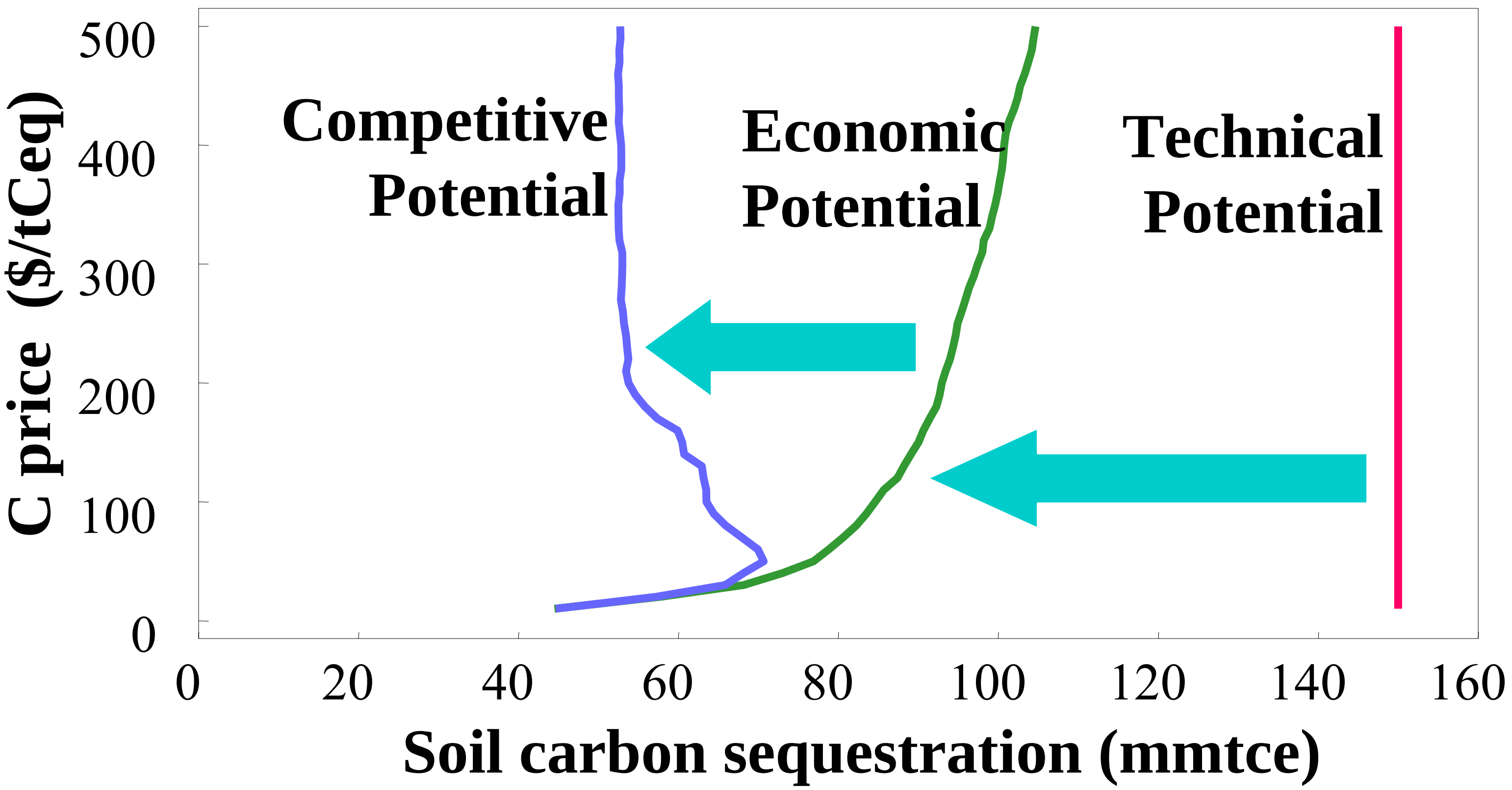


- Small importance of CH_4 and N_2O
- Different strategies dominate at different price levels

What issues might IAM modelers consider?

Undesirableness of sequestration only modeling

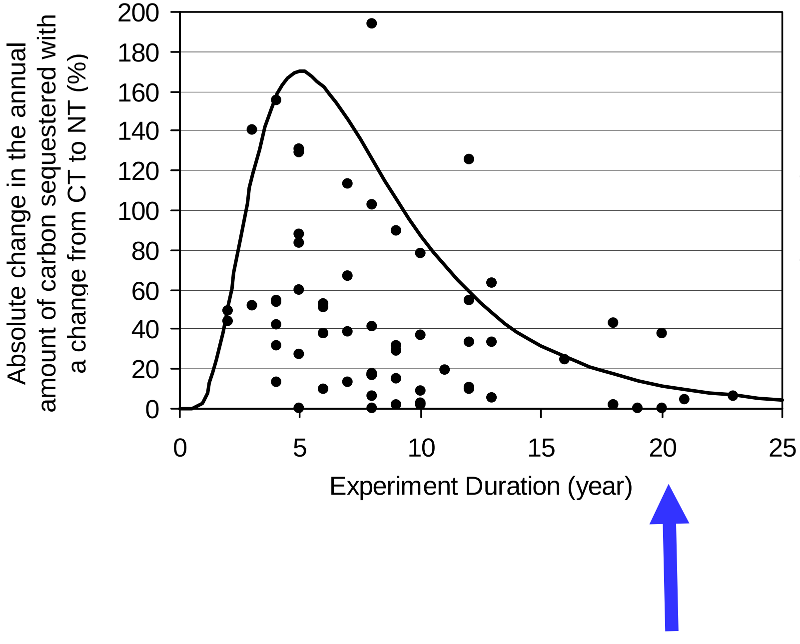
Example: U.S. ag soil potential:

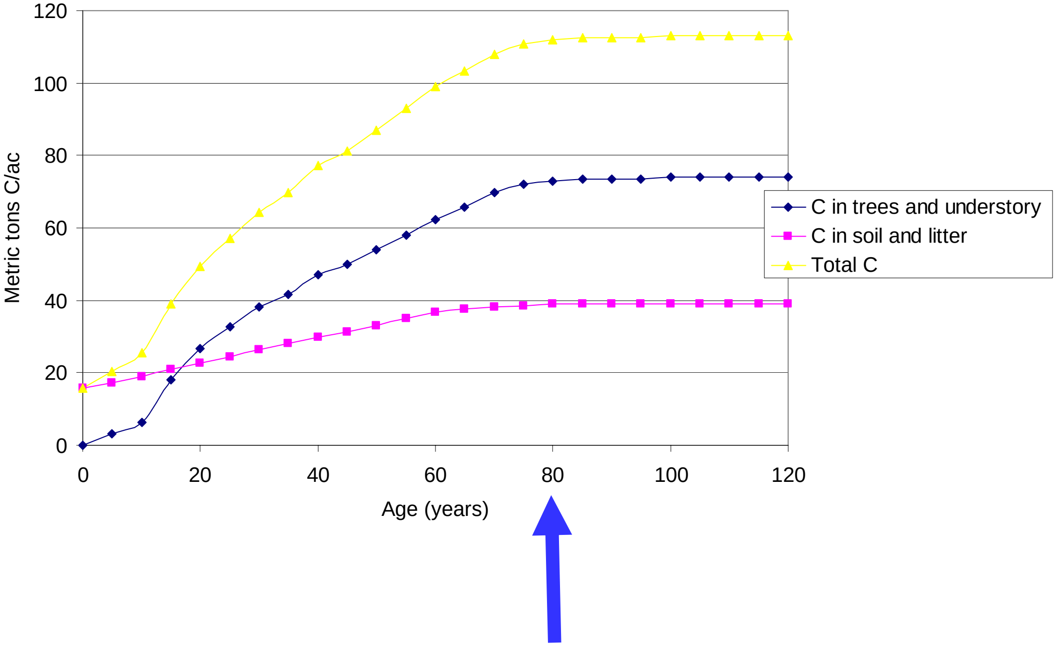


What issues might IAM modelers consider?
Dynamics

Absolute Change in the Annual Rate of Carbon Sequestered Following a Change from Conventional Tillage (CT) to No-Till (NT) - West and Post

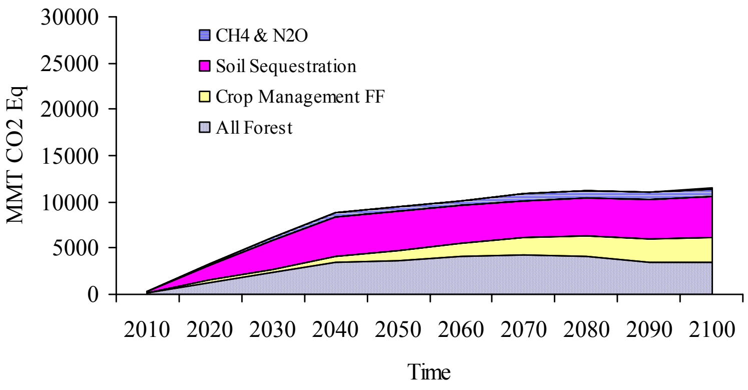
Carbon Accumulation on an Afforested Southeastern Pine Stand, to Saturation -- Birdsey



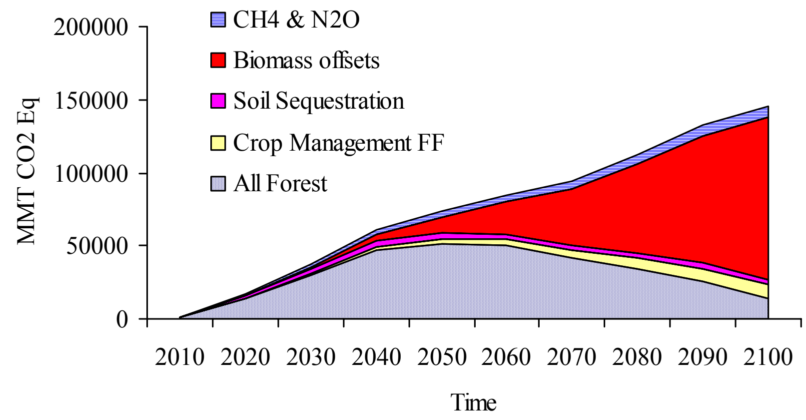


What issues might IAM modelers consider?

