The Impacts of Changes in Federal Timber Harvest on Forest Carbon Sequestration in Western Oregon

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Northwest Forest Plan and harvests on western Oregon federal forests

- Northwest Forest Plan
  - Federal forest management guidelines
  - Anticipated WOR cuts: 556 MMBF
  - Actual WOR harvests:
    - 315 MMBF ('95-'99)
    - 94 MMBF ('00-'07)
- Continued debate on federal forest management and timber harvest
  - Increase cuts to NWFP levels proposed for economic benefits and wildfire
  - Possible losses of ecosystem values

Carbon and Public Forests

- Large carbon losses possible when old growth public forests cut
  (Harmon et al. 1990, Schulze et al. 2000)
- WOR, WWA federal timberlands sequestered 200Mt of carbon (1953-2000)
  (Smith & Heath, 2004)
- Future public carbon storage?

http://www.krisweb.com/krisgualala/krisdb/html/krisweb/index.htm

Questions

- **What would be the impacts on regional carbon flux of variation in allowable levels of harvest on federal forest lands?**
  - Substitution across owners
  - Changes in industry composition
- **Would it be possible to achieve a given level of regional <u>net</u> forest carbon flux with a smaller reduction in regional timber harvest through "coordinated" management of the joint public-private land base?**
  - Age and stocking structures of federal and private lands differ markedly with a wide range of current stocking and growth in each ownership

OVERVIEW OF MODELING APPROACH

DYNAMIC REGIONAL FOREST SECTOR MODEL
(MAXIMIZE DISCOUNTED LOG MARKET SURPLUS)

LOG DEMAND: LUMBER and PLYWOOD MILLS
PROCESSING CAPACITY ENDOGENOUS (OUTPUT BOUND AND DEMAND SHIFT)

LOG SUPPLY: PRIVATE and PUBLIC FOREST LANDS
INVENTORY and SILVICULTURAL REGIME ENDOGENOUS

CARBON ACCOUNTING IN SIX POOLS: TREES (LIVE AND DEAD), UNDERSTORY, FOREST FLOOR (LITTER), WOODY DEBRIS (LARGE), SOIL AND PRODUCTS

TIMBERLAND AREA CHANGE EXOGENOUS

REGIONAL BOUNDARIES: SUPPLY OF LOG IMPORTS TO REGION
DEMAND FOR LOG EXPORTS FROM REGION

SCENARIOS

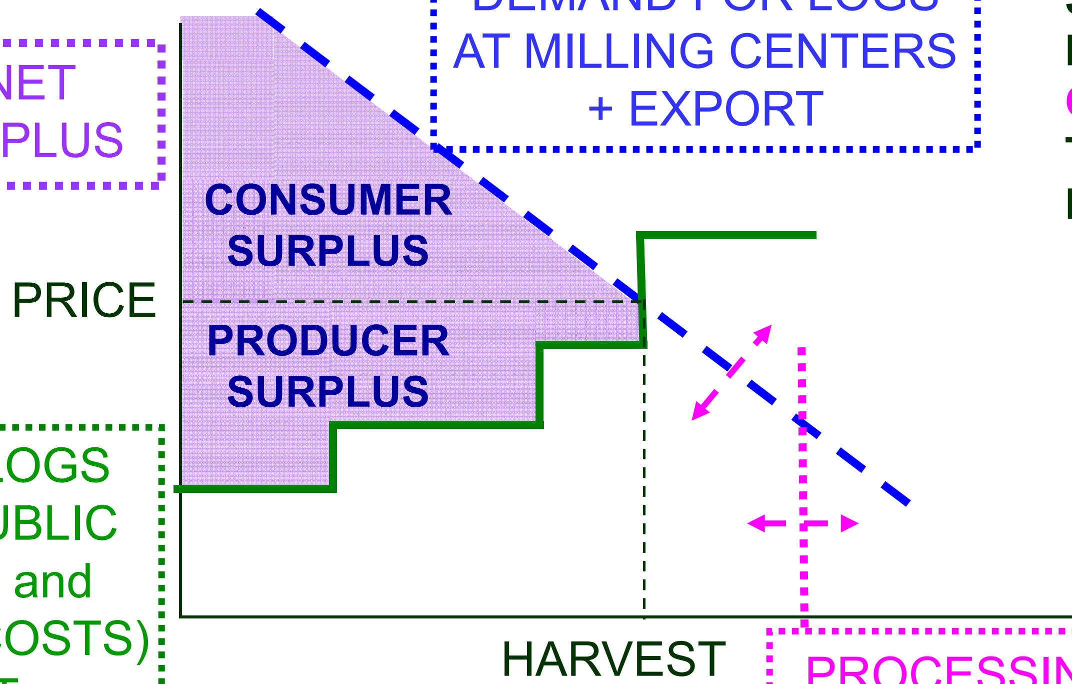
- ALTERNATIVE LEVELS OF REGIONAL FEDERAL HARVEST (0 to MAX S-Y NDEF)
  - VOLUMES <u>OFFERED</u> FOR SALE (UPPER BOUND), NOT A FIXED LEVEL
- REGIONAL CARBON FLUX "TARGETS"
  - VARY HARVESTS BY ALL OWNERS TO MEET FLUX TARGET TO MINIMIZE MARKET WELFARE LOSSES

Methods: Spatial Market Model

MAXIMIZE NET MARKET SURPLUS

DEMAND FOR LOGS AT MILLING CENTERS + EXPORT

SHIFTS WITH PRODUCT PRICE, CAPACITY, TECHNOLOGY, & NON-WOOD COSTS



SUPPLY OF LOGS PRIVATE + PUBLIC + (HARVEST and TRANSPORT COSTS) + IMPORT

PROCESSING CAPACITY

PRIVATE SUPPLY SHIFTS WITH COSTS OF MANAGEMENT & INTEREST RATE, PUBLIC SUPPLY WITH PUBLIC POLICIES

SHIFT WITH PRODUCT PRICE, EQUIPMENT COSTS, DEPRECIATION, INTEREST RATE

Log Demand

- **Demand equations** (lumber and plywood)
  - **Estimate at regional level, disaggregate to mills**
  - **Normalized, restricted quadratic profit function approach**
    - **Lumber output and log, labor and "all other" factor inputs**
    - **Capital stock quasi-fixed, measured by "output capacity"**
    - **Log price endogenous, lumber and other factor prices predetermined**
    - **Estimate system: profit, supply, and two factor demand relations**
    - **Impose symmetry and convexity**
    - **Lumber estimated as differences to avoid nonstationarity concerns**
    - **Iterative 3SLS**

