Aboveground biomass production of 30 shrub willow and 7 hybrid poplar varieties over four coppice harvest cycles

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College of Environmental Science and Forestry

Overview

- Background
- Methods
  - Trial planted in 1997 with 32 willow and 7 hybrid poplar clones harvested four times
- Results and Discussion
  - Patterns for willow clones
  - Patterns for poplar clones
- Conclusions

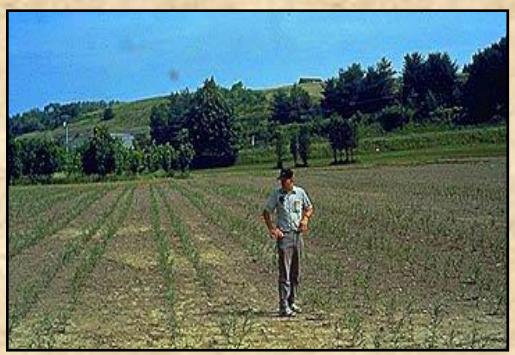
Background

- Willow biomass cropping system is designed using a coppice management system on 3 – 4 year rotations for 7 or 5 harvests respectively from a single planting
- Yield is expected to increase from first to second rotation (Volk et al. 2001) and then be maintained over the subsequent rotations
- These assumptions impact analysis of the system including economics, GHG and energy balances
- Long term data available on willow biomass crops is limited

Willow Biomass Production Cycle

Site Preparation

Planting



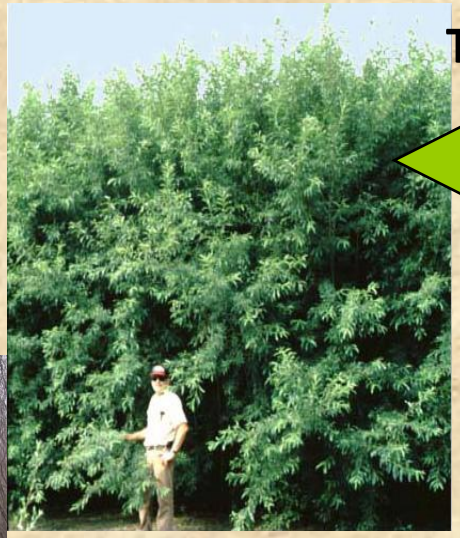
First year growth

Coppice

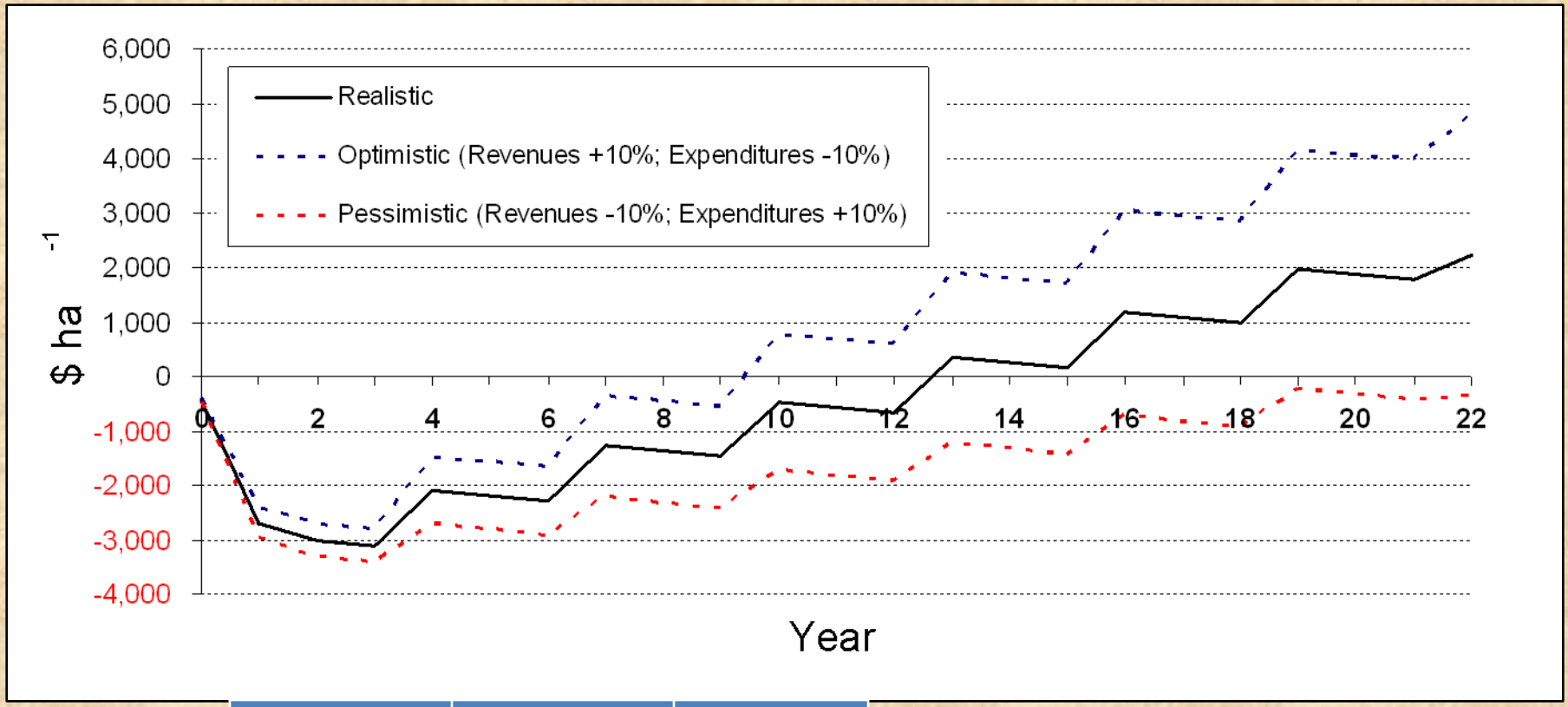
Early spring after coppicing

One-year old after coppice

Three-year old after coppice



Economics of Willow Over 7 Rotations



	NPV $ ha^{-1}	IRR (%)
Realistic	101	5.5
Optimistic	1,571	10.8%
Pessimistic	-1,338	-1.4%