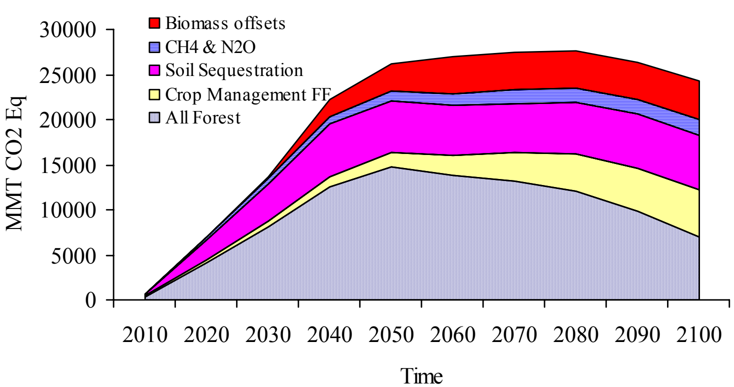
Dynamics



Cumulative Contribution at a $5 per tonne CO2 Price



Cumulative Contribution at a $50 Price



Cumulative Contribution at a $15 Price

Note

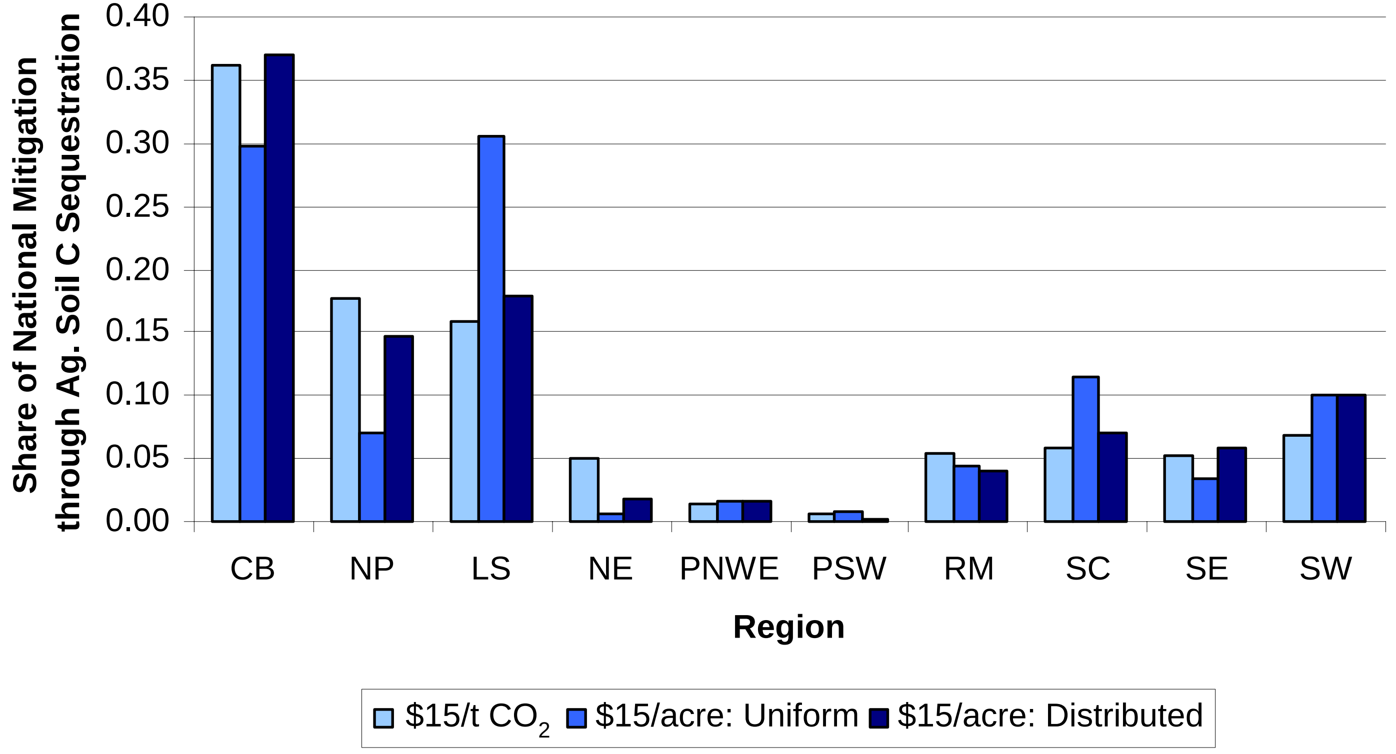
Effects of saturation on sequestration
Growing nonco2 and biofuels

Source Lee, H.C., B.A. McCarl and D. Gillig, "The Dynamic Competitiveness of U.S. Agricultural and Forest Carbon Sequestration," 2003.

What issues might IAM modelers consider?