LOG DEMAND = D[LOG PRICE, PRODUCT PRICE (INCLUDING CHIPS), LABOR PRICE, TIME, CAPACITY]

  - **Log demand elasticities at sample means: -.47 for lumber, -.72 for plywood**

Log Demand, continued

- Disaggregate to mills in proportion to estimated mill outputs in 1998 (base year)
  - Assumes all elasticities same at mill and regional level
- **Capacity**
  - Capacity bounds product output (log consumption) at the mill level and regional capacity shifts the log demand relations
  - Capacity changes with depreciation (set at a constant rate) and additions (which follow a two-tier cost structure)
    - depreciation offset, only maintain current capacity
    - expansion (most costly)

$$\textbf{Capacity(t)} = \textbf{Capacity(t-1)}[1-\delta]^5 + \textbf{Depreciation Offset(t)} + \textbf{Expansion(t)}$$

LOG SUPPLY

- PRIVATE LANDS
  - ACT AS LAND VALUE MAXIMIZERS (GIVEN PRICES)
  - ENDOGENOUS SELECTION OF FUTURE SILVICULTURAL REGIME AT TIME OF REGENERATION
  - SAME REGIMES AND SAME INTEREST RATE USED FOR BOTH INDUSTRIAL AND NON-INDUSTRIAL OWNERS
  - NON-INDUSTRIAL HARVEST SUBJECT TO CONSTRAINTS ON AGE CLASS STRUCTURE TO MIMIC IMPACTS OF NON-MARKET OBJECTIVES

LOG SUPPLY

- PUBLIC LANDS
  - FEDERAL
    - UPPER BOUND ON HARVEST SET BY POLICY (ACTUAL HARVEST DEPENDS ON MARKET)
    - SILVICULTURAL REGIMES MAY CHANGE AT TIME OF REGENERATION HARVEST WITHIN LIMITS OF NW FOREST PLAN LAND ALLOCATIONS
    - CHOICE OF PARCELS TO OFFER BASED ON MINIMIZATION OF MANAGEMENT COSTS
  - STATE
    - MANAGEMENT PLANS BROADLY SIMILAR TO FEDERAL
    - SAME SUPPLY STRUCTURE

K-STOCK (CAPACITY) ADJUSTMENT

- COSTS OF CAPACITY ADDITION INCLUDED IN OBJECTIVE
- TWO TYPES OF CAPACITY ADJUSTMENT
  - NEW CAPACITY
  - MAINTENANCE OF EXISTING CAPACITY (OFFSET DEPRECIATION)
- INTRODUCES ADDITIONAL NONLINEARITY IN OBJECTIVE

INVENTORY AND YIELDS

- INVENTORY MODELED AT THE PLOT LEVEL
  - PLOTS TREATED AS DISTINCT TIMBER LOCATIONS FOR TRANSPORT COSTS
  - PLOT CHARACTERISTICS ALLOW MORE DETAILED HARVEST COST COMPUTATIONS

- YIELDS FOR ALL SILVICULTURAL REGIMES ON EACH PLOT PROJECTED USING INDIVIDUAL TREE GROWTH MODELS

CARBON ACCOUNTING

- TREES (EQUATIONS FOR ABOVE AND BELOW-GROUND BIOMASS—TREE-BY-TREE)
- UNDERSTORY AND LITTER BASED ON YIELD-LIKE RELATIONS DEPENDING ON AGE SINCE LAST HARVEST
- LARGE WOOD DEBRIS BASED ON DECAYING INPUT FROM LAST HARVEST + DOWNED MORTALITY
- SOIL CONSTANT
- <u>INCLUDES PRODUCT CARBON</u>: BASED ON HALF-LIFE ANALYSIS
- CARBON COMPUTED VIA CONTRAINTS IN SOLUTION (SO AVAILABLE TO POLICY SCENARIOS)

PLAN OF SCENARIOS

- VARY MAXIMUM PUBLIC CUT FROM 0 TO MAX LRSY (NDEF)—OBSERVE REGIONAL FLUX IMPACTS
- FOR EACH MAXIMUM PUBLIC HARVEST LEVEL, IMPOSE A REGIONAL CARBON FLUX TARGET THAT MAY VARY FROM CURRENT (2005) TO 2X CURRENT LEVELS—EXAMINE HARVEST REDUCTIONS

Federal Land-Use Allocations and Key Watersheds

	Northwest Forest Plan		
	Key Watershed Classification		
LAND USE ALLOCATION	Tier 1+2	non-Key	
	Thousand acres		
Wilderness and Reserves	657	767	
Late Successional Reserves	1,318	1,756	
Adaptive Management Areas	76	497	4,612
Matrix and Riparian Reserves	684	2,359	
Totals	2,735	5,379	8,114

