Simulated Carbon Projections for Uneven-aged Northern Hardwood Stands

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Introduction

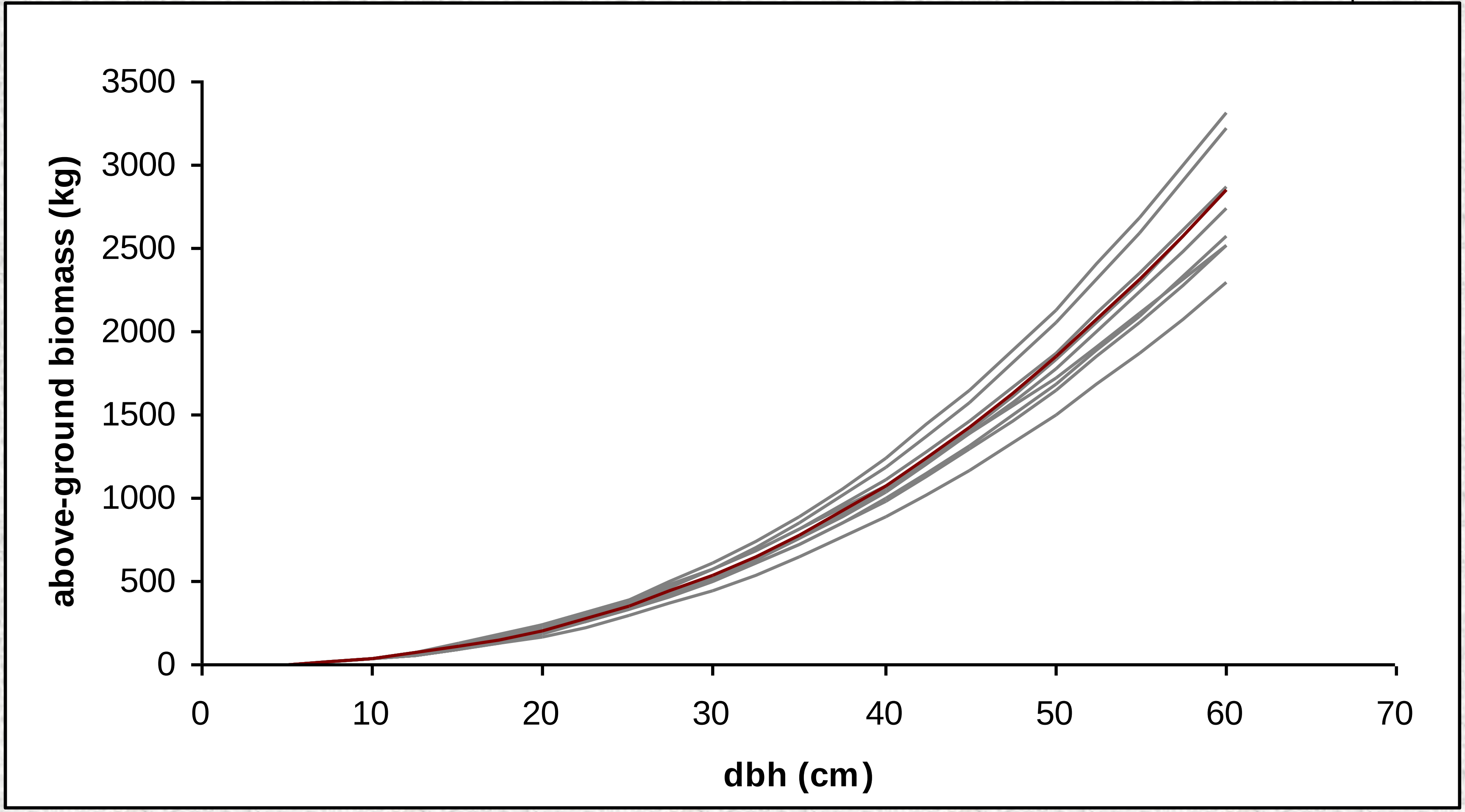
- The goal of this project was to provide forest managers with information to facilitate decisions about silvicultural alternatives for managing uneven-aged northern hardwood stands dominated by sugar maple with respect to carbon.