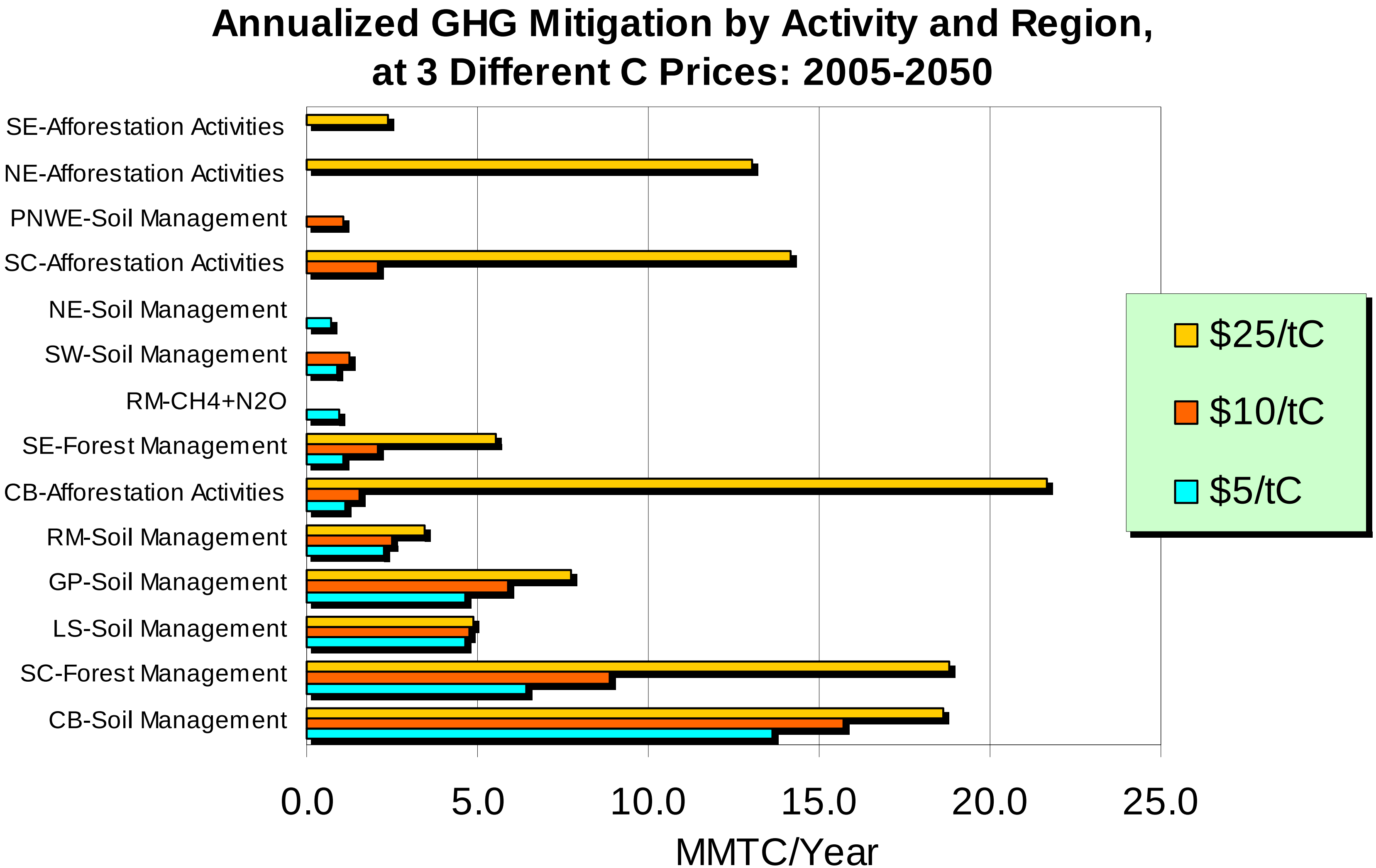
Regional heterogeneity

Regional Shares of Agricultural Soil Carbon Sequestration



What issues might IAM modelers consider?