Note: Areas include forested and non-forested lands

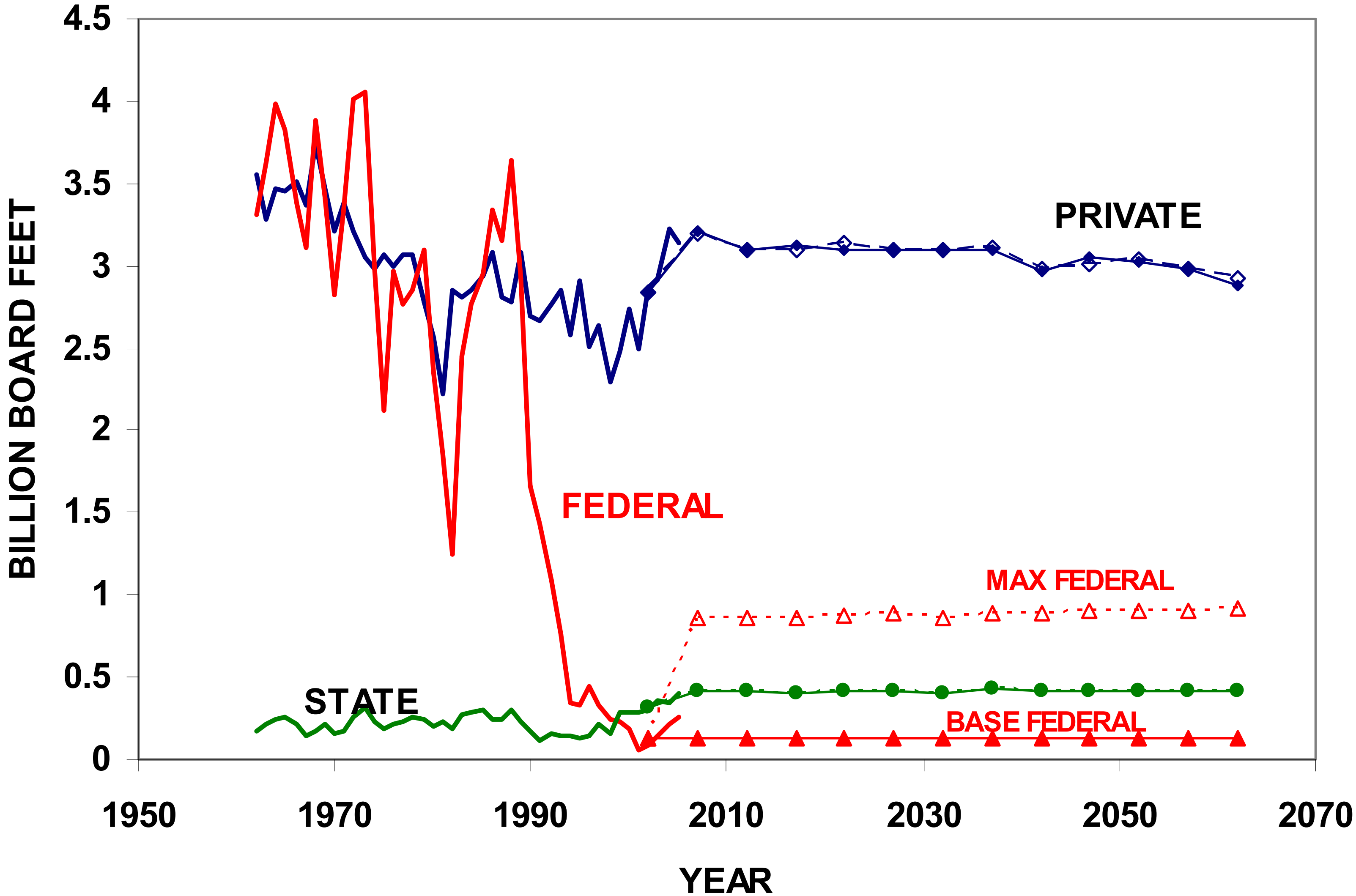
Results: Current Carbon Stock
How well does our carbon accounting work?

- **Comparison of current carbon stock (tonnes/ha)**

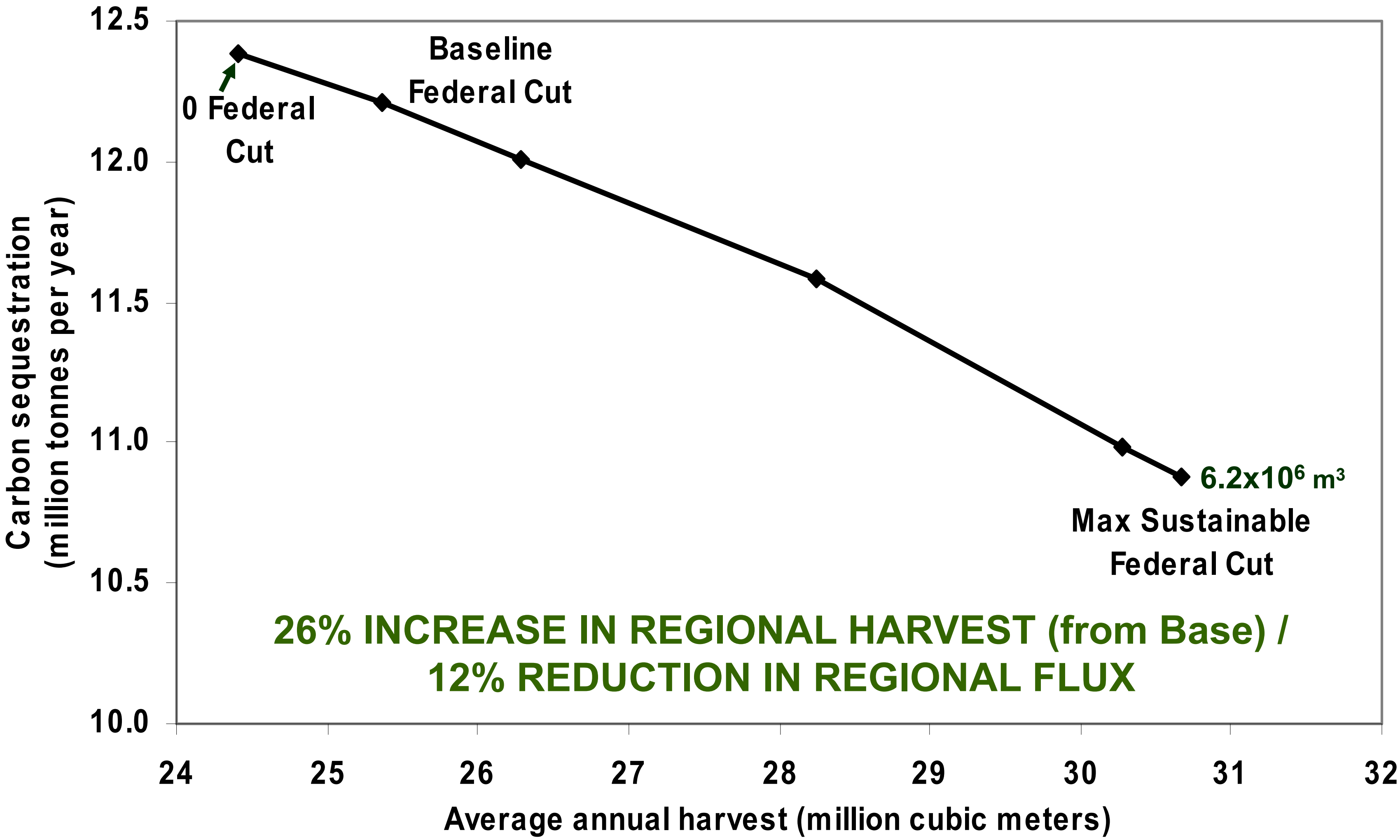
	Region/ owners	Live Carbon	Dead Carbon	Product Carbon
Heath et al. ('03)*	PNW/all	102.8	45.6	-
Birdsey&Lewis('03)*	OR/all	82.3	42.4	26.4
Law et al. ('04)†	WOR/all	128.6 - 196.8	38.4 - 49.5	-
This study †	WOR/all	144.2	39.5	38.2
	/Private	82.7	35.3	61.0
	/USFS	204.9	45.3	19.8
	/OPUB	161.4	34.1	21.9
	/State	176.2	48.3	26.5