- We modified a growth and yield simulator to predict changes on both the production and recoverable yields of both wood and carbon.

Growth and Yield Simulator

- Based on 1983 version of Hansen simulator
- Re-written in Fortran 90
- Updated eleven sub-routines to simulate diameter growth, mortality, ingrowth, and cut over different cutting cycles
- Added stochastic components in the diameter growth and mortality models
- Information is outputted to files in terms of plot and total stand summary values

Growth and Yield Simulator



Biomass Models

- The models took the form of

$$\ln wt\ (kg) = b_o + b_1 \ln DBH$$

- Correction factors were computed to account for the transformation bias

Species	b_o	b_1	R^2	ERE	Mean % difference
S.Maple	-1.849	2.3947	99.7%	10.7%	8.44%
A.Beech	-1.7448	2.3613	99.4%	16.4%	12.8%
Y.Birch	-1.9708	2.4139	99.7%	12.2%	9.22%

Biomass Models

- Carbon content by species was determined following the IPCC 2006 Guidelines (Lamlom and Savidge, 2003)

Species	Carbon Fraction of Dry Matter
S. Maple	0.4932
A. Beech	0.4627
Y. Birch	0.4660

Simulation

- Four management options were simulated for three cutting cycles each
- Three selection system options were used based on Arbogast (1957) and Hansen and Nyland (1987), and a diameter-limit cut
  - 21.1 m^2ha^{-1} with a 10 yr cutting cycle*
  - 17.2 m^2ha^{-1} with a 15 yr cutting cycle*
  - 14.9 m^2ha^{-1} with a 20 yr cutting cycle*
  - Diameter-limit cut truncated at 30 cm with a 20 yr cutting cycle*