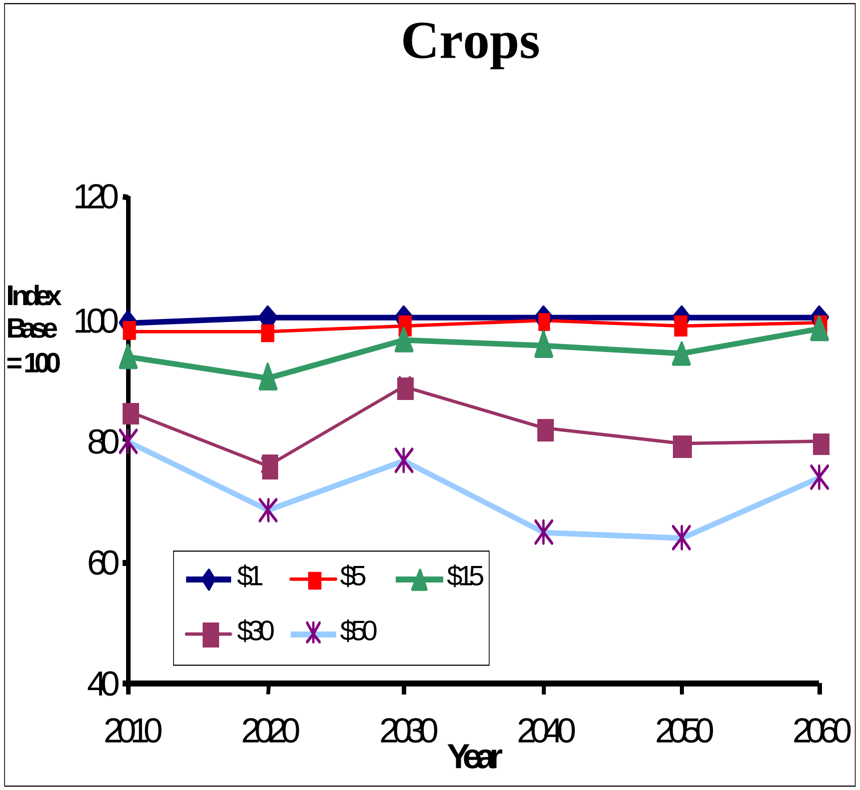
Regional heterogeneity

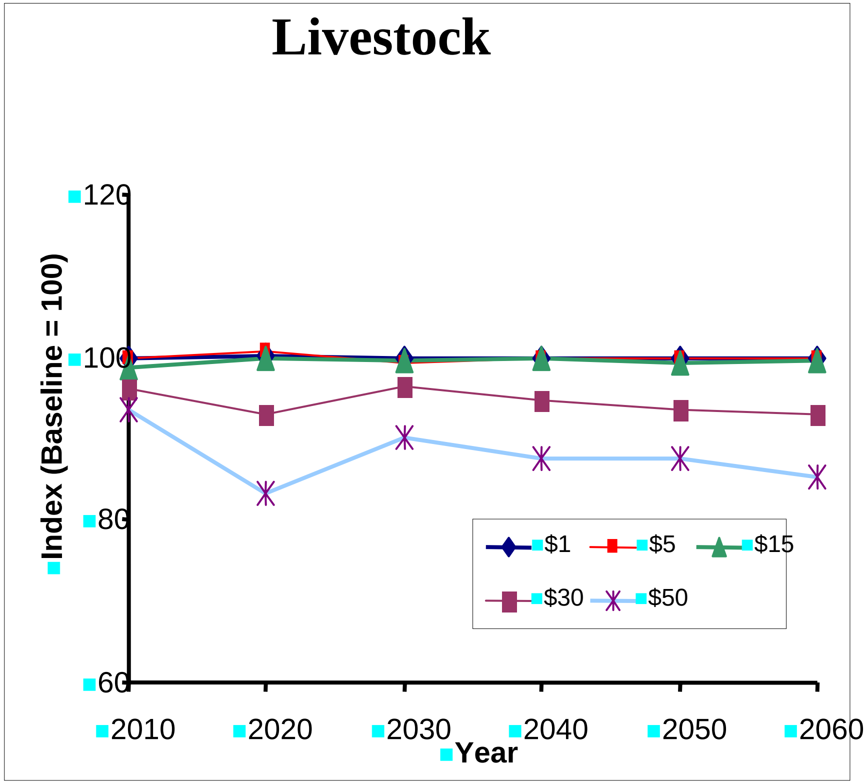


What issues might IAM modelers consider?

Substitution with traditional production – short and long run

Production Quantity Index over Time

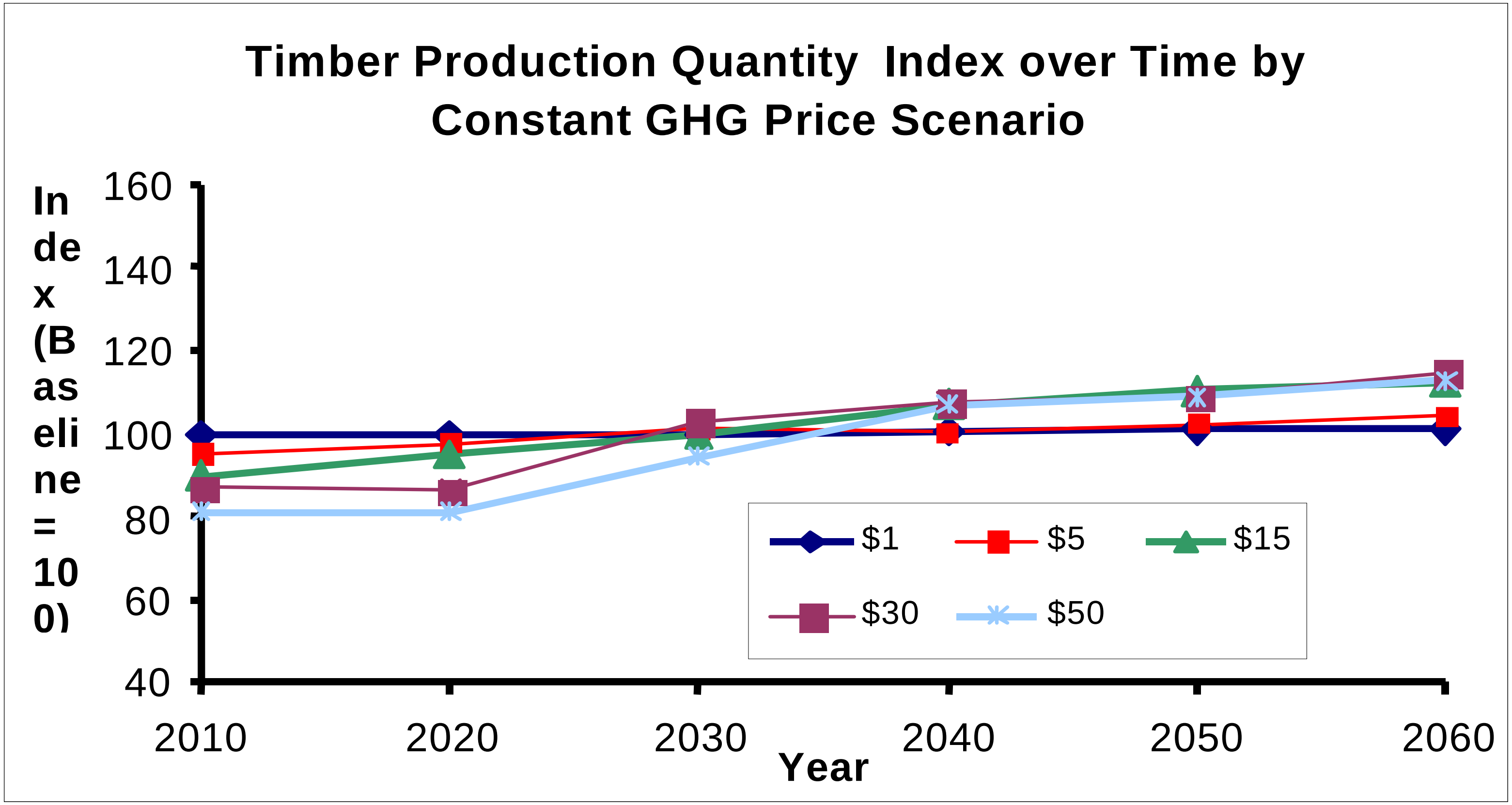




Substitutes

What issues might IAM modelers consider?