Note: * Estimate of carbon stock in 1997; and † carbon stock in 2002.

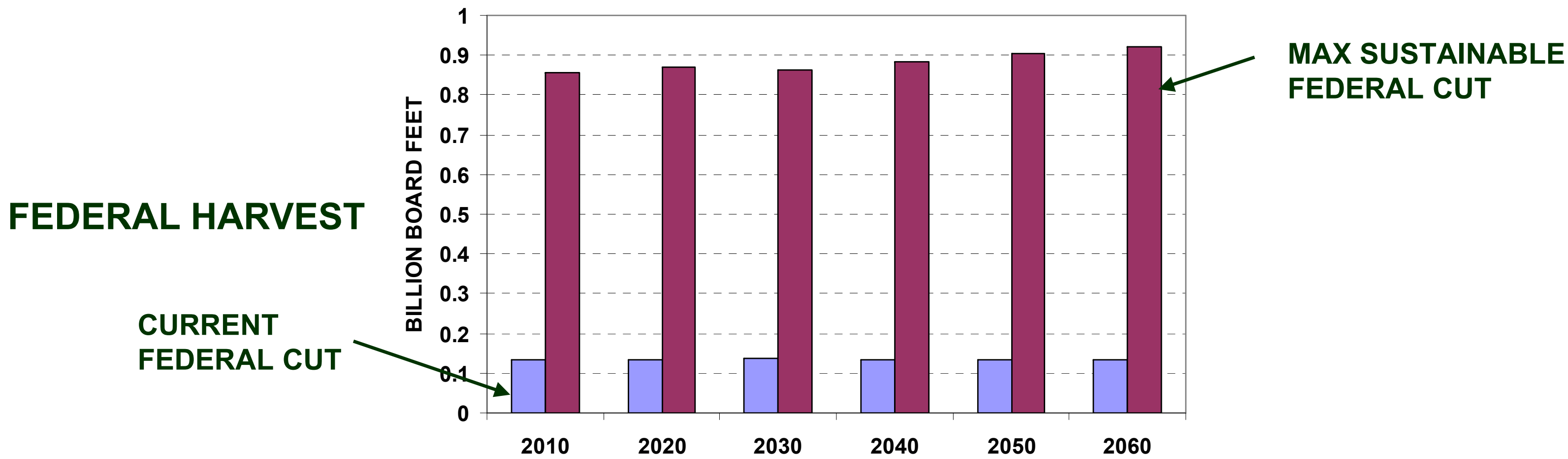
HISTORICAL AND PROJECTED HARVESTS: CURRENT AND MAX FEDERAL CUT

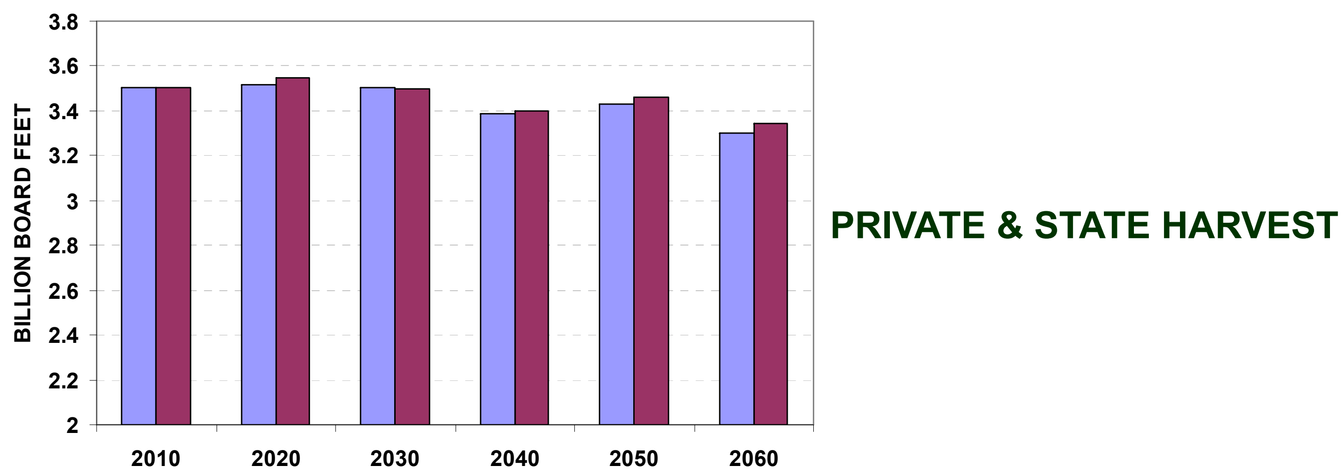