(Buchholz and Volk, in press)

Objectives

- Objectives:
  - Original: Assess the relative performance of 32 willow and 7 poplar clones during the establishment year and first coppice rotation (Tharakan et al. 2005)
  - Secondary: Measure changes in production of 32 willow and 7 poplar clones over multiple rotations

Methods

- Trial planted in 1997 in Tully, NY using 25 cm long dormant cuttings at a density of 18,500 plants ha^{-1}
- Well to excessively well drained Palmyra gravelly silt loam soil with 3.5% soil organic matter
- Coppiced after the first growing season
- Harvested every three years for four rotations
- Fertilized with 112 kg N ha^{-1} after each harvest

Plant Material

- 32 willow clones from the University of Toronto program and wild collections in central NY. Data from 30 clones presented due to poor survival of two clones.
  - S. *alba (SA2)*
  - S. *capera (S365)*
  - S. *dasyclados* (SV1)
  - S. *eriocephala (9 clones – S287, S185, S19,S25, S546, S557, S566, S646, S652)*
  - *S. eriocephala hybrids (3 clones – S301, S599, S625)*
  - S. *purpurea (12 clones – 94001, 94003, 94004, 94005, 94006, 94009, 94012, 94013, 94014, 94015, PUR12, PUR34, SH3)*
  - S. *sachalinensis (SX61)*
  - *S. miyabeana (SX64, SX67)*

Plant Material

- 7 hybrid poplar clones
  - Carolina – *Populus deltoides x P. nigra cv. Carolina*
  - DN5 – *P. deltoides x P. nigra*
  - DN34 - *P. deltoides x P. nigra*
  - DN70 - *P. deltoides x P. nigra*
  - DN74 - *P. deltoides x P. nigra*
  - NM5 – *P. nigra x maximowizii*
  - NM6 - *P. nigra x maximowizii*

1997 GENETIC SELECTION TRIAL

N

Gravel road

NATIVE WILLOW CUTTING ORCHARD

GRAVEL ROAD

S301	NM6	S625	SV1	PUR34	94012	S646	94013	S566	94015
94001	S546	S25	S365	STRCO	94014	94003	S287	94009	94004
S557	PUR12	DN34	S599	94005	SX61	DN5	NM6	NM5	SX67
94006	SH3	S652	DN74	SX64	SA2	S185	S19	DN70	CARO
94006	NM6	S546	94015	SH3	S646	DN70	S19	PUR34	94009
S25	S301	94005	SX61	SA2	94003	DN74	S625	SX67	S365
NM5	S599	DN5	STRCO	S557	94004	SV1	SX64	DN34	PUR12
S652	94012	94001	S287	94014	94013	S185	S566	CARO	NM6
CARO	94006	SX61	94009	DN74	SV1	S652	94003	PUR34	94014
NM6	94012	94004	S599	S625	SX67	S566	SH3	94013	S646
S301	S557	S185	S19	94001	DN70	94015	STRCO	DN5	DN34
S25	SA2	PUR12	S546	S365	SX64	NM5	S287	94005	NM6
94009	94005	SH3	DN74	S566	94001	SV1	94006	NM6	94004
S625	STRCO	SX61	S185	S646	SX67	S25	S652	DN70	S287
NM5	SV1	S365	CARO	94003	S546	S301	DN34	S19	94015
S557	PUR34	DN5	NM6	94014	94013	PUR12	SA2	SX64	S599