* Peak biomass

FINDINGS

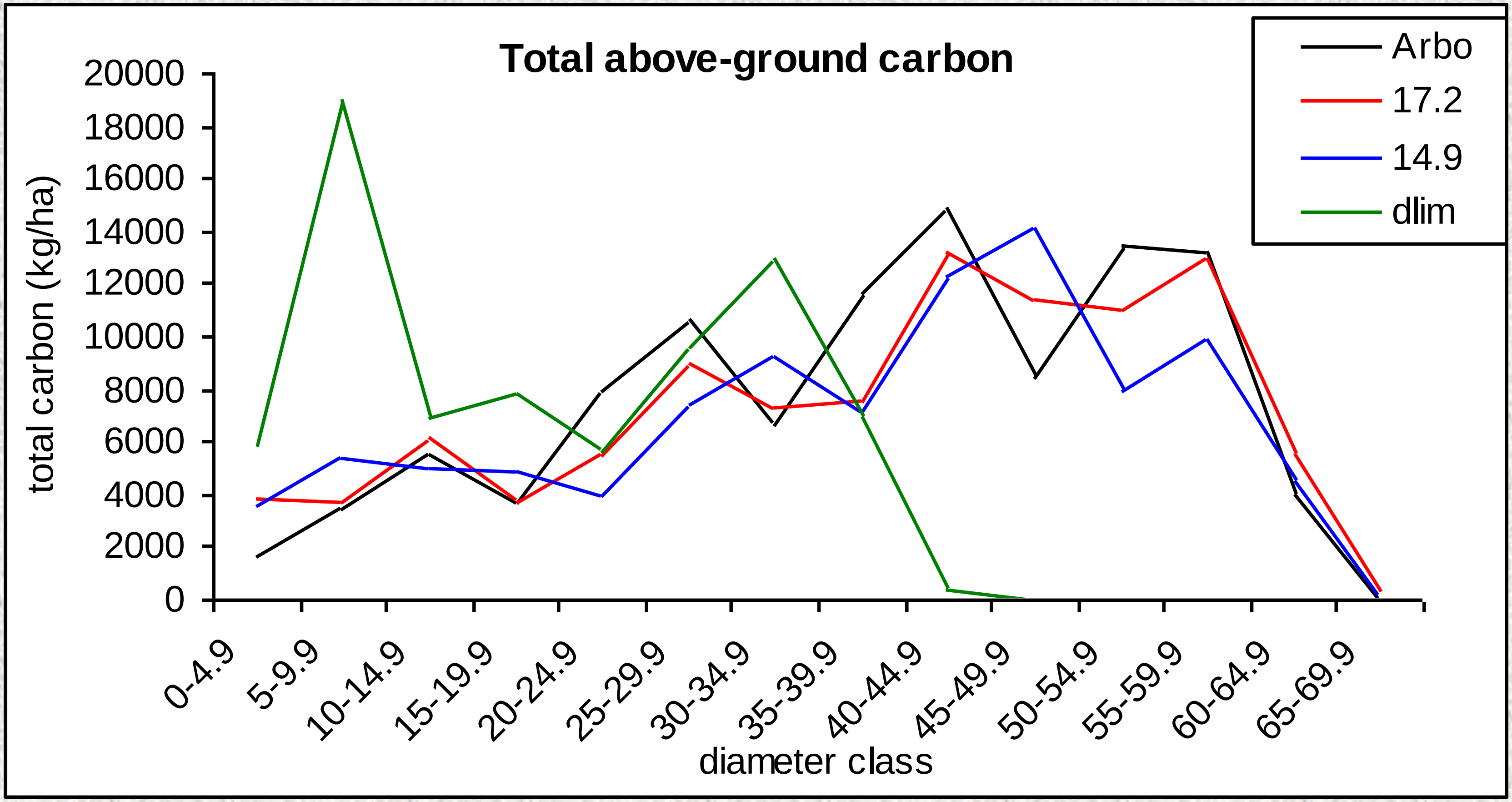
Annual TMV Production (m^3/ha/yr)
poles, small sawtimber, large sawtimber

Option	1st cut cycle	2nd cut cycle	3rd cut cycle
Arbo	4.46	3.85	3.83
17.2	3.89	3.20	3.04
14.9	3.31	2.68	2.74
Dlim	2.78	1.60	3.45

Total Harvest Volume

- Arbogast structure - 10 yr cutting cycle
  - Average harvest volume of 4.15 m^3/ha/yr
- 17.2 m^2/ha - 15 yr cutting cycle
  - Average harvest volume of 3.53 m^3/ha/yr
- 14.9 m^2/ha - 20 yr cutting cycle
  - Average harvest volume of 3.0 m^3/ha/yr
- Diameter limit cut - 20 yr cutting cycle
  - Average harvest volume of 1.77 m^3/ha/yr

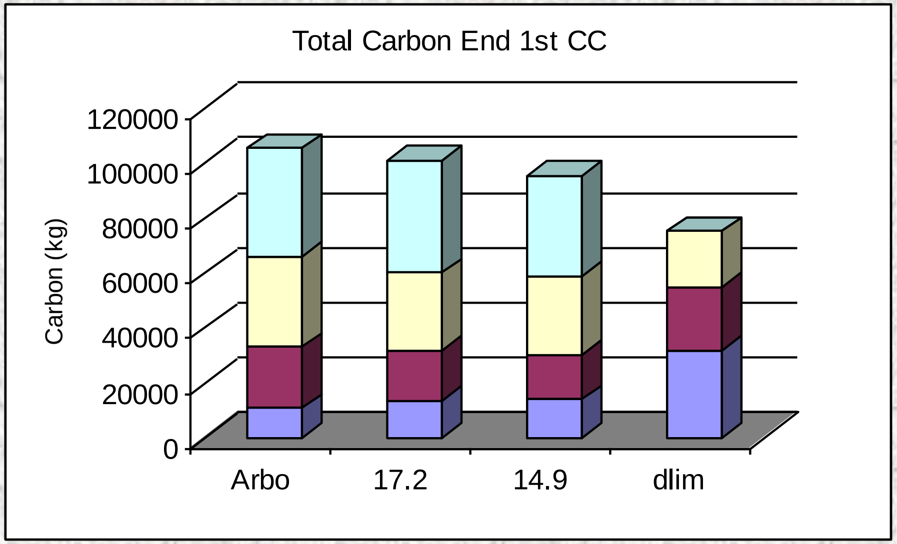
Total carbon at end of first cutting cycle