Results: Regional Carbon Flux and Harvest Impacts of Expanded Federal Cut

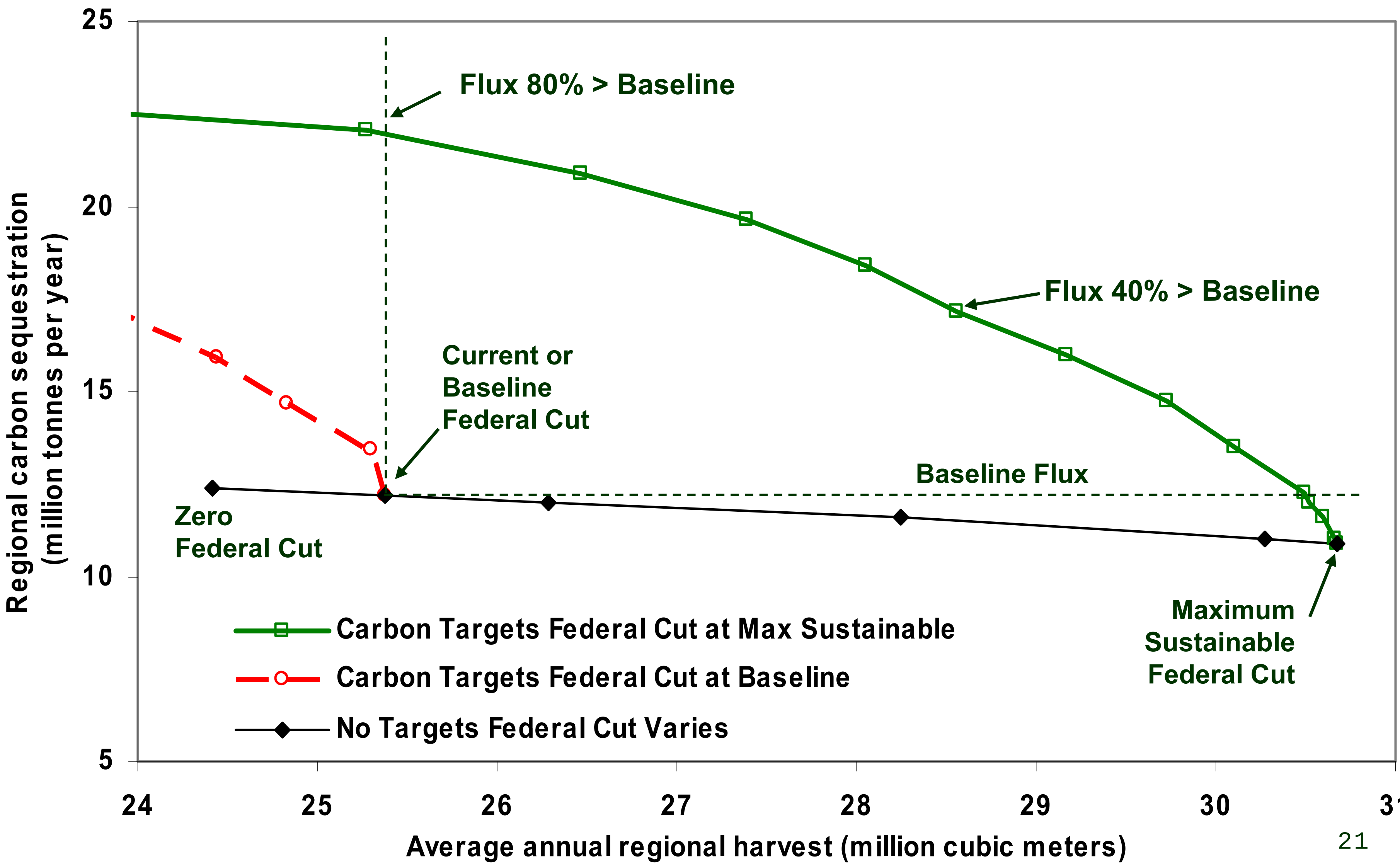


Results: Harvest Projections--current and maximum federal harvest