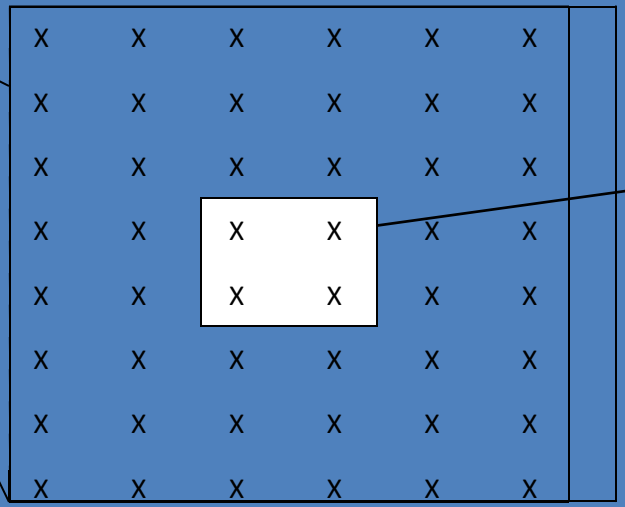
REP 4

REP 3

REP 2

REP 1

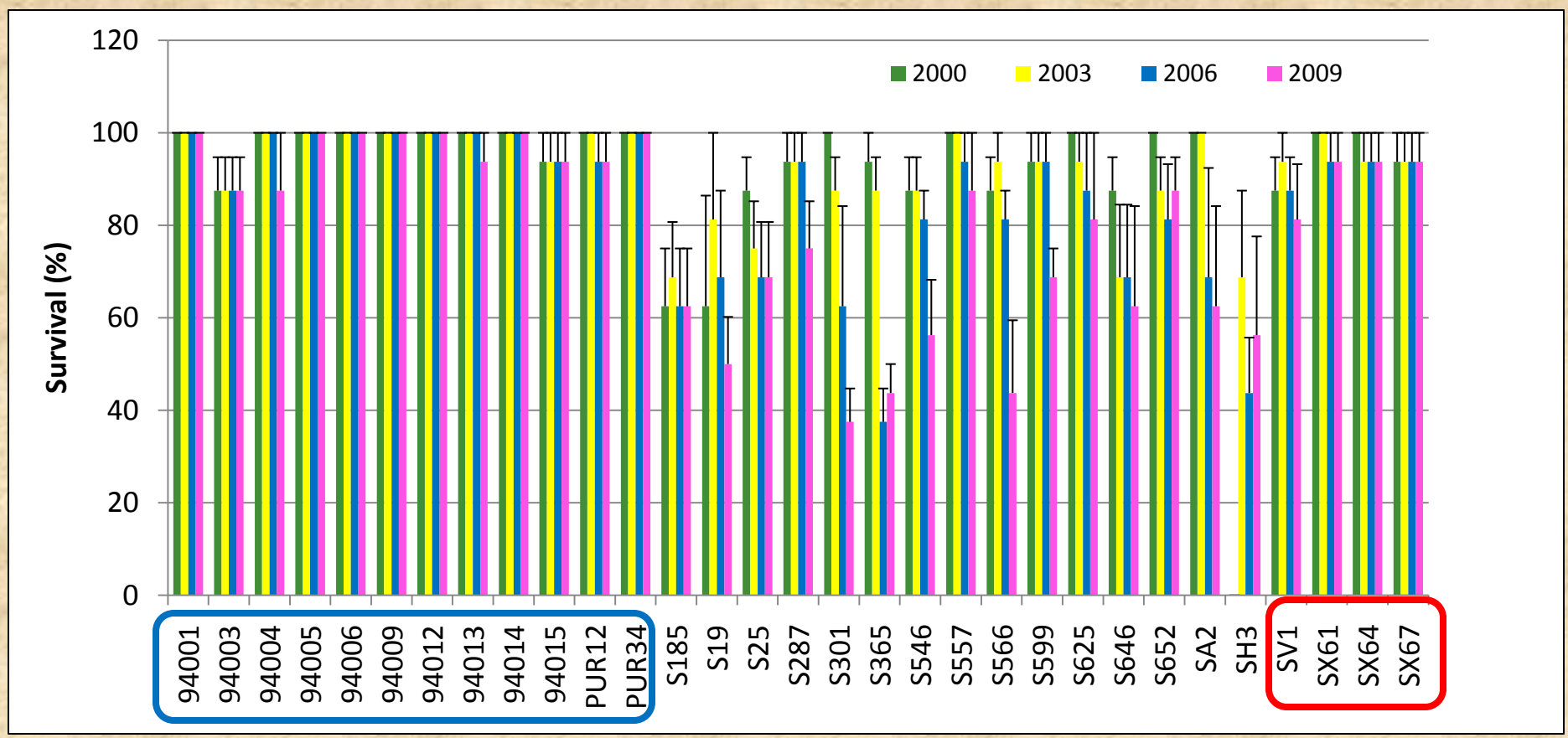
CLONE-SITE TRIAL



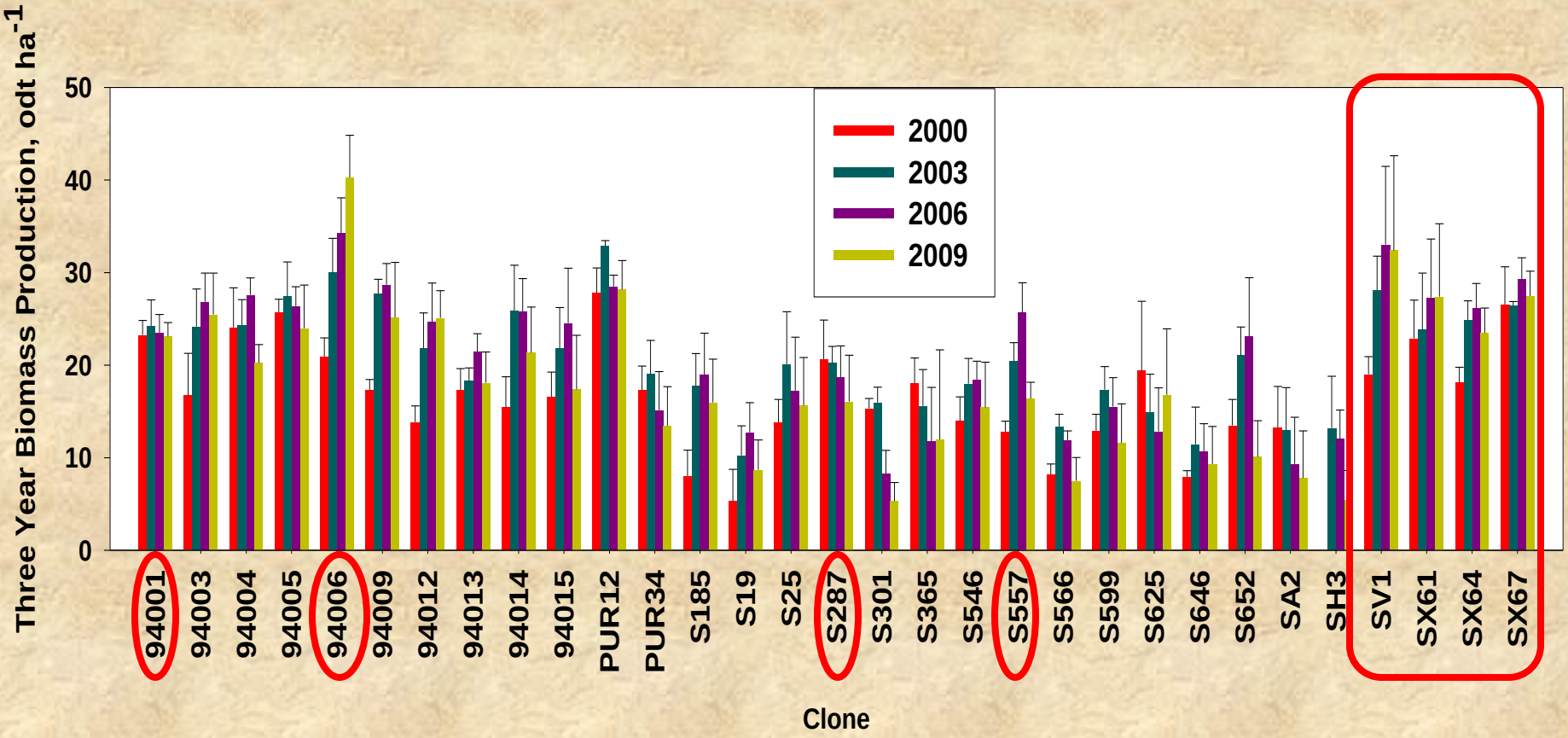
Measurement trees

Genetic Selection Trial, Tully - July 1997

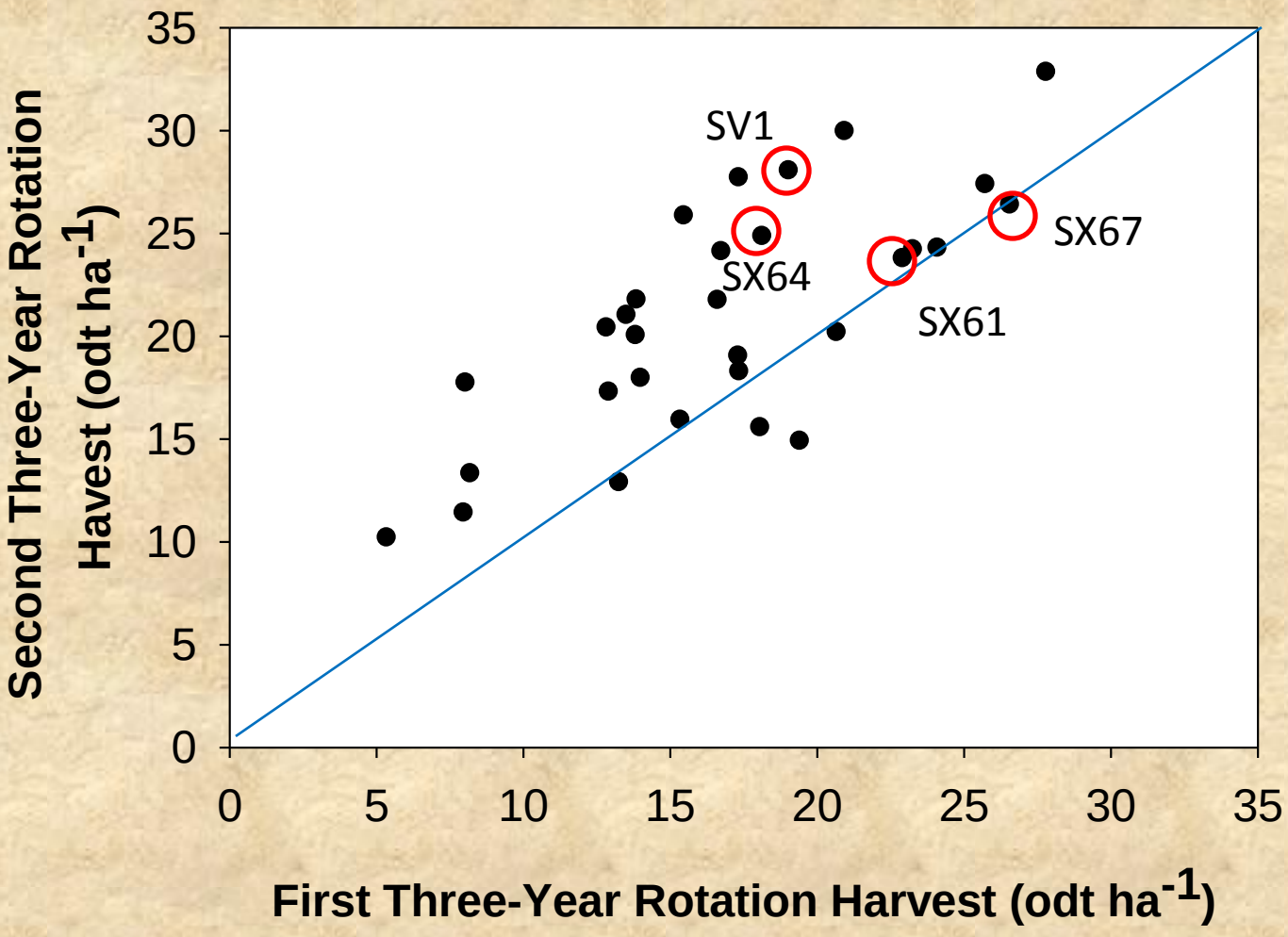
Willow Survival



Change in Production of Willow Over Four Rotations

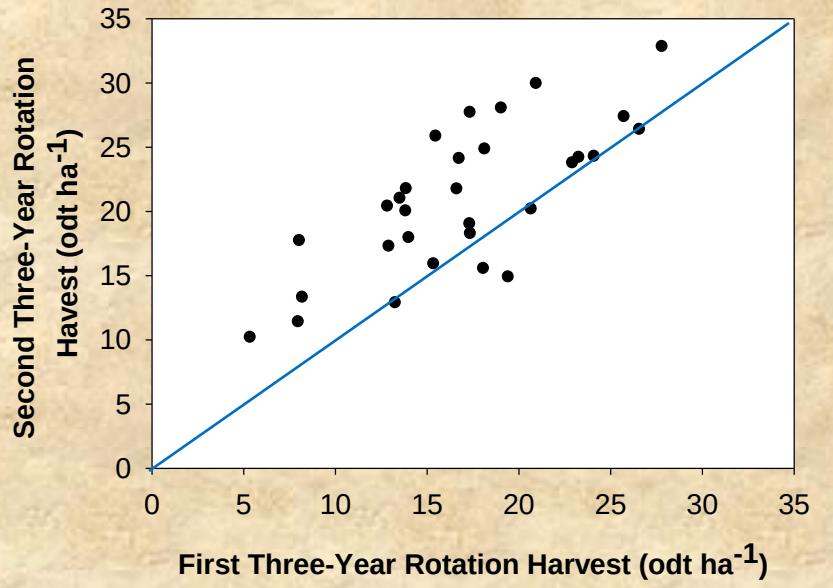