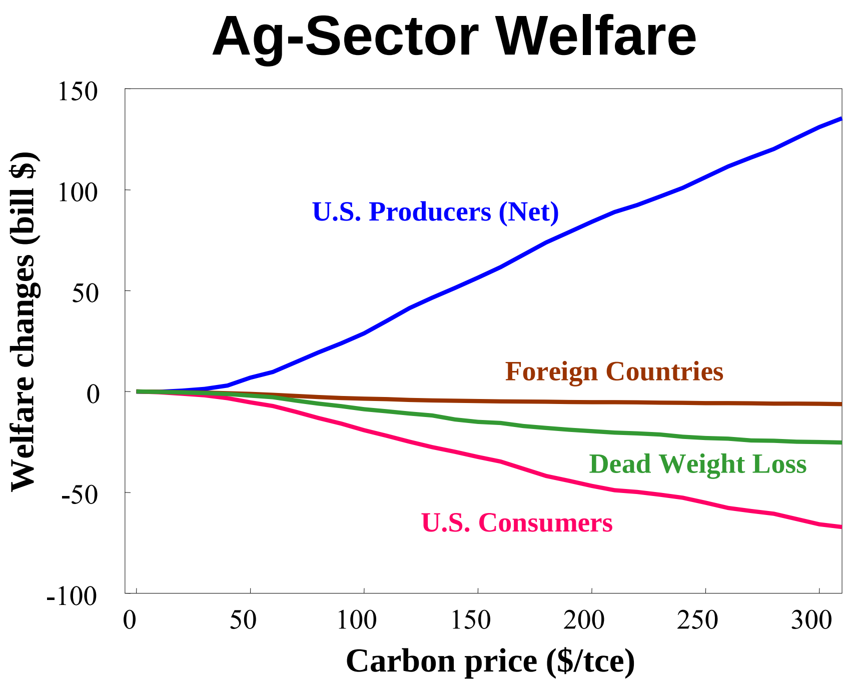
Substitution with traditional production – short and long run

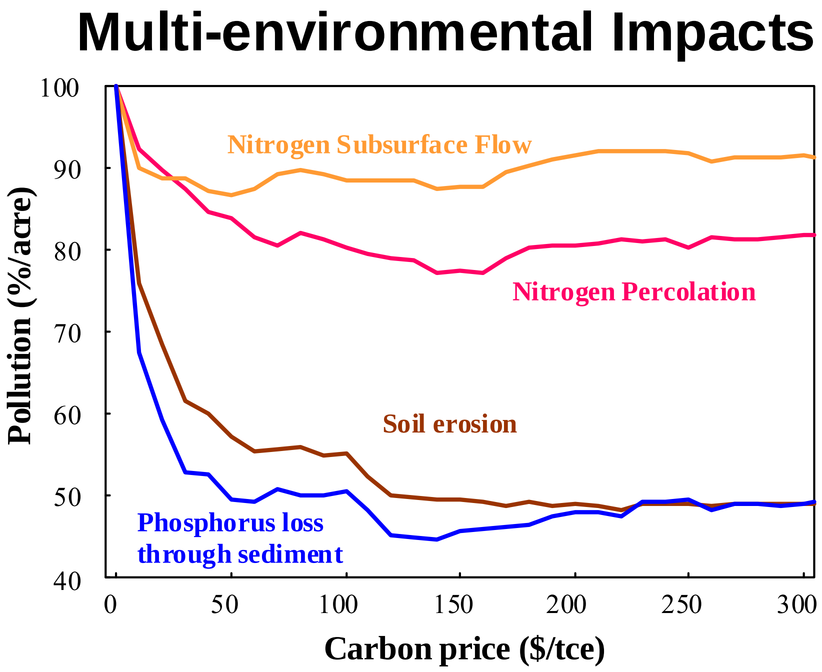


Near term Substitutes, Long Run Complement

What issues might IAM modelers consider?

Co-benefits





Gain here but lose in energy sector

Probably should ignore for now

What issues might IAM modelers consider?
Fungibility

A number of concepts have arisen that are likely to differentially characterize the contribution of alternative possible offsets within the total regulatory structure. These involve:

Permanence
Additionality
Leakage
Uncertainty

General concern price may differentiate based on characteristics like a grading standard

What issues might IAM modelers consider?
Fungibility

Grading standards

#2 yellow corn, CD plywood,
long staple cotton

Receive a price premium/discount depending upon product characteristics and consumer cost of using

GHG offsets may have consumer cost effects being not fully claimable due to

Permanence
Additionality
Leakage
Uncertainty

What issues might IAM modelers consider?

Fungibility- How do we derive price discount?

$$\text{CurCostPerTon} = \frac{\text{PresValueCostOfOffset}}{\text{QuantityOffsetToday}}$$

$$\text{PresValueCostOfOffset} = \sum_{t=0}^{T} \frac{\text{PriceOffsetInYear}_t\ \text{QuantityOffsetInYear}_t + OtherCost_t}{(1+\text{D}isc)^t}$$

$$\text{QuantityOffsetToday} = \sum_{t=0}^{T} \frac{\text{QOffset}_t}{(1+\text{D}isc)^t}$$

$$\text{CurCostPerTon} = \frac{\sum_{t=0}^{T} (Offset\,\text{Pr}*(QOffset_t - Buyback_t) + OthCost_t\,)/(1+Disc)^t}{\sum_{t=0}^{T} ClaimQuanOffset_t\,/(1+Disc)^t}$$

Note I have a non constant price variant

What issues might IAM modelers consider?