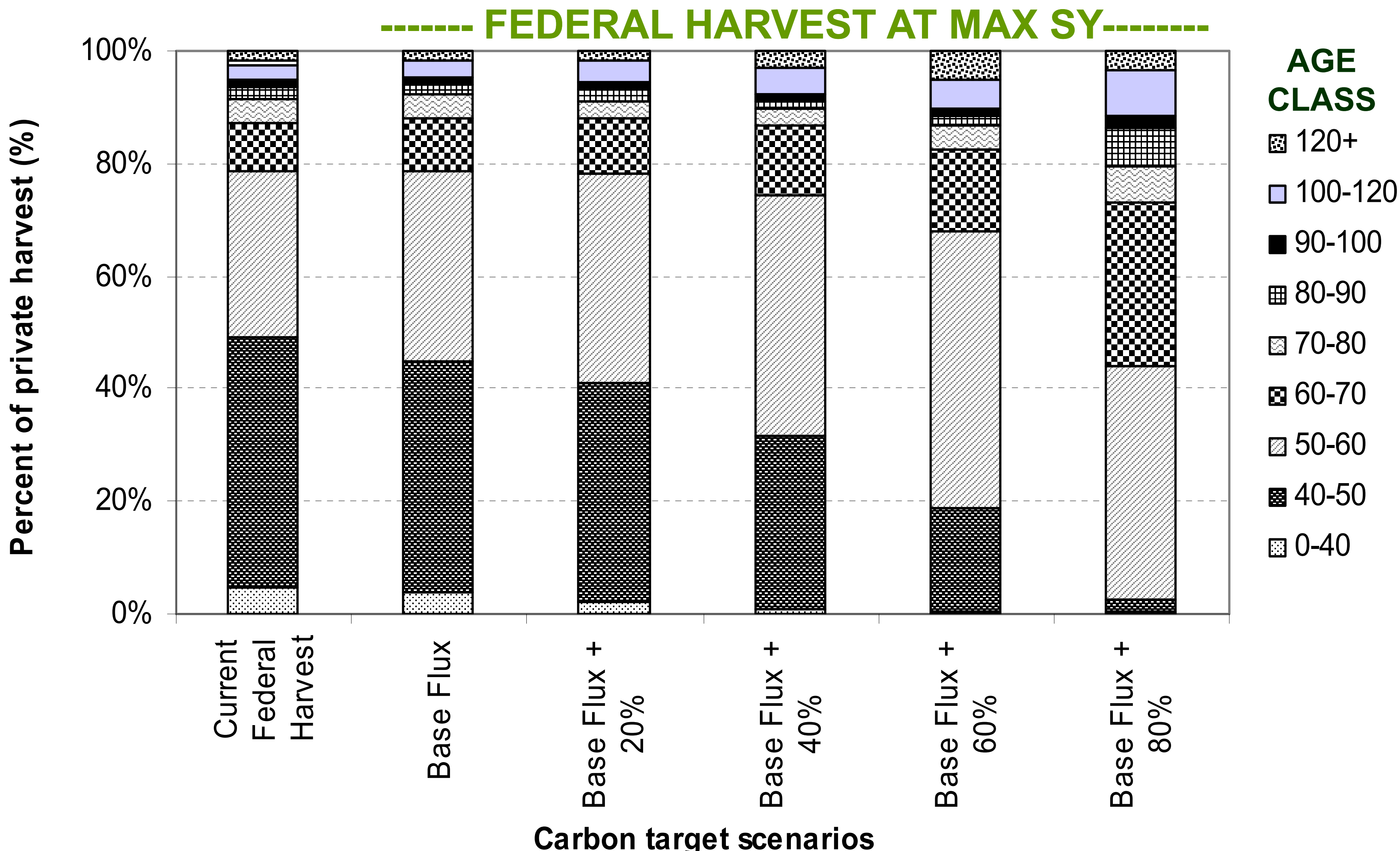




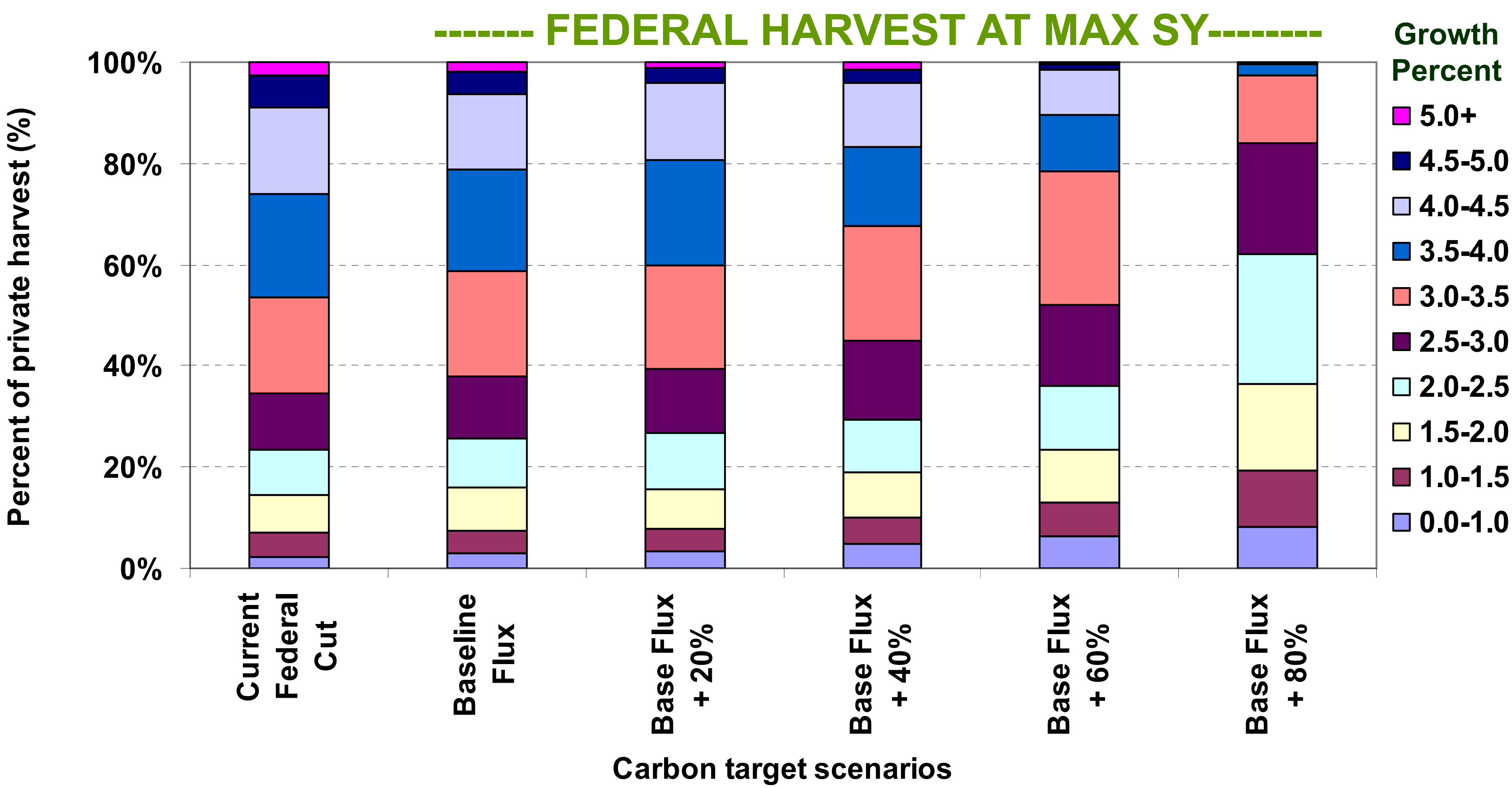
Harvest And Carbon Flux Trade-off For Various Regional Carbon Targets And Two Alternative Levels Of Federal Cut



