Carbon Sequestration in Californian Forests; Two Case Studies in Managed Watersheds

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Motivation

- Can Forest Management Type Influence Total Carbon Storage ?
- 100 year time period – Use Existing Growth and Yield Models?
- Wood Products and landfills---how to account and track them?
- Study is a collaboration between Dr. James, Dr. Eckert and Dr. Krumland

- A PDF copy of the full study and an executive summary can be found at:

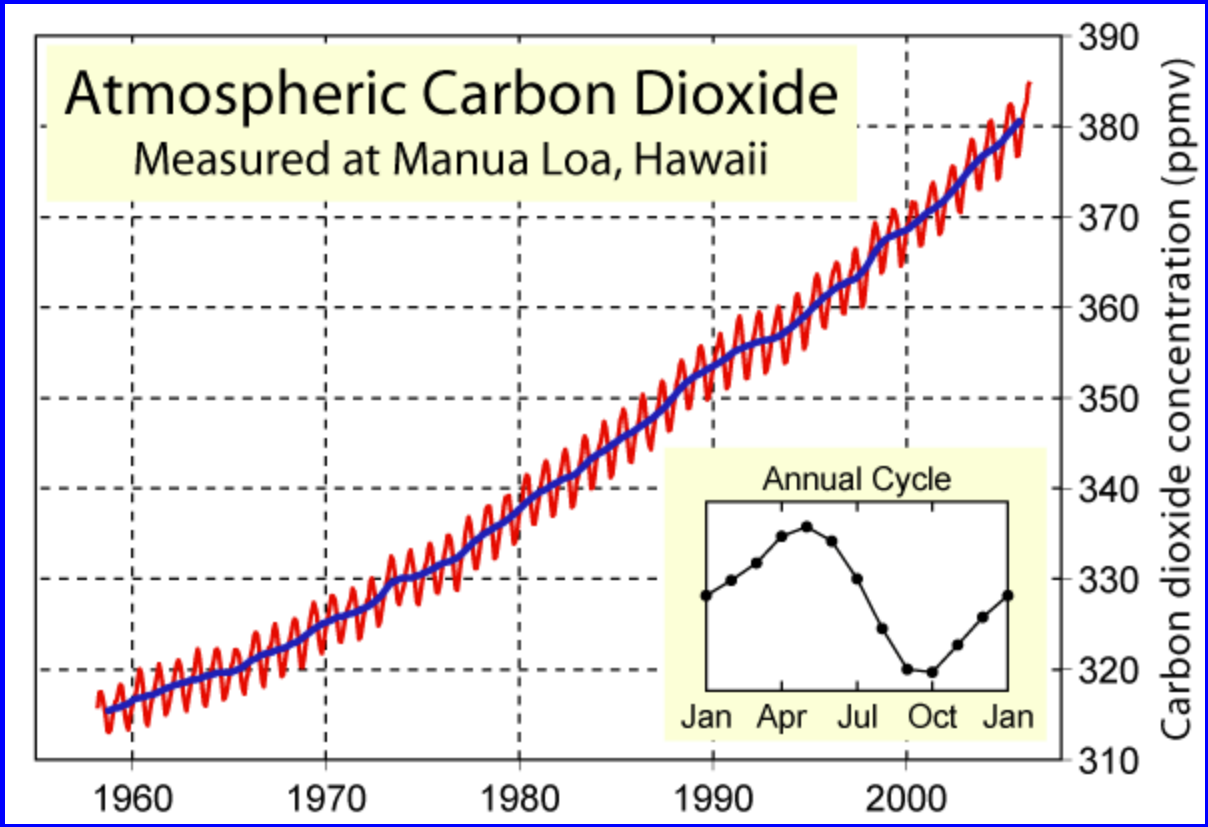
www.spi-ind.com

Then go to the "Our Forests" link and the "Research & Monitoring' page.

Carbon Fun Facts

Forests and the soils beneath them are sinks for organic carbon. They hold twice the C mass found in any other terrestrial biome and more than twice the C than that in the **entire atmosphere** (FAO 2006).

FAO 2006 is the United Nation's Food and Agriculture Organization (FAO)



Note the seasonal rise and fall in CO2 concentrations (magnified in the inset). This represents a winter high, followed by a seasonal drop as vegetation becomes active in the spring and grows into summer. Northern hemisphere forests account for the lion's share of this--probably about half of the carbon uptake. Once vegetation goes into dormancy, atmospheric concentrations rise again. Most of the earth's seasonal vegetation is in the northern hemisphere, and this explains the cyclic pattern. The non-seasonal vegetation in the tropical latitudes also draw out a lot of carbon, but their effect is essentially constant throughout the year. So the seasonal flux is largely that of vegetation in the northern hemisphere.

Carbon in Forests

- **1/2** of all the above ground plant material in a forest – live and dead - is carbon on a weight basis.
- Additional 60+% below ground carbon in the form of roots and soil carbon.
- Carbon budgets concentrate on biomass estimation.
- Carbon Storage Components –
  Sources of Additions and Losses

Where's The Forest Carbon?
Medium size mixed conifer forest

Pool	**Sub Pool**	**Carbon(%)**
Soil		38
Floor	Duff & Litter	8
	LWD	2
Snags		1
Shrubs		1
Live Trees		50
Total		100

Watershed Study Basis

- Two Watersheds
  - 1) High site II – well stocked (172 ft^2 BA/acre)
  - 2) Mid site III – moderately Stocked (90 ft^2)
- Armed with:
  - Ground inventories
  - GIS
  - Growth models
- Estimate carbon budgets over a landscape based upon 100 year modeling effort