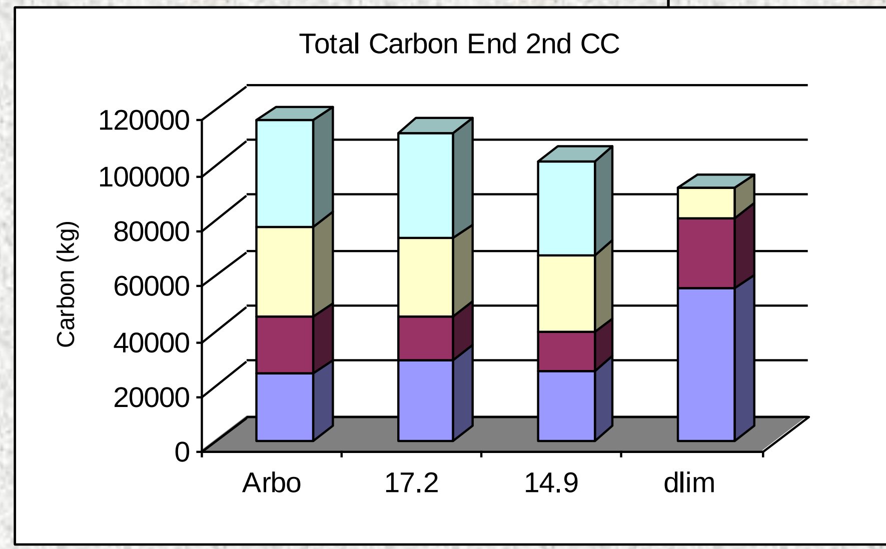


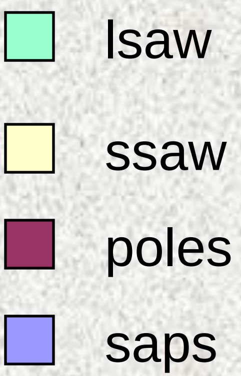
Total Carbon Sequestered at end of each cycle (kg/ha)

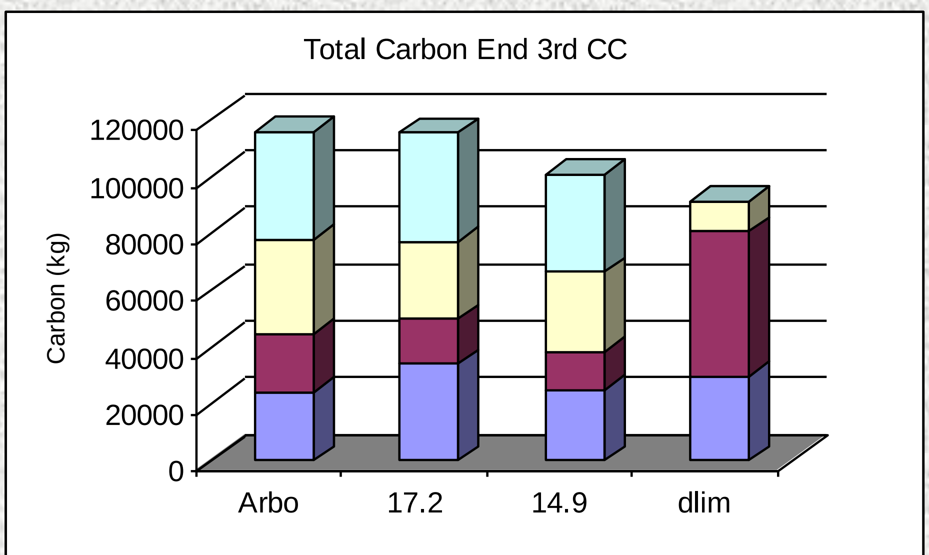
Option	1st cycle	2nd cycle	3rd cycle
Arbo	105412.2 ± 2708	116243.7 ± 2671	115634.7 ± 2384
17.2	101080.2 ± 3081	111819.5 ± 3176	115234.8 ± 3186
14.9	95438.1 ± 3691	101320.0 ± 3503	100657.5 ± 3532
Dlim	75001.2 ± 1667	91550.3 ± 2196	91131.7 ± 2352