Willow 1st to 2nd Rotation



First to Second Rotation

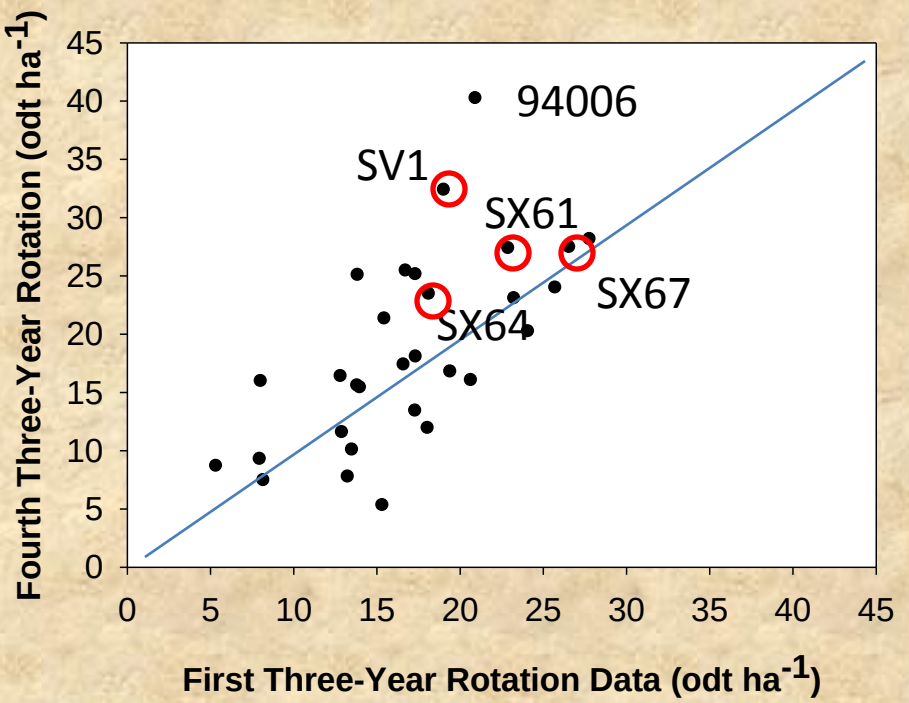
- Change in production ranged from -30% to 55%
- 25 clones increased, 5 clones decreased
- Production increased by 19.4% across all clones
- Top ten clones in first rotation increased by 23.0%
- SX clones and SV1 increased by 21.6%



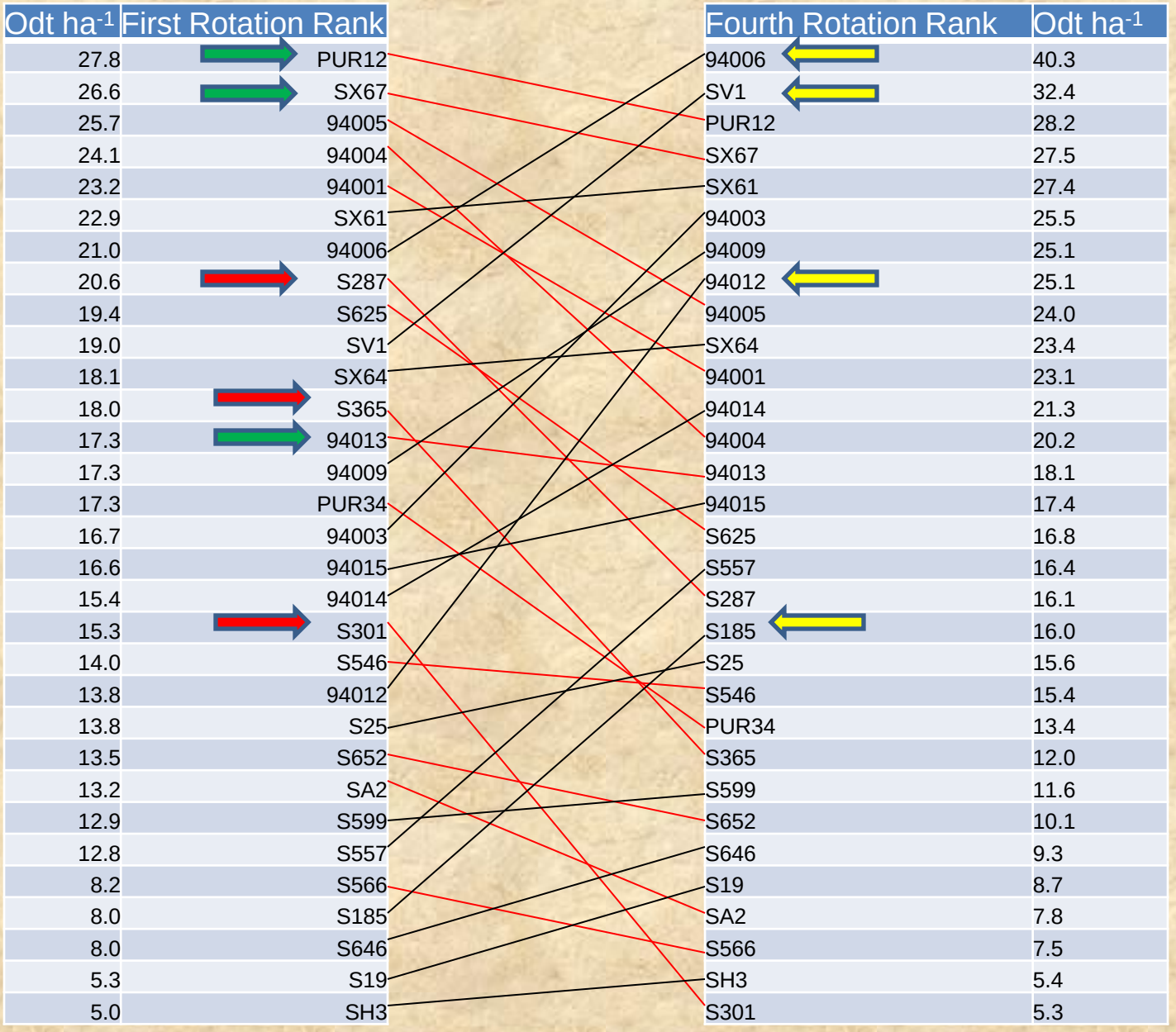
Change in production from 1st to 2nd rotation for 30 willow clones in Tully, NY

Willow Production

- Yield in 4th rotation ranged from 5.4 to 40.2 odt ha^{-1}
- Top ten clones produced 27.9 odt ha^{-1}
- Change in production from 1st to 4th rotation ranged from -65% to 99%
- 17 clones increased, 13 clones decreased
- Production increased 13.6% across all willow clones
- Top ten increased by 60.0%
- SX clones and SV1 increased by 30.8%