The Study Data

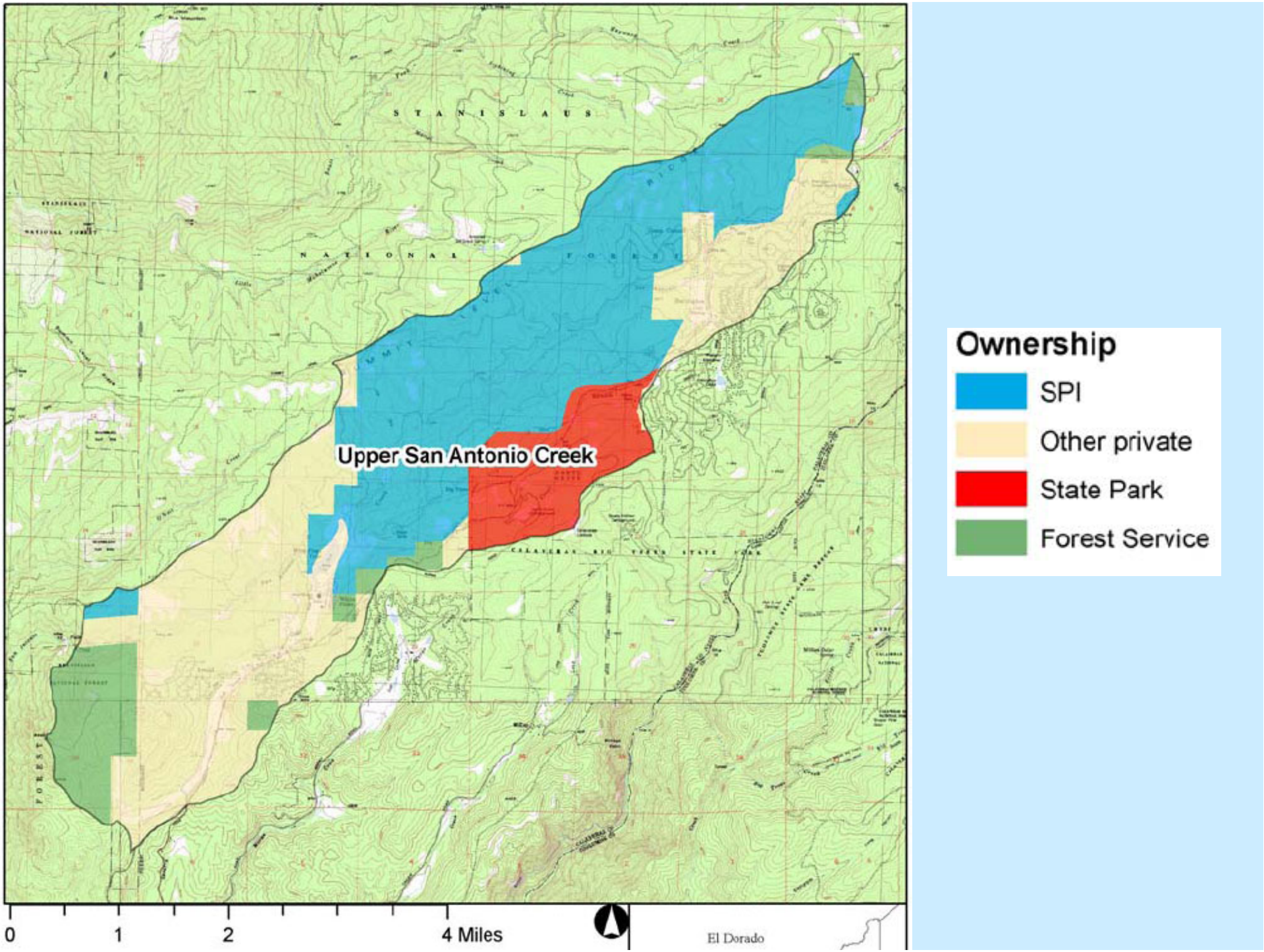
- Inventory: 1 plot every 4 acres
  - Live trees: Species, DBH, Ht, Crown
  - LWD: Dia, decay class
  - Snags: DBH, Ht
  - 1 site tree – every other plot
- Stands: Stratified into BA density, Age, Over story height classes
- Only use land base considered for plantation management (85%)