Fungibility- How do we derive price discount?

To derive price discount equate a perfect perpetual offset with an imperfect one

$$\mathrm{CurCostPerTon}_{perfect} = \frac{\sum_{t=0}^{T} (Offset\,\mathrm{Pr} * (QOffset_t - Buyback_t) + OthCost_t\,)/(1+Disc)^t}{\sum_{t=0}^{T} ClaimQuanOffset_t\,/(1+Disc)^t}$$

$$QOffset = QOffset_t$$

$$Buyback_t = 0$$

$$OthCost_t = 0$$

$$ClaimQuanOffset_t = QOffset$$

$$CurCostPerTon_{perfect} = Offset\,\mathrm{Pr}$$

$$CurCostPerTon_{perfect} = CurCostPerTon_{imperfect}$$

What issues might IAM modelers consider?

Fungibility- How do we derive price discount?

Permanence case

$$\text{CurCostPerTon}_{\text{impermanent}} = \frac{\sum_{t=0}^{T} (\text{OffsetPr} * (1 - \text{discount}) * (\text{QOffset}_t - \text{Buyback}_t) + \text{OthCost}_t)/(1+\text{Disc})^t}{\sum_{t=0}^{T} \text{ClaimQuanOffset}_t / (1+\text{Disc})^t}$$

OffsetPr	is discounted $= \text{OffsetPr} * (1 - \text{PermDiscount})$
QOffset_t	varies with t
Buyback_t	$<> 0$ if leasing or if project reverses
OthCost_t	$<> 0$
ClaimQuanOffset_t	$= \text{QOffset}_t$
$\text{CurCostPerTon}_{\text{perfect}}$	$= \text{CurCostPerTon}_{\text{imperfect}}$

$$\text{OffsetPr} = \frac{\sum_{t=0}^{T} (\text{OffsetPr} * ((1 - \text{PermDiscount}) * \text{QOffset}_t - \text{Buyback}_t) + \text{OthCost}_t)/(1+\text{Disc})^t}{\sum_{t=0}^{T} \text{ClaimQuanOffset}_t / (1+\text{Disc})^t}$$

implies

$$\text{PermDiscount} = \frac{\sum_{t=0}^{T} (\text{Buyback}_t + \text{MainCost}_t / \text{PriceOffset})/(1+\text{Disc})^t}{\sum_{t=0}^{T} \text{QuanOffset}_t / (1+\text{Disc})^t}$$

What issues might IAM modelers consider?

Fungibility - Other Cases

$$\text{UncertaintyDisc} = Z_\alpha * \text{CV}$$

$$\text{AdditionalityDisc} = \frac{\sum_{t=0}^{T} \text{QuanOffset}_t * \text{ProportionAdditional}_t / (1+\text{Disc})^t}{\sum_{t=0}^{T} \text{QuanOffset}_t / (1+\text{Disc})^t}$$

$$\text{LeakageDisc} = \frac{\sum_{t=0}^{T} \text{QuanOffset}_t * (1-\text{ProportionLeakage}_t) / (1+\text{Disc})^t}{\sum_{t=0}^{T} \text{QuanOffset}_t / (1+\text{Disc})^t}$$

$$\text{PricetoOffsetProducer} = \text{Offsetprice} * (1-\text{PermDisc}) * (1-\text{UncerDisc}) * (1-\text{AddDisc}) * (1-\text{LeakDisc})$$

What issues might IAM modelers consider?
Fungibility - Other Cases

$$\text{ProportionAdditional} = \frac{\text{WithProjectOffsets - BaselineOffsets}}{\text{WithProjectOffsets}}$$

$$\text{ProportionLeaking} = \frac{e * C_{ot}}{[e - E * (1 + P)]\, C_{pr}}$$

e is the price elasticity of supply for off project producers.

E is the price elasticity of demand for commodity produced.

Cot is GHG emissions per unit of increased commodity production outside project.

Cpr is GHG offsets per unit of reduced commodity production in project.

P is relative market share and is quantity of commodity produced by project divided by market amount produced.

What issues might IAM modelers consider?

Fungibility - Empirical

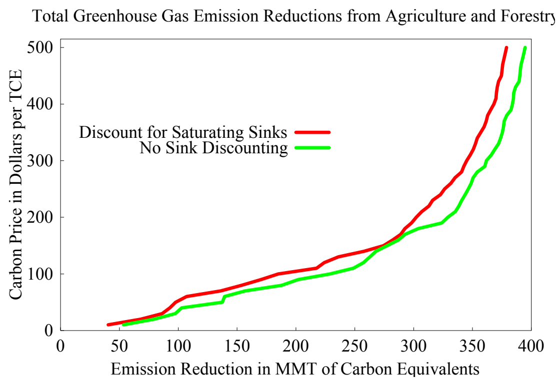
Beaumont through Columbus Texas area has historically produced rice. In 1985, 600,000 acres. In 2000, 214,000 acres. Policy, environment and markets are applying pressure. Today, many rice producers are in quest of new opportunities. Trees, other crops and pasture provide possible alternatives to some.