Change in production from 1st to 4th rotation for 30 willow clones in Tully, NY



Odt ha^{-1}	First Rotation Rank	Fourth Rotation Rank	Odt ha^{-1}
27.8	PUR12	94006	40.3
26.6	SX67	SV1	32.4
25.7	94005	PUR12	28.2
24.1	94004	SX67	27.5
23.2	94001	SX61	27.4
22.9	SX61	94003	25.5
21.0	94006	94009	25.1
20.6	S287	94012	25.1
19.4	S625	94005	24.0
19.0	SV1	SX64	23.4
18.1	SX64	94001	23.1
18.0	S365	94014	21.3
17.3	94013	94004	20.2
17.3	94009	94013	18.1
17.3	PUR34	94015	17.4
16.7	94003	S625	16.8
16.6	94015	S557	16.4
15.4	94014	S287	16.1
15.3	S301	S185	16.0
14.0	S546	S25	15.6
13.8	94012	S546	15.4
13.8	S25	PUR34	13.4
13.5	S652	S365	12.0
13.2	SA2	S599	11.6
12.9	S599	S652	10.1
12.8	S557	S646	9.3
8.2	S566	S19	8.7
8.0	S185	SA2	7.8
8.0	S646	S566	7.5
5.3	S19	SH3	5.4
5.0	SH3	S301	5.3

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21.0	94006	94009	25.1
20.6	S287	94012	25.1
19.4	S625	94005	24.0
19.0	SV1	SX64	23.4
18.1	SX64	94001	23.1
18.0	S365	94014	21.3
17.3	94013	94004	20.2
17.3	94009	94013	18.1
17.3	PUR34	94015	17.4
16.7	94003	S625	16.8
16.6	94015	S557	16.4
15.4	94014	S287	16.1
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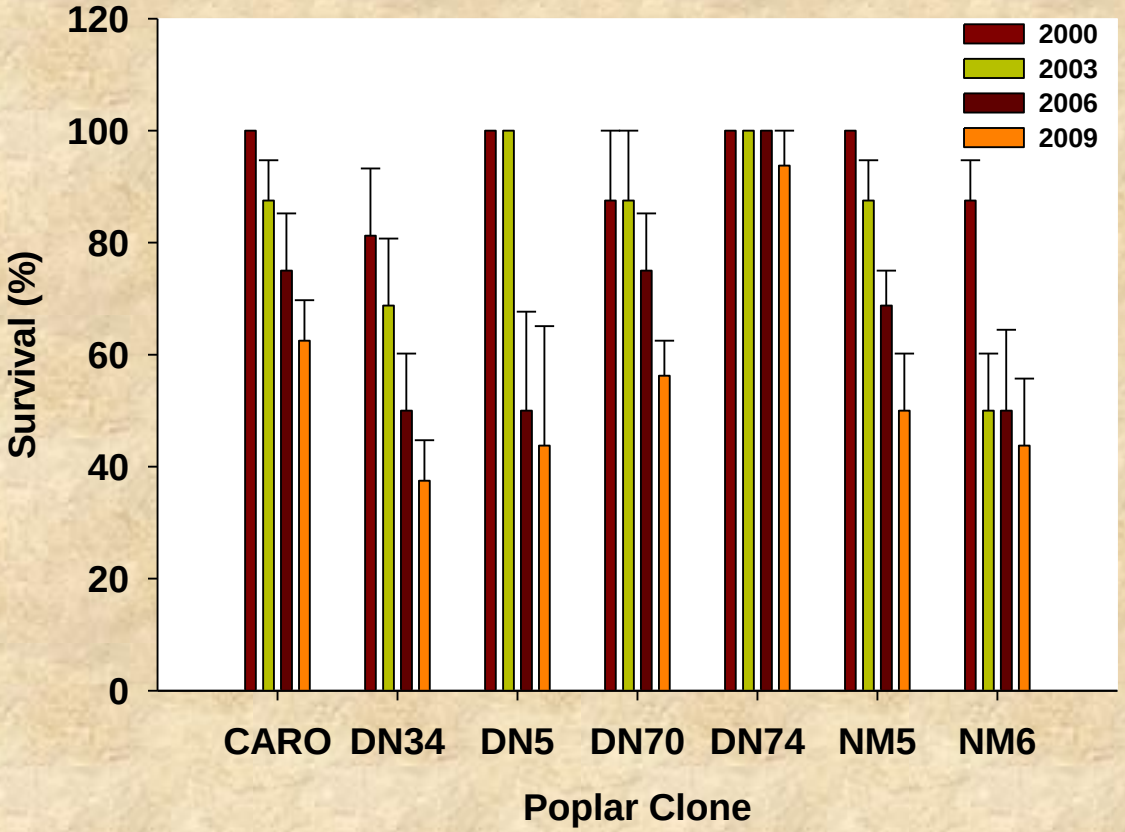
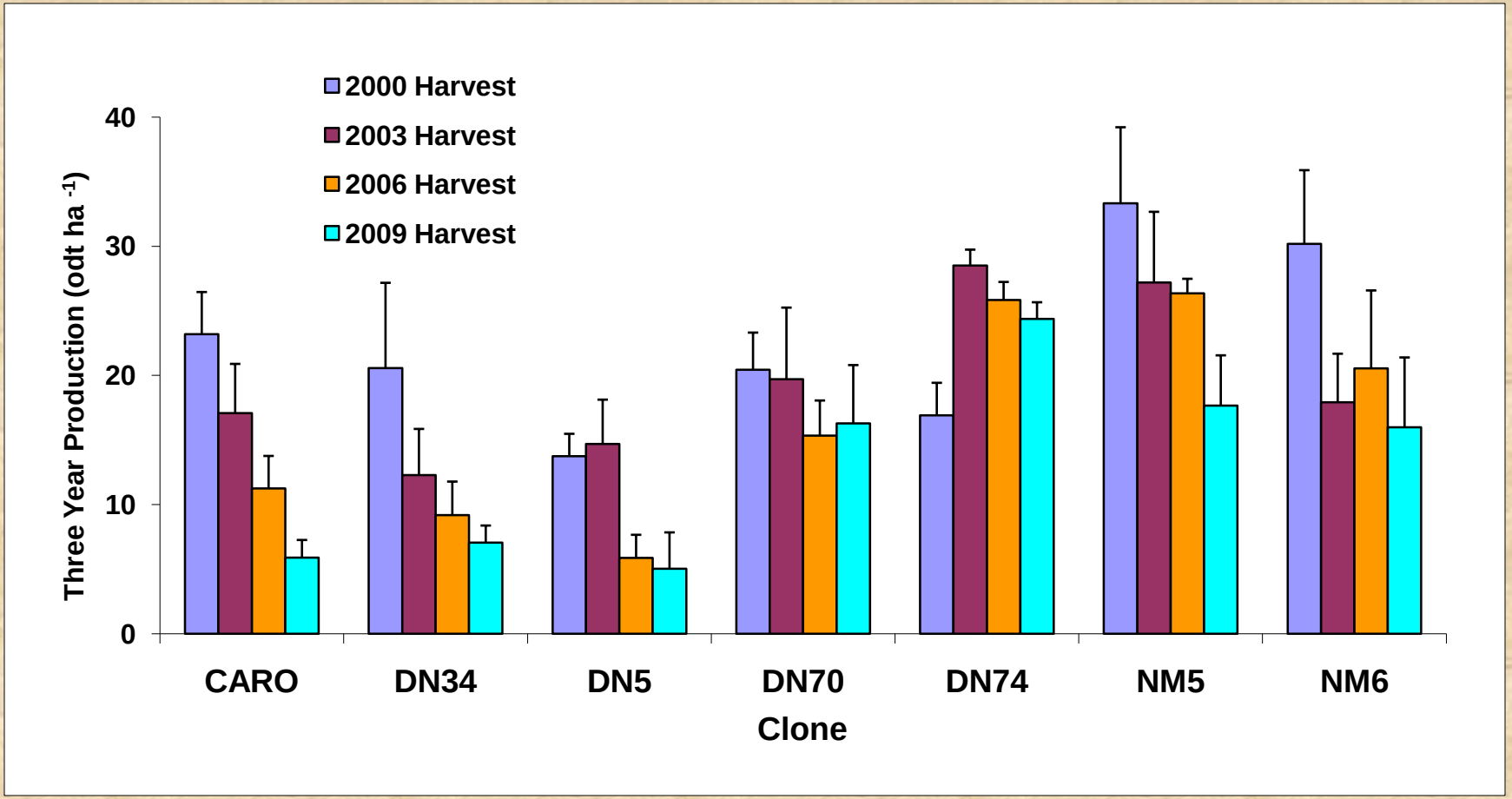
13.8	94012	S546	15.4
13.8	S25	PUR34	13.4
13.5	S652	S365	12.0
13.2	SA2	S599	11.6
12.9	S599	S652	10.1
12.8	S557	S646	9.3
8.2	S566	S19	8.7
8.0	S185	SA2	7.8
8.0	S646	S566	7.5
5.3	S19	SH3	5.4
5.0	SH3	S301	5.3