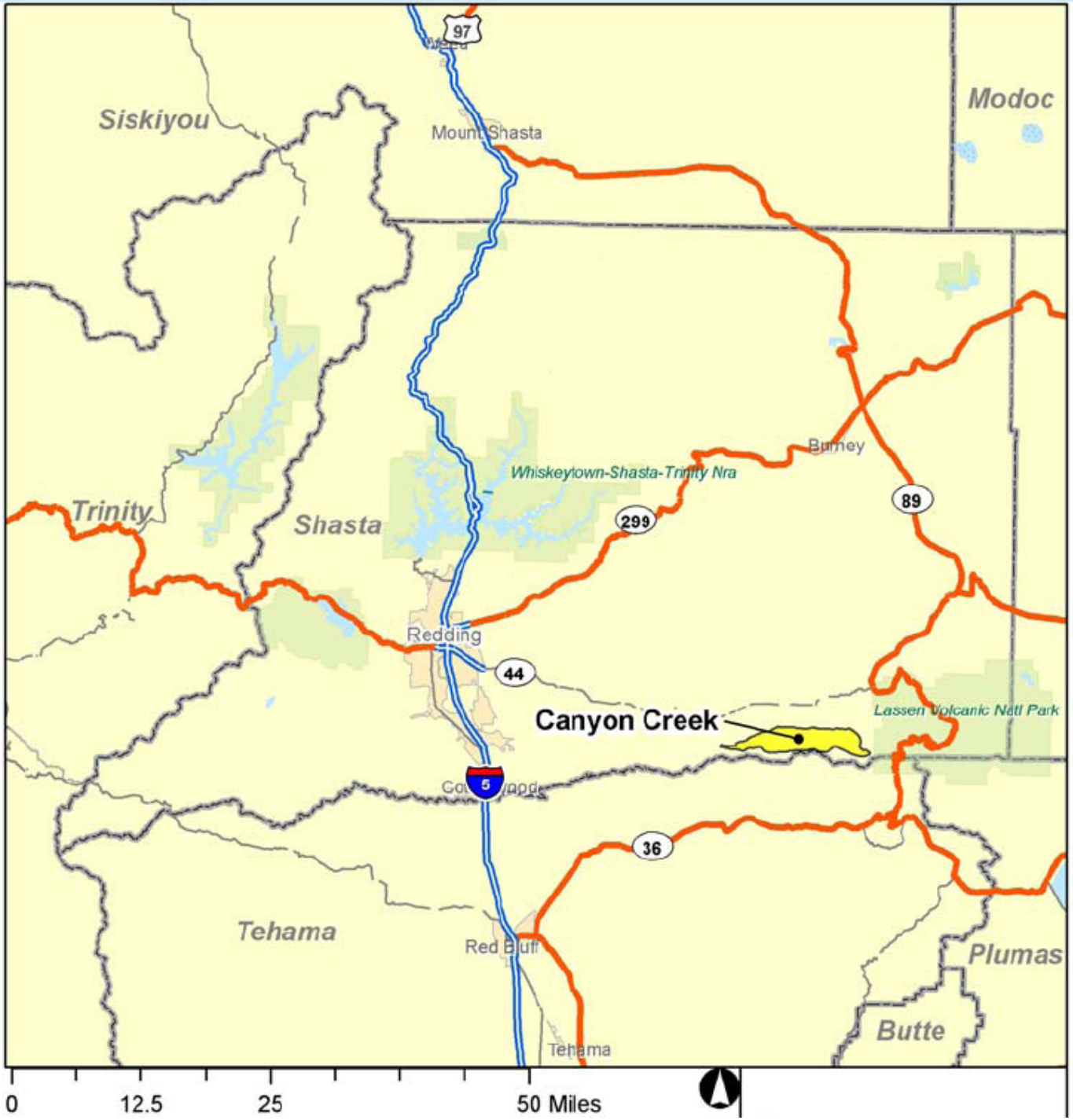
Watersheds

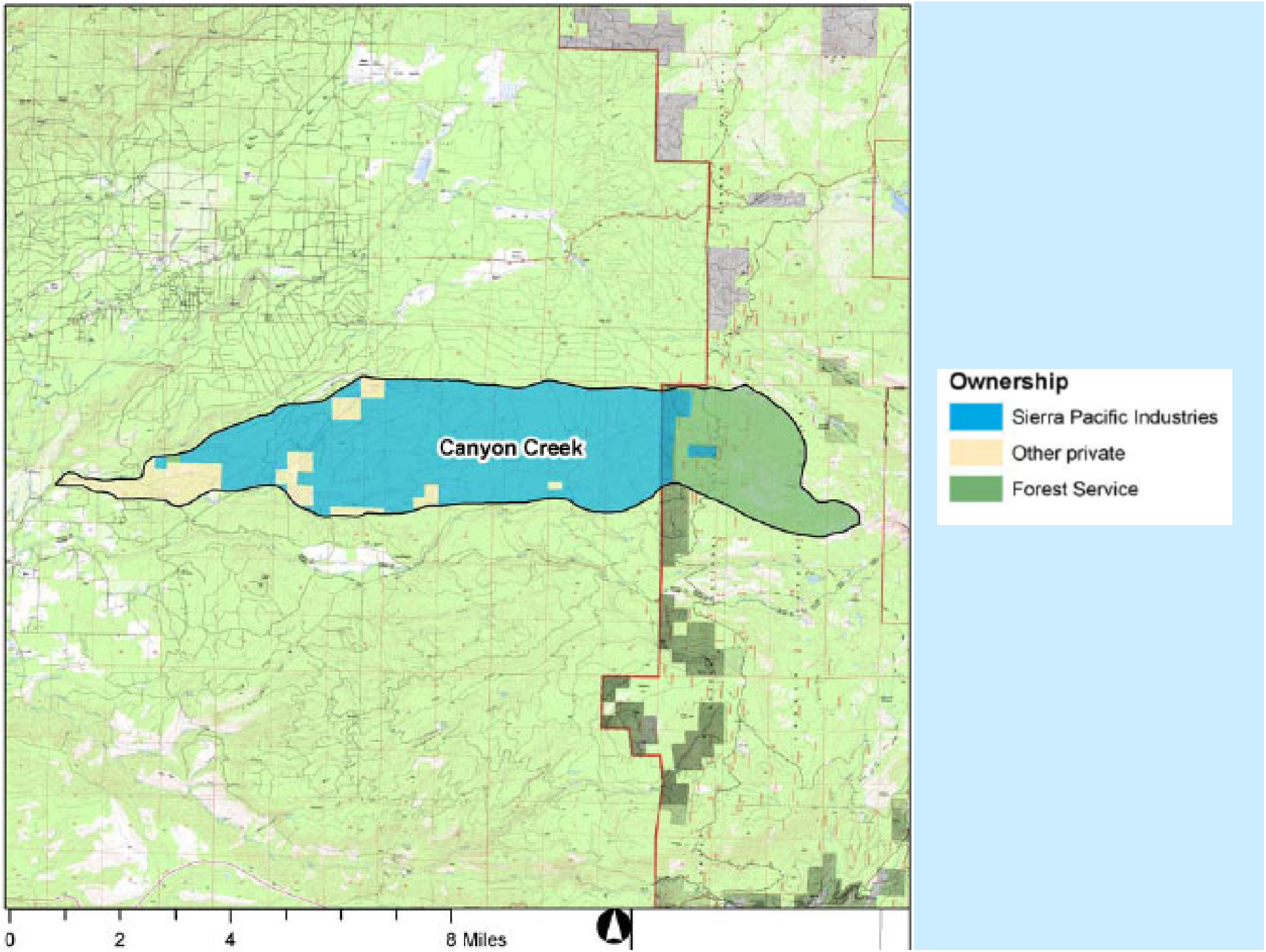
- **USA**
  - 4200 ft3/acre
  - site index 90 (50 year breast high age basis)
  - 80+ years old – dominant over story height