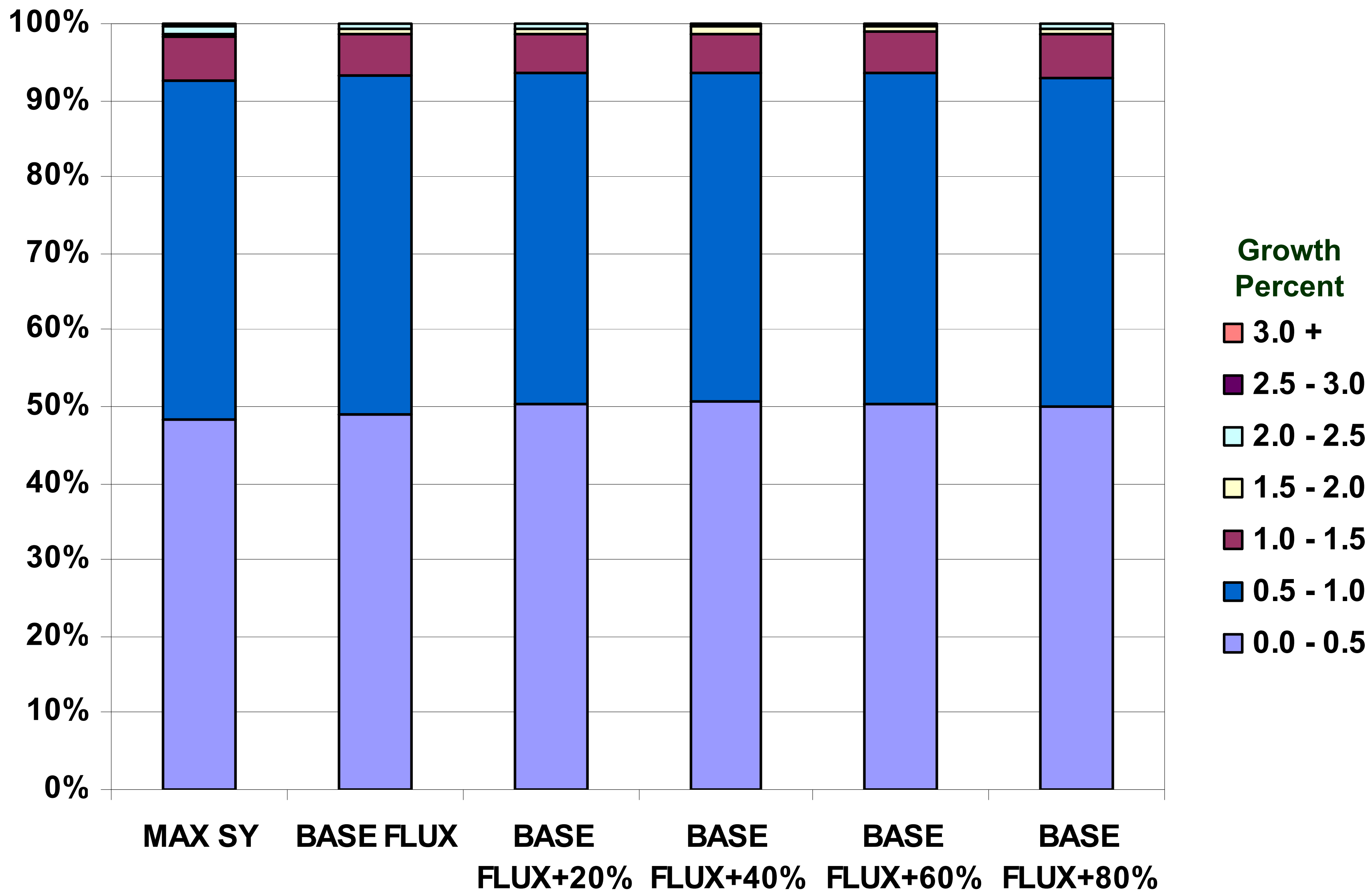
Results: Concentration of Private Cut by Age Class



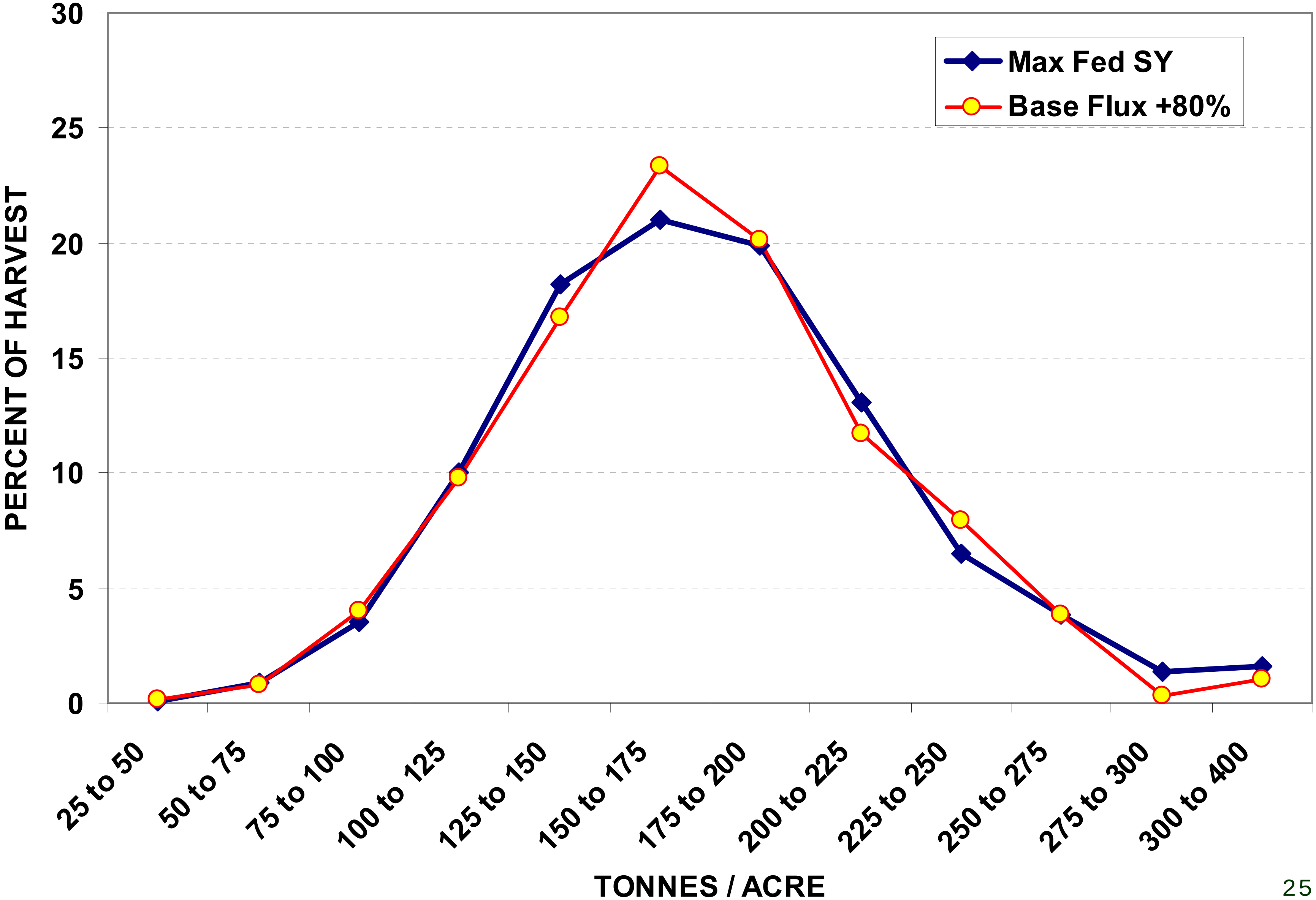
Results: Concentration of Private Cut by Carbon Growth Rate