Poplar Survival

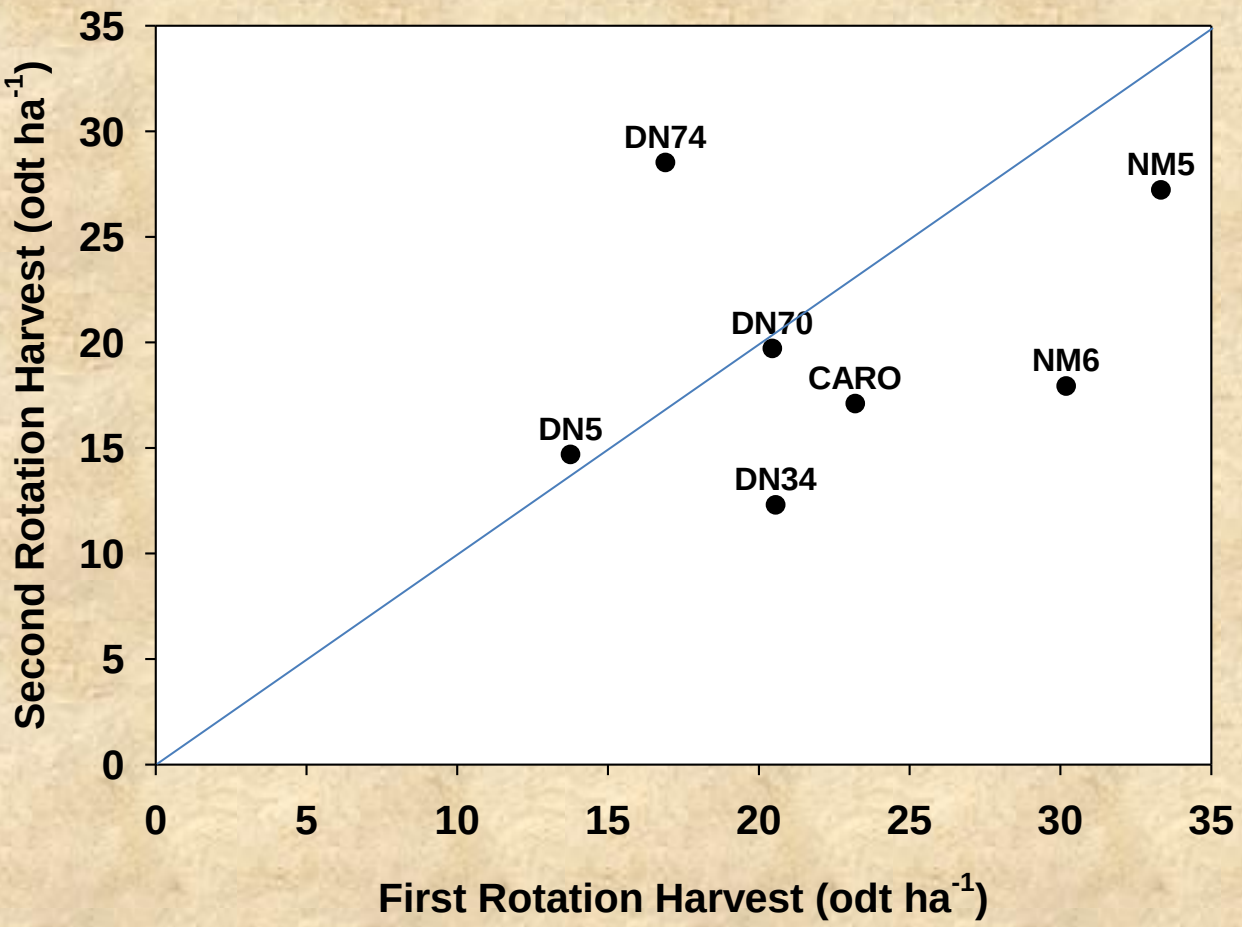
- Survival was >80% for all clones in the first rotation
- Declined so that by the fourth rotation was less than 65% for all clones expect DN74