- Canyon Creek
  - 2500 ft3/acre
  - site index 70 (50 year breast high age basis)
  - 60+ years old – dominant over story height

Sacramento
Placerville
Cameron Park
El Dorado
Alpine
88
Rancho Murieta
Amador
Ione
Jackson
Calaveras
Calaveras Big Trees State Park
Upper San Antonio Creek
49
4
108
Rancho Calaveras
Angels City
Tuolumne
Mono Vista
San Joaquin
Sonora
Yosemite Natl Park
Stockton
Manteca
Escalon
Oakdale
Stanislaus
Mariposa
Modesto
Waterford
0
10
20
40 Miles


Upper San Antonio Creek
Ownership
SPI
Other private
State Park
Forest Service
0
1
2
4 Miles
El Dorado

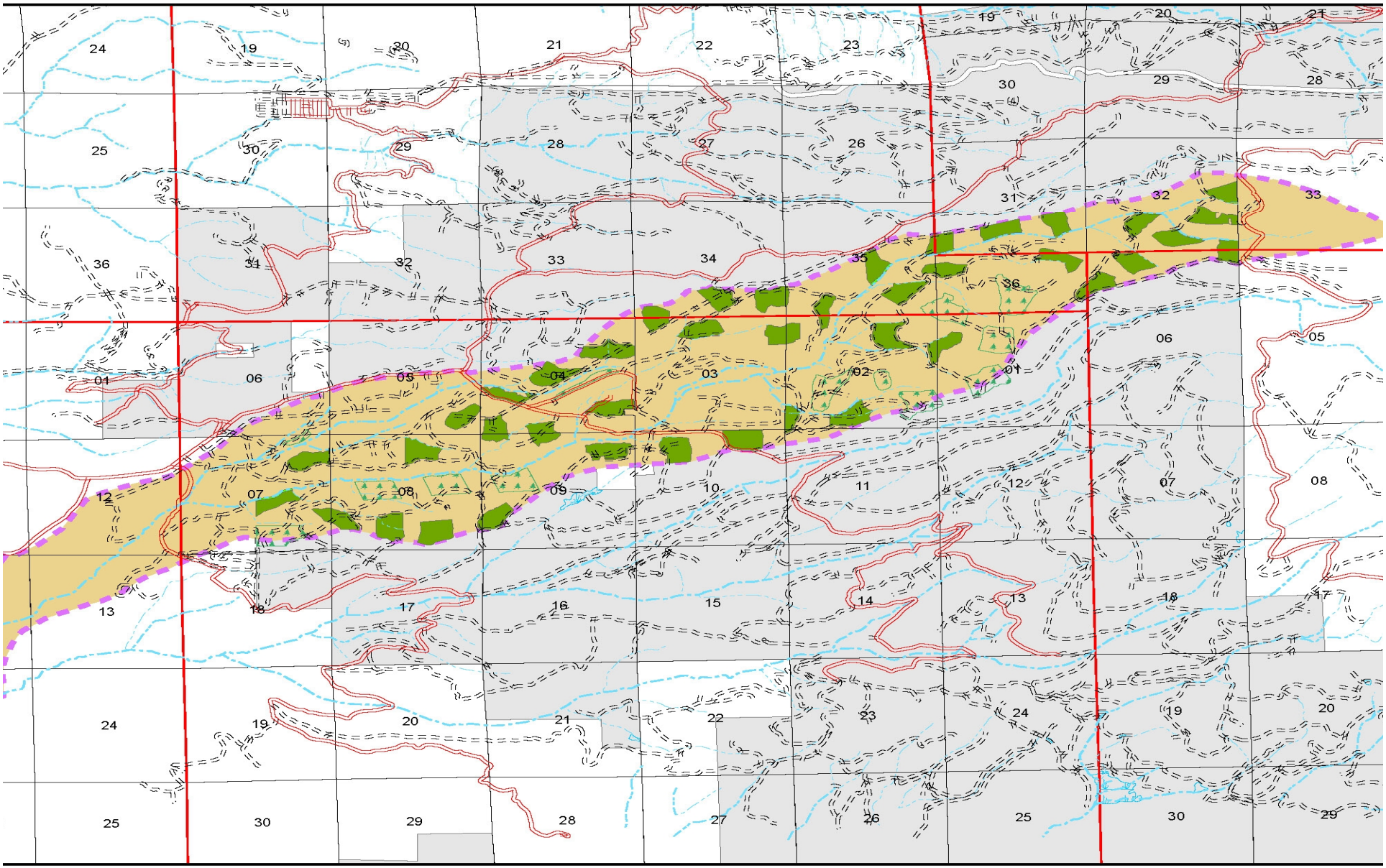

97
Siskiyou
Mount Shasta
Modoc
Burney
Whiskeytown-Shasta-Trinity Nra
Trinity
Shasta
299
89
Redding
44
Canyon Creek
Lassen Volcanic Natl Park
5
36
Tehama
Red Bluff
Plumas
Butte
Tehama
0
12.5
25
50 Miles


Canyon Creek
Ownership
Sierra Pacific Industries
Other private
Forest Service
0
2
4
8 Miles

Management Scenarios

- **Intensive:** Even-aged plantation silviculture - harvest and reforest 12.5% of the land base per decade. (high investment approach) (80 year rotation)
- **Option C Selection**: Harvest reduces basal area 25% -45% of initial stocking at 100 years down to minimum stocking under California Forest Practice Rules. (low investment approach) (relies on natural regeneration)
- **Custodial:** Removes 1% of the basal area in a watershed per year. 10% per decade. Maintain current stocking. (low investment low return approach) (relies on natural regeneration)
- **Regulated:** A theoretical, fully regulated forest with periodic harvest equal to periodic growth in a stable equilibrium over time. (idealized approach)

Plantations



The Assumptions/Caveats

- Every forest carbon pool (Soil carbon, Floor, Snags, Shrubs) except LBM and logging slash was at equilibrium. Sequestration = Emissions
  - Soil carbon = 43 tons/acre
  - Floor/snags/shrubs = 12 tons/acre
- Additional harvest residue/logging slash pool maintained separately.
- Wood Products/Landfill pools maintained separately.