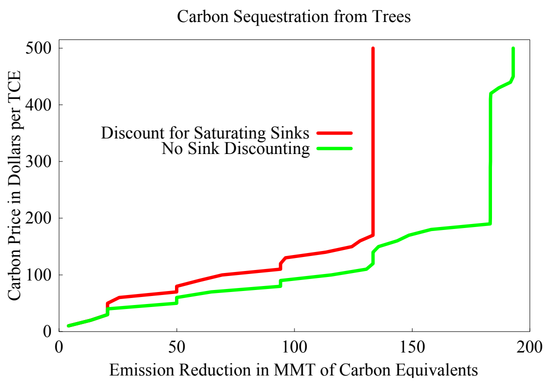
	Perm	Add	Leak	Uncer	All	Salable
Rice to crops	30%	12%	32%	21%	67%	**33%**
Rice to pasture	50%	4%	17%	21%	69%	**31%**
Rice - trees(pulp)	30%	1%	16%	21%	54%	**46%**
Rice - trees (saw)	10%	1%	16%	21%	41%	**59%**

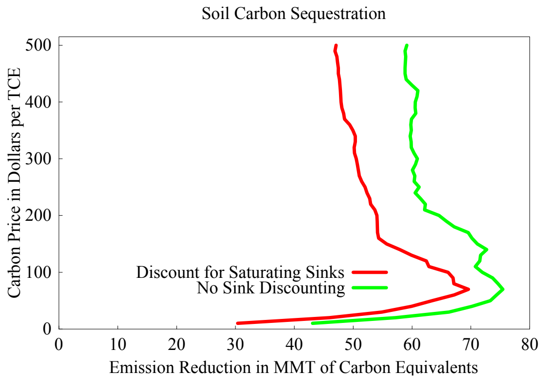
What issues might IAM modelers consider?

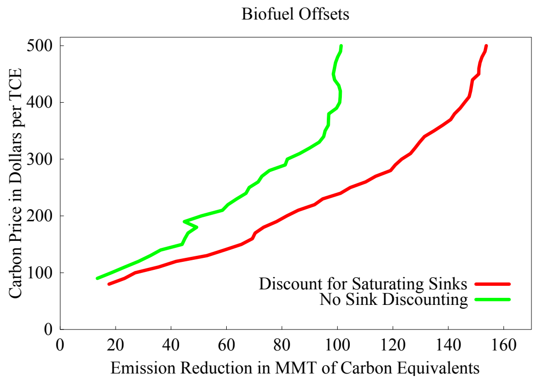
Fungibility - Aggegate

FASOM handles permanence, domestic additivity, domestic leakage, some uncertainty, Back to ASM permanence only









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Fungibility

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Work items

More land detail

Avoiding perfect Price foresight

Depicting anticipated possibly regionalized policy scope and applicability

Using response functions from FASOM type models

- **Now upgrading to avoid foresight and be more dynamic**

Project direction recharacterizing land

In Forestry

Cls Land suitability

Cls	Land suitability
FORONLY	Forested land suitable only for forest uses
FORCROP	Currently forested land that was once crop land
FORPAST	Currently forested land that was once pasture
CROPFOR	Afforested land that came from crop land
PASTFOR	Afforested land that came from pasture land

Owner

FI	Forest industry lands
OP	Other private ownership

Project direction recharacterizing land

In Forestry

Species types of forest stands specifying rotation

(10 as opposed to 2)

BOT_HARD	HARD	UP_HARD
DOUG_FIR	NAT_PINE	OAK_PINE
OTH_SWDS	PLNT_PINE	PLT_PINE
SOFT		

Tree age

0-4 to 95-99 in 5 year increments plus 100+

used to be 10 year age classes

Project direction recharacterizing land

In US Forestry

Site land quality

HI **ME** **LO**

MgtIntensity management applied (25 types as opposed to 4)

trad_plnt_pine	lo	plnt_med
plnt_hi	short_rotswds	reserved
Passive	affor	nat_regen
Plant	plant+	affor_cb
plnt_lo_thin	plnt_med_thin	plnt_hi_thin
nat_regen_thin	plant_thin	
part_cut_lo	part_cut_hi	part_cut_hi+
natregen_partcut_md	natreg_pcut_hi	lo_part_cut
ntregen_partcut_lo		

Project direction recharacterizing land

Forest products

SWSAWTLOGWOODS	SWPULPLOGWOODS	SWFUELLOGWOODS	
HWSAWTLOGWOODS	HWPULPLOGWOODS	HWFUELLOGWOODS	
SWSAWTLOGMILL	SWPULPLOGMILL	SWFUELLOGMILL	
HWSAWTLOGMILL	HWPULPLOGMILL	HWFUELLOGMILL	
SLUM	SPLY	SWMISC	SRESIDUES
HLUM	HPLY	HWMISC	HRESIDUES
OSB			
SPWOOD	HPWOOD	HWPULP	SWPULP
AGRIFIBERLONG	AGRIFIBERSHORT	OLDNEWSPAPERS	OLDCORRUGATED
WASTEPAPER	PULPSUBSTITUTE	HIGDEINKING	NEWSPRINT
UNCFREESHEET	CFREESHEET	UNCGROUNDWOOD	CGROUNDWOOD
TISSUE	SPECIALTYPKG	KRAFTPKG	LINERBOARD
CORRUGMED	SBLBOARD	RECBOARD	CONSTPAPER
DISPULP	SWKMPULP	HWKMPULP	RECMPULP
CTMPMPULP			

Project direction recharacterizing land

In US Agriculture

Periods **Years**

2000-2100 in 5 year intervals

Land type

W3-8Land	wetlands
LOEILand	lo erodable crop land
MDEILand	medium erodable crop land
SVEILand	Severely erodable crop land
Pasture	Pasture land
AUMS	AUM grazing land
CRP	CRP (Conservation Reserve Program)

Project direction recharacterizing land

In US Agriculture

TLTECH tillage types

Vent Conventional Tillage
Cons Conservational Tillage
Zero Zero Tillage

Plus duration

years 0 to 30 that crop has been in this tillage type