Total carbon by group at end of each cutting cycle



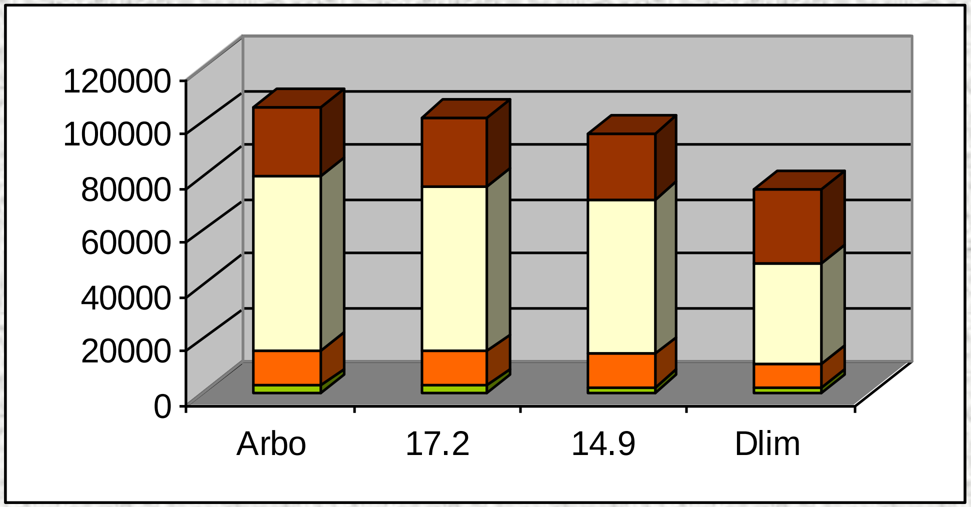




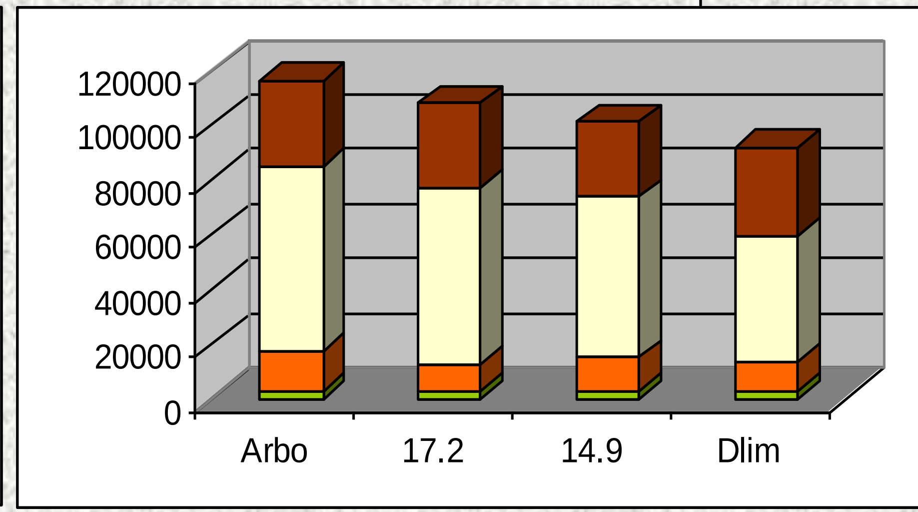


Sequestered carbon by components at end of each cutting cycle

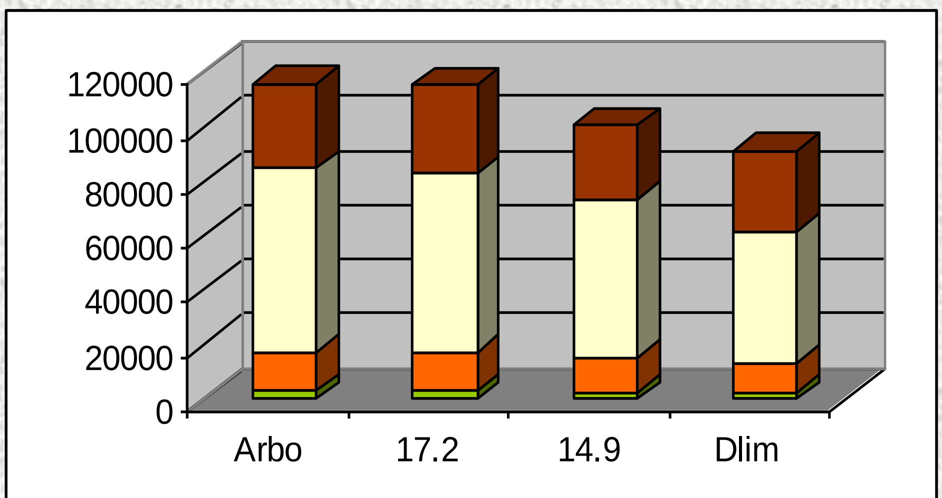
1st cycle



2nd cycle



3rd cycle



branch

stemwood

stembark

foliage

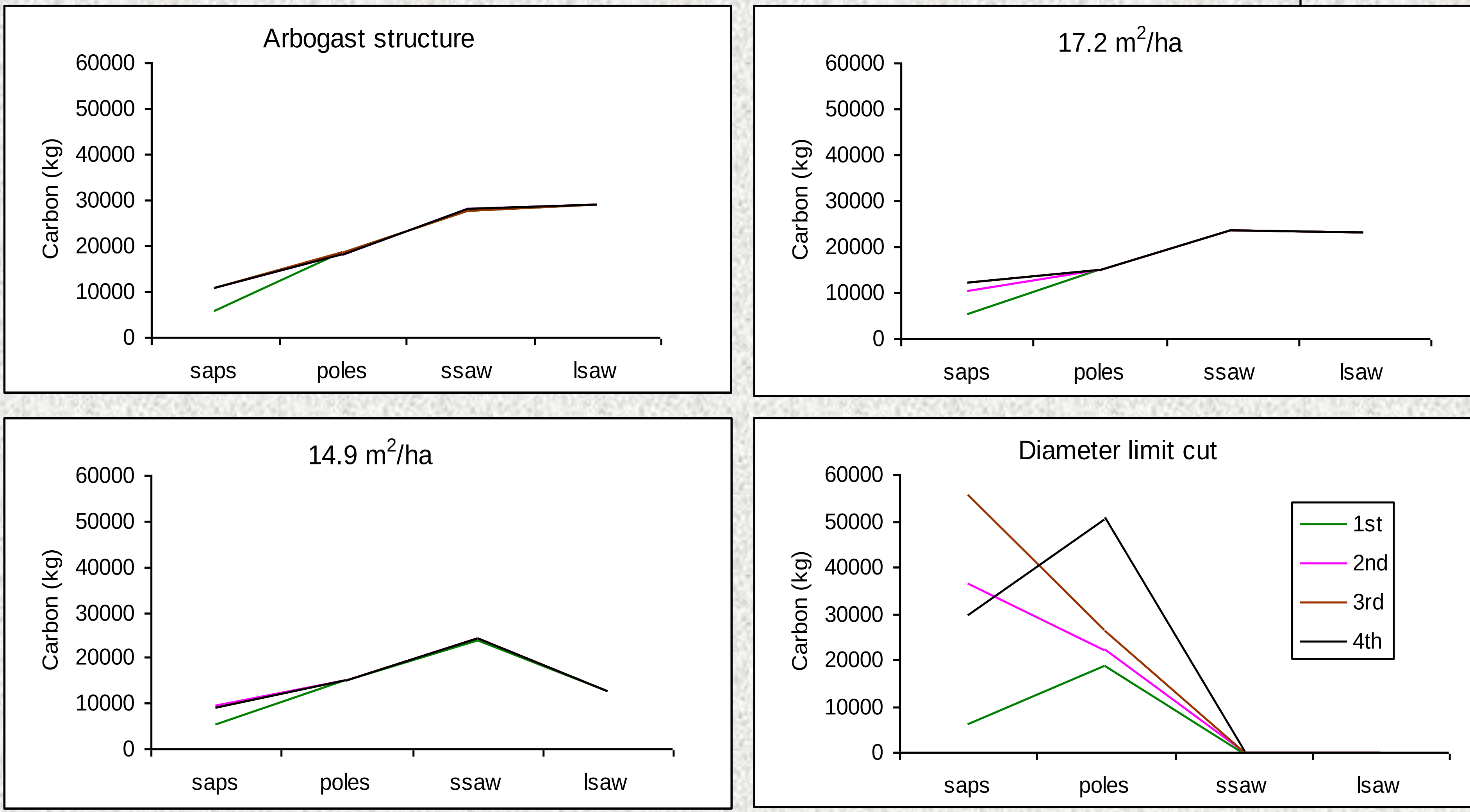
Total Carbon Production (kg/ha/yr)

Option	1st cycle	2nd cycle	3rd cycle
Arbo	2422.8	2995.1	2966.1
17.2	2279.4	2661.4	2766.7
14.9	1891.6	1969.4	1963.5
Dlim	2522.5	1635.7	473.2

Carbon Harvested at end of each cutting cycle (kg/ha) (kg/ha/yr)

Option	1st cycle	2nd cycle	3rd cycle