Harvest Residue and Logs

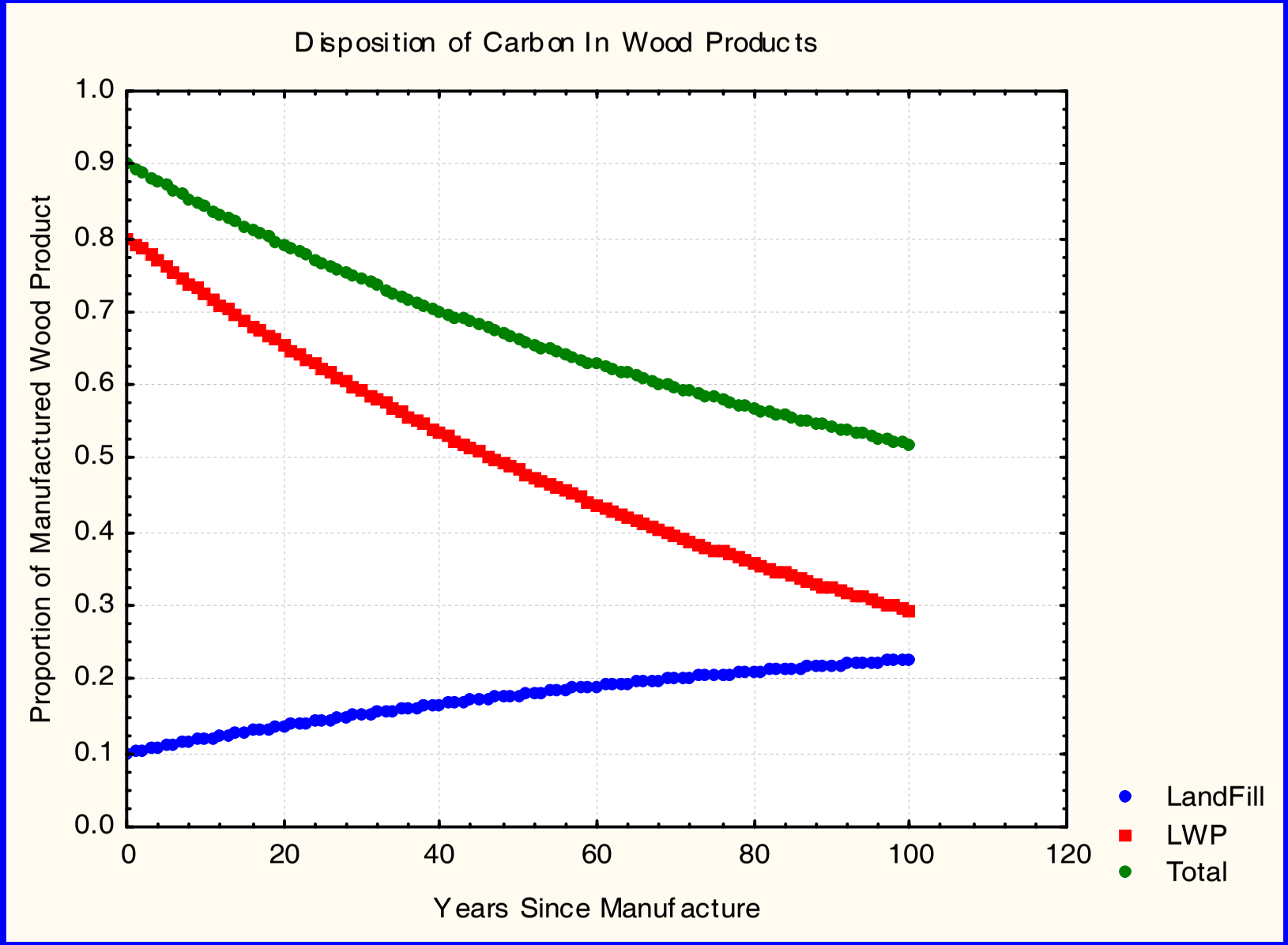
- Harvesting removes the entire LBM from the Forest Carbon Pool.
- 45% LBM – Harvest logs (stem wood and bark)
- 55% LBM – Harvest Residue/Slash: foliage, branches, stumps, roots, tree tips, unmerchantable (<8” DBH) trees)

Long Term Wood Products

- ‘National’ recovery is ~ 60%
- SPI: ~ 70%
- All material that arrives at the mill is used in some form or another.
  - Weighed
  - Measured
- Long term products(70%)
    - Lumber, MDF furnish, Pulp and paper chips
- Short term (immediate emissions) products (30%)
  - Hog fuel – local electric cogeneration facilities
  - Bark/landscaping materials
  - Animal bedding

Landfill!

Long Term Wood Products



Inventory Results

Live Biomass Estimates

- **Need estimates of**
  - Stem wood biomass
  - Bark biomass
  - Crown biomass (foliage and branches)
  - Roots

Live Biomass Methods

2) Allometric functions (CCAR requirements)

LBM = f (DBH) for trees
(sum to get plot/per acre totals)