Poplar Biomass Production Over Four Rotations

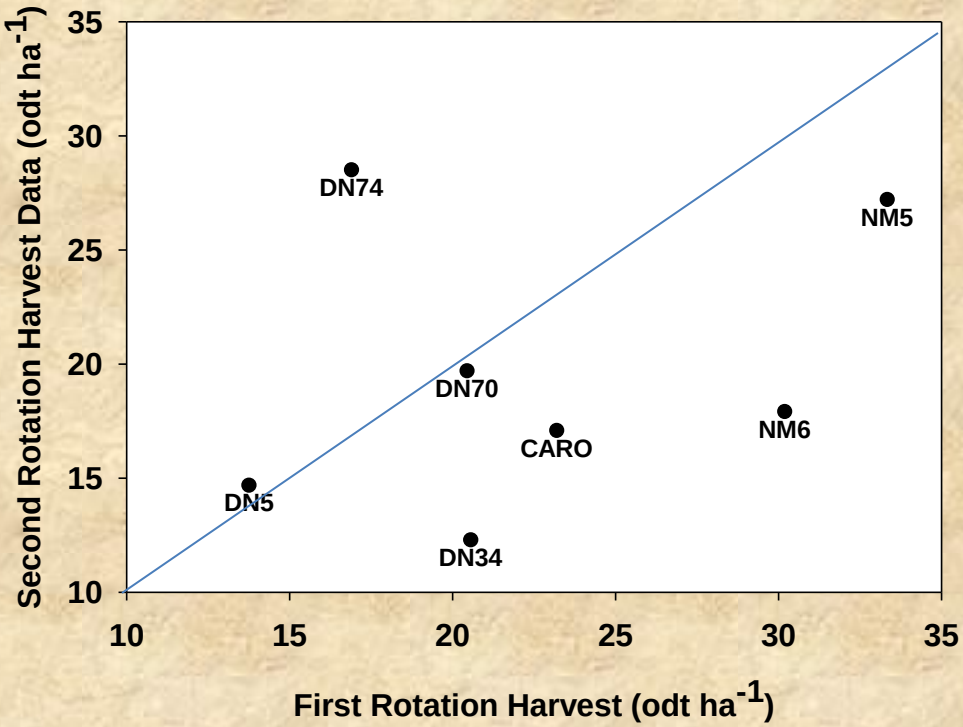


Change in Production from 1st to 2nd Rotation



Change in Production from 1st to 2nd Rotation

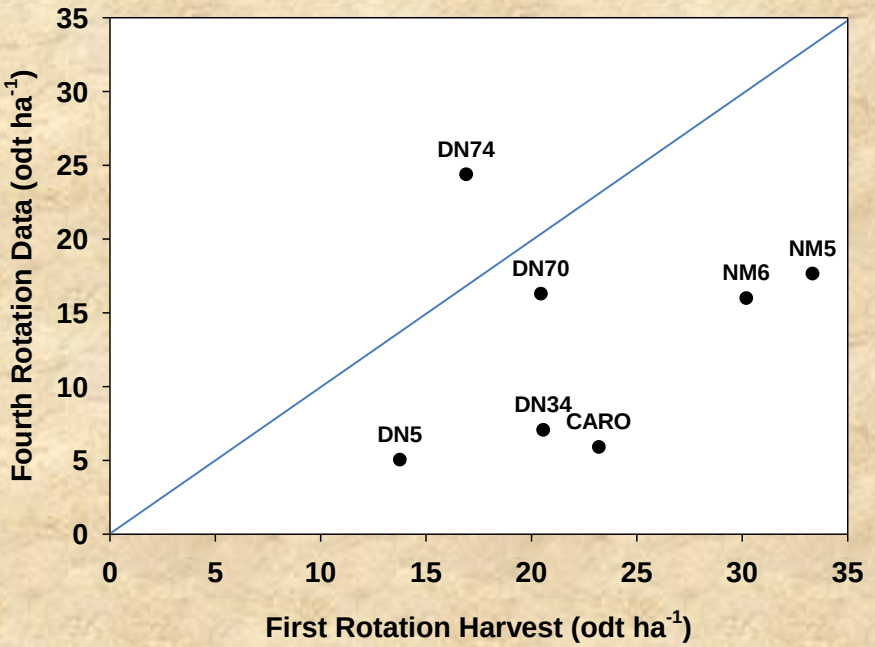
- Production drops for 5 of the seven hybrid poplar clones
- Large increase for DN74 (40.7%)
- Production decreases by 21.6% across all hybrid poplar clones



Hybrid poplar production in the first and second rotation in Tully, NY

Hybrid Poplar from 1st to 4th Rotation

- Fourth rotation production ranges from 5.0 to 24.4 odt ha^{-1}
- Average production is 13.2 odt ha^{-1}
- Production drops for 6 of the 7 hybrid poplar clones
- Large increase for DN74 (44.2%)
- Production decreases by 39.1% across all hybrid poplar clones



Hybrid poplar production in the first and fourth rotation in Tully, NY

Discussion

- For willow clones that have been selected for commercial production, as well as a number of others, there is a significant increase in yield from first to second rotation
- Some clones that did not perform well in the first rotation have done well over time
  - Notable ones are *S. purpurea* clones 94006 as well as 94003, 94009 and 94012
- Ranking of clones changes over multiple rotations
  - Only 60% of the top ten clones in the fourth rotation were in the top ten in the first rotation
- Monitoring trials through seven rotations will help to verify or change assumptions for modeling

Discussion

- For most hybrid poplar production decreased over time
  - DN74 was the exception
- These hybrid poplar clones at this location did not perform well in short rotation coppice systems, planted at a density of ~18,500 plants ha^{-1}
- Septoria is well established at the Tully research station and was a factor over time.

Acknowledgements

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