Arbo	19389 1939/yr	16677 1668/yr	16357 1636/yr
17.2	25706 1714/yr	20720 1381/yr	19726 1315/yr
14.9	29191 1460/yr	23335 1167/yr	23761 1188/yr
Dlim	20229 1011/yr	10810 541/yr	10722 536/yr

Standing Carbon at Start of each Cutting Cycle



Summary

- The Arbogast structure had the greatest annual TMV for all 3 cutting cycles and resulted in the greatest annual harvest volume with approximately 54% in LSAW and 30% in SSAW
- Three balanced designs resulted in operable cuts over three cutting cycles with stable distributions and consistent TMV
- Diameter limit cut failed to produce large sawtimber during any of the three cutting cycles and did not produce enough volume for an operable cut for the last two cutting cycles
- The Arbogast structure with a 10 year cutting cycle sequestered the greatest annual amount of total carbon

Summary

- Annual sequestered carbon increased for the three balanced designs across the three cycles and resulted in a stable pool of above-ground carbon at the start of each cutting cycle
- Total carbon production for the diameter limit cut decreased by 35% in the second cutting cycle and by 80% in the third cutting cycle
- Carbon distribution among components remained consistent for all options
- Carbon by group remained consistent for three balanced designs but shifted to saps and poles for diameter-limit cut