3) Stand estimators – Model 2

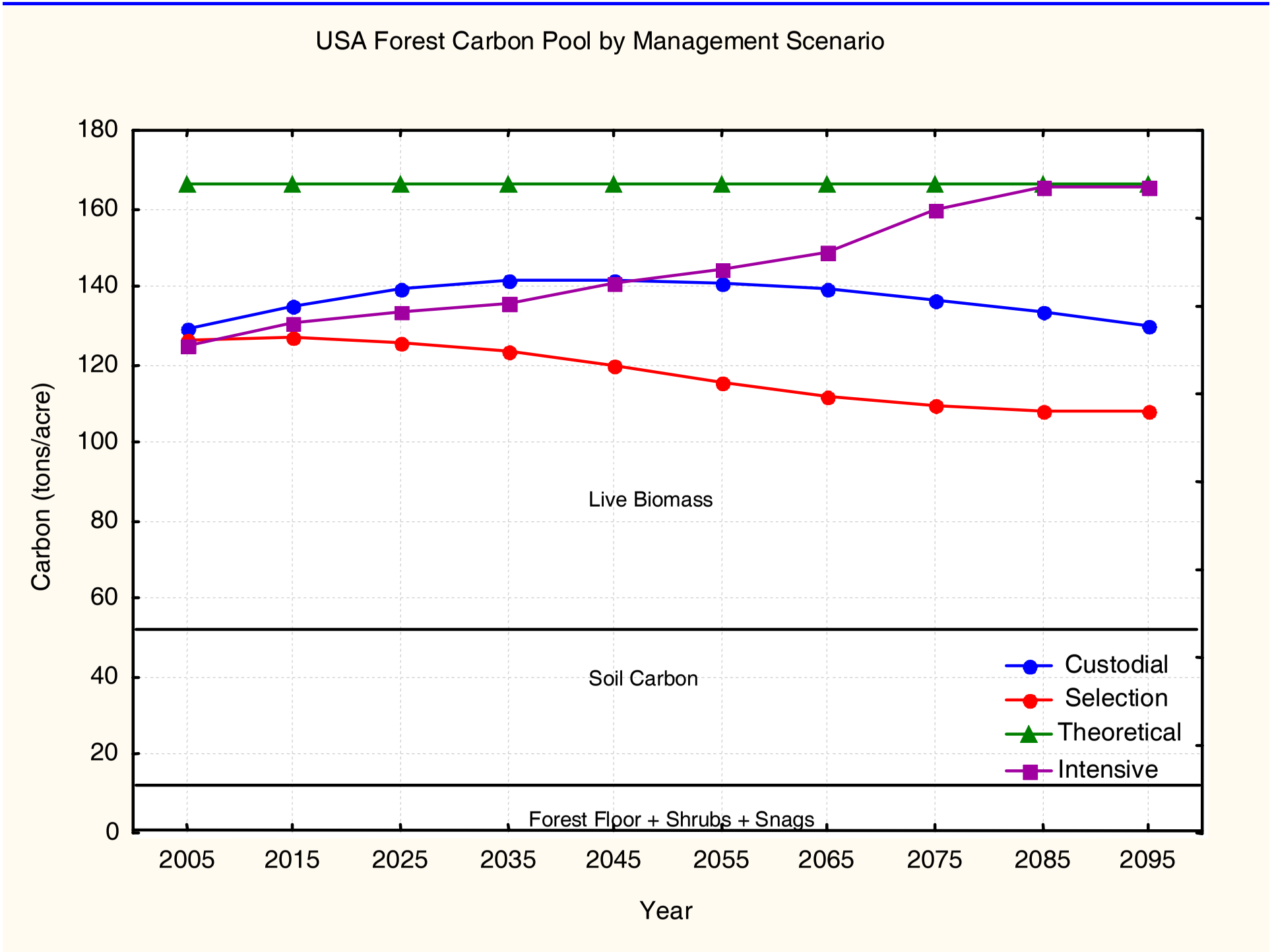
LBM = f(stand stem wood volume)
(apply to per acre stand estimates)