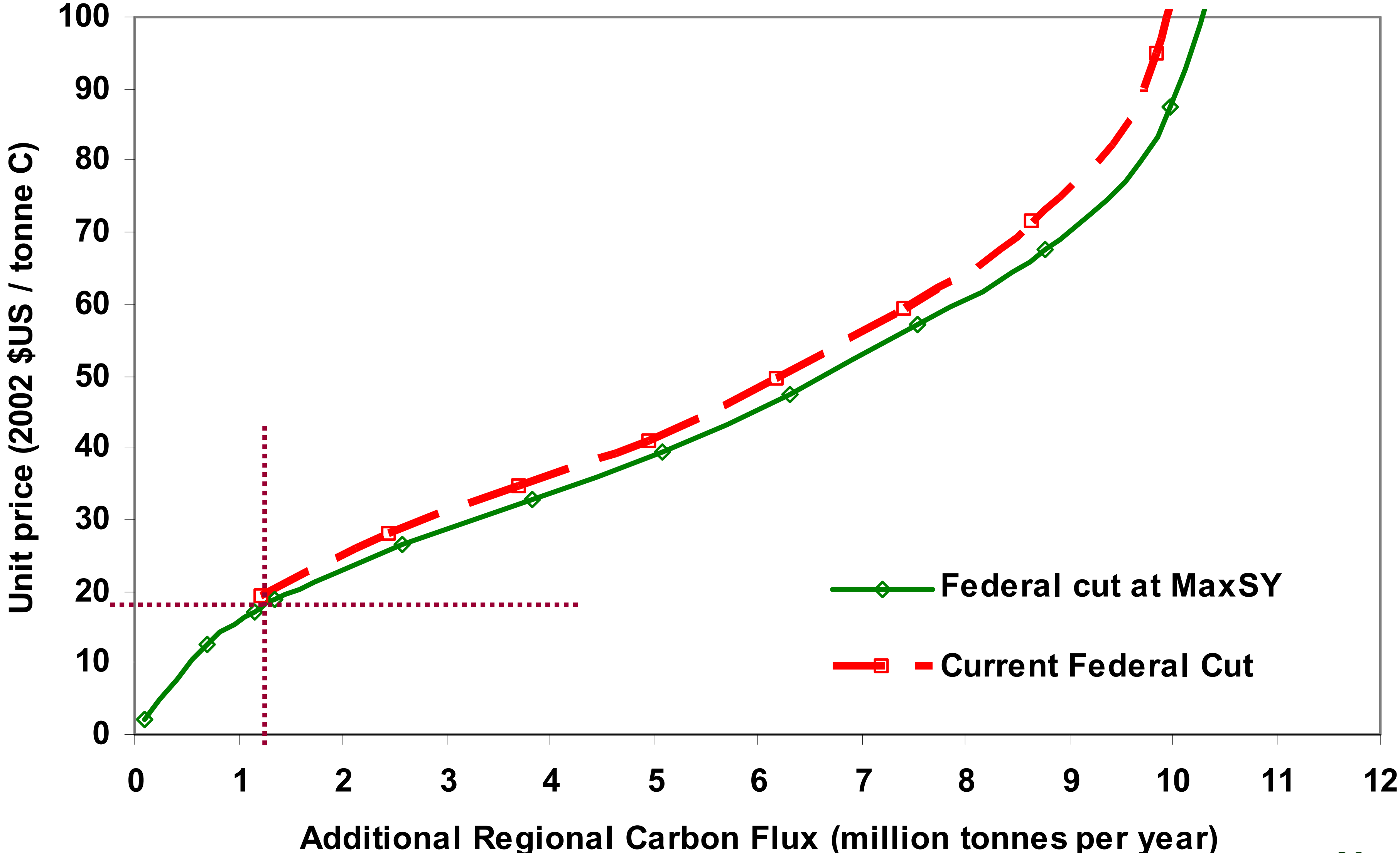
FEDERAL HARVEST BY CARBON GROWTH RATE CLASS AND SCENARIO



DISTRIBUTION OF FEDERAL HARVEST BY CARBON DENSITY CLASS



MARGINAL COST OF ADDITIONAL REGIONAL FLUX FOR TWO LEVELS OF FEDERAL CUT



Summary & Conclusions

- Regional carbon flux declines as regional harvest rises
  - Max sustainable WOR federal cut: 885 MMBF
  - Market surplus rises 23% (consumer/federal gainer, others loser)

- Significant opportunities for substituting harvest and carbon flux between federal and private/state lands
  - Increase in federal harvest, but decrease in other harvests
  - Carbon flux loss on federal lands is offset by gain on other lands
  - Little change in federal harvest mix by age, C growth or C density

- Carbon subsidy / tax can mimic carbon flux target
  - Baseline carbon target ≈ C flux at $15-17 tonne C
  - Carbon payment exceeds market surplus loss