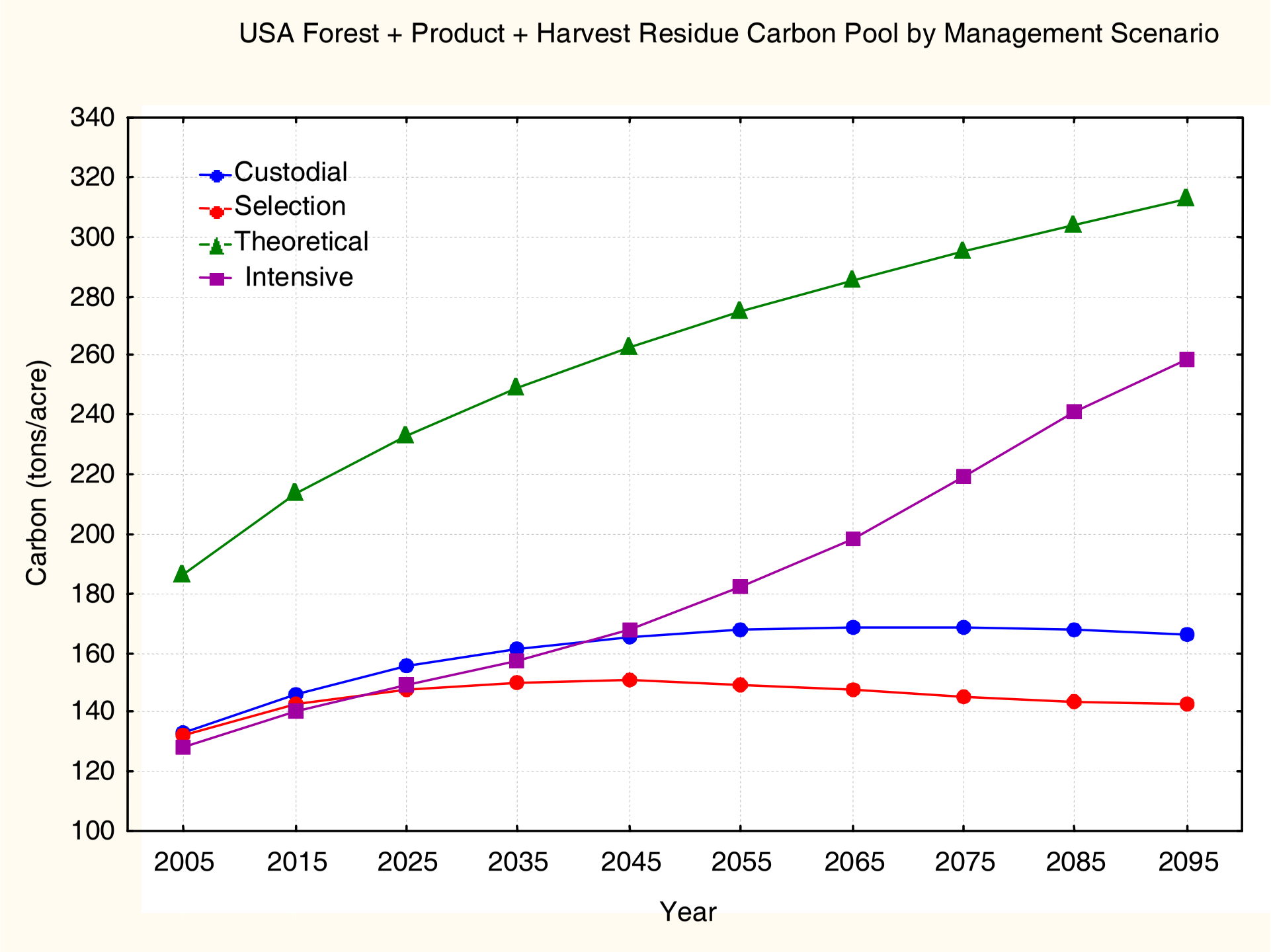
Live Biomass Methods

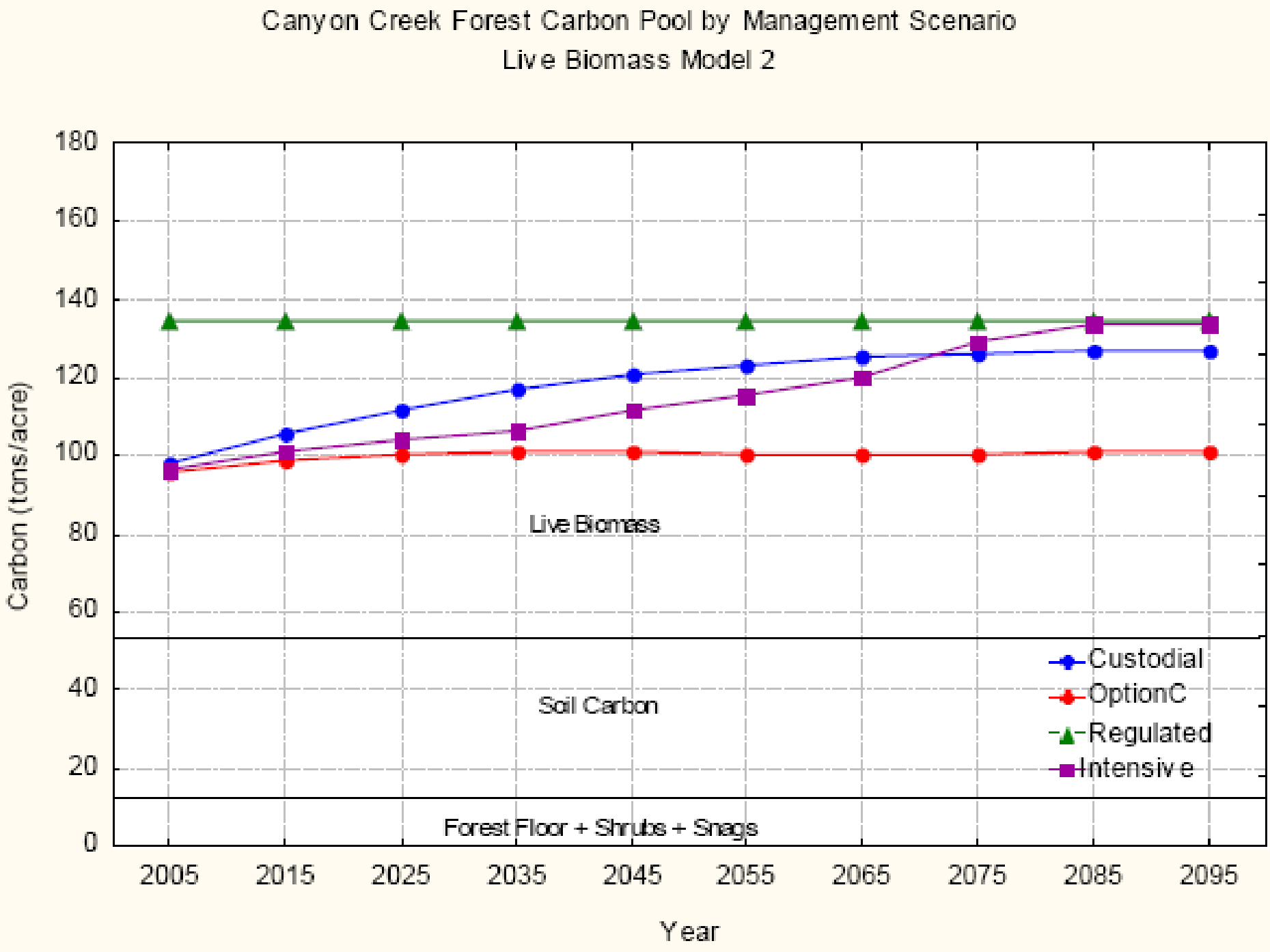
1) Proportional allocation

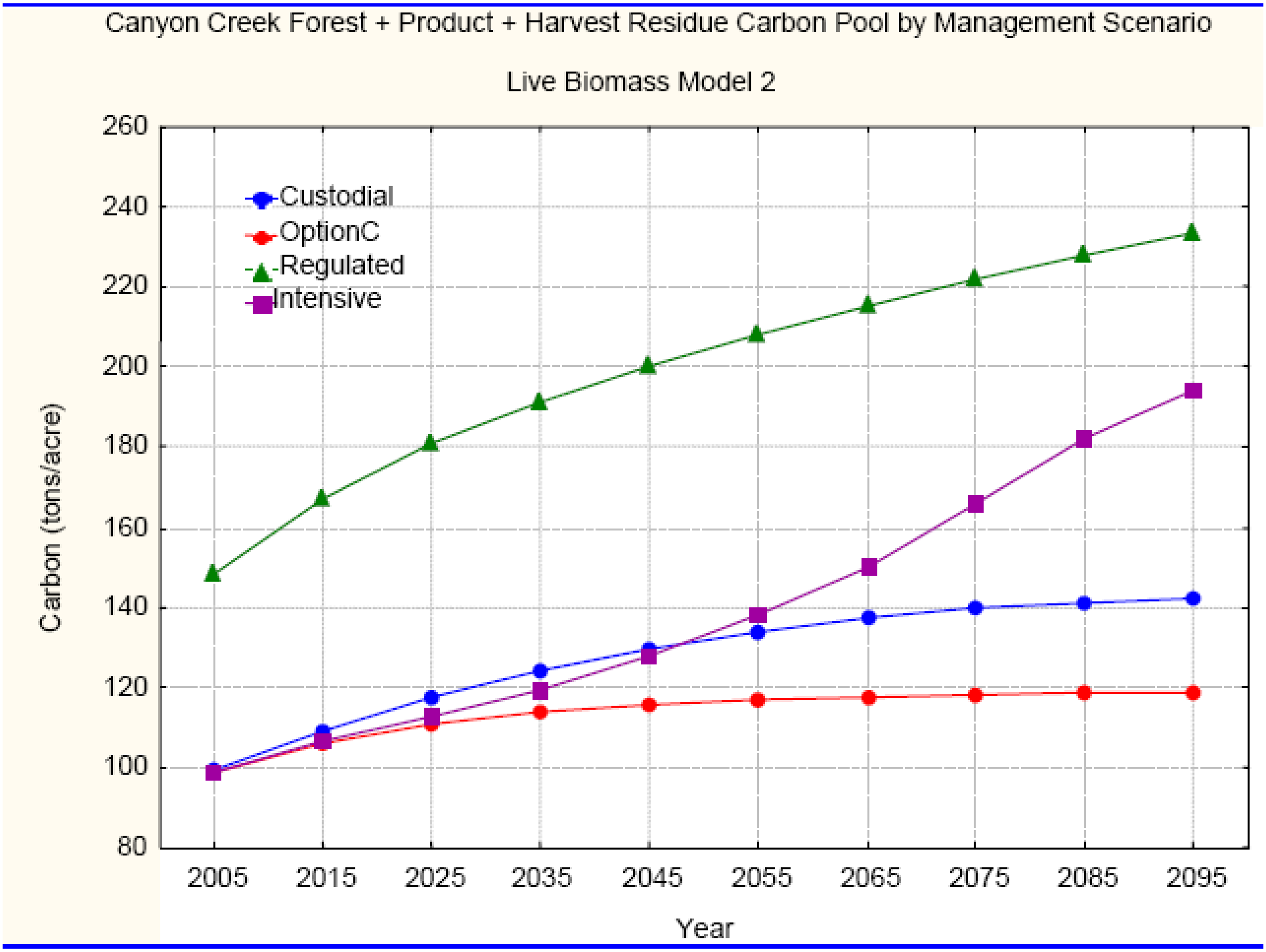
Source	Crown	Stem Wood	Bark	Roots
National Scale – Model 1	18	54	10	18
CA – Model 2	39	36	7	18

Carbon Budget Results


USA Forest Carbon Pool by Management Scenario
Carbon (tons/acre)
180
160
140
120
100
80
60
40
20
0
Live Biomass
Soil Carbon
Forest Floor + Shrubs + Snags
Custodial
Selection
Theoretical
Intensive
2005
2015
2025
2035
2045
2055
2065
2075
2085
2095
Year


USA Forest + Product + Harvest Residue Carbon Pool by Management Scenario
Custodial
Selection
Theoretical
Intensive
Carbon (tons/acre)
340
320
300
280
260
240
220
200
180
160
140
120
100
2005
2015
2025
2035
2045
2055
2065
2075
2085
2095
Year


Canyon Creek Forest Carbon Pool by Management Scenario
Live Biomass Model 2
Carbon (tons/acre)
180
160
140
120
100
80
60
40
20
0
Live Biomass
Soil Carbon
Forest Floor + Shrubs + Snags
Custodial
OptionC
Regulated
Intensive
2005
2015
2025
2035
2045
2055
2065
2075
2085
2095
Year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Live Biomass Model 2
Custodial
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2015
2025
2035
2045
2055
2065
2075
2085
2095
Year

Table S.1 *Additions* in carbon credits as compared to Option C Selection management by forest and total carbon pool basis during the 10th decade.

Watershed	Management Scenario	Forest Carbon Pool based (Tons C/acre)	Total Carbon Pool based (Tons C/acre)	Percent Change from Forest to Total carbon pool basis
USAW	Intensive	35	95	+166%
USAW	Custodial	22	23	+5%
CCW	Intensive	33	75	+127%
CCW	Custodial	26	23	-7%

THE STUDY SHOWS

- With intensive management and accounting for carbon in products, as much as 150% more tons of carbon per acre can be sequestered compared to other less intensive management scenarios.

- Failing to account for carbon taken from CO^2 in the air and stored in forest products and mill residue significantly understates the total amount of carbon sequestered by California's managed forestlands.

- On the Sierra Pacific acres that the State has approved for intensive management as compared to selection management, the net gain in the amount of carbon and CO^2 sequestered over the next 10 decades could offset the annual CO^2 emissions from over 877,000 vehicles or greater than 5 million tons of CO^2 equivalents.

- Protocols that accurately assess total carbon and CO^2 sequestration over time, including wood products and that allow widespread participation on the part of forest landowners should be developed for California.

Ideas for Discussion

- Need to deal with cross sector issues (biomass energy vs fossil fuels) (using wood in replacement for non-renewable fossil fuel intensive building materials)
- Need more precise biomass models for CA
- Need CA specific allometric equations
- Need policy to reflect carbon sequestration in wood products and different management practices.