Opportunities and Challenges of Silvopastures in Saskatchewan

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History of forest use in North America

- Clearing land for agricultural purposes began with native Americans
- Continued with early European settlement
  - Multiple uses:
    - Timber-based products
    - Livestock grazing
    - Harvesting of edibles
    - Hunting
- Industrialization of society
  - Agriculture and forests became more a singular in purpose

- Agroforestry
  - A land management approach that deliberately combines the production of trees with other crops and/or livestock. By blending agriculture and forestry with conservation practices.
  - optimizes economic, environmental and social benefits
  - Alley cropping, riparian forest buffers, windbreaks, silvopastures




Silvopastoral systems: The real thing!

- Silvopastoral systems are very intensive systems in which the forage system is an improved pasture of introduced grasses or legumes that are managed under normal agronomic principles;

- This differs from forest grazing as it is a more extensive approach to resource use

- Silvopasture is by far the most common AF practice in developing countries and is also quite common in temperate coniferous forest regions (Pacific Northwest, Southeastern U.S., Southwestern Australia and New Zealand)

One of the many pine silvopasture systems in the southern U.S.

source: www.al.nrcs.usda.gov/technical/photo/pas_hay.html

Effects on microclimate

- Compared to an open pasture, the microclimate among trees has:
  - Reduced wind speed
  - Reduced solar radiation
  - More moderate temperature regime
  - Higher humidity
  - Lower rates of evapotranspiration
  - Reduced soil temperatures
  - Higher soil moisture levels

(Lin et al. 1999; Lehmkuhler et al. 2003; Sharrow and Ismail 2004, Thevathasan and Gordon 2004)

Forage quality and quantity

- Increased nutritive values of warm- and cool-season grasses has been documented

  (Krueger 1981; Eriksen and Whitney 1981)

- Buergler et al. (2006) determined that as tree density increased
  - Reduced NDF
  - Reduced TNC
  - No effect on CP

Forage quality and quantity

	Full sun	50% shade	80% shade
ADF			
Orchardgrass	35	35	33
Ryegrass	32	33	32
Smooth bromegrass	33	34	34
Tall fescue	33	34	35
NDF			
Orchardgrass	65	64	61
Ryegrass	60	59	56
Smooth bromegrass	55	58	55
Tall fescue	58	61	60
CP			
Orchardgrass	15	17	18
Ryegrass	15[a]	16[a]	18[b]
Smooth bromegrass	17[a]	18[a]	20[b]
Tall fescue	14[a]	15[a]	18[b]

Adapted from Lin et al. 2001

Forage quality and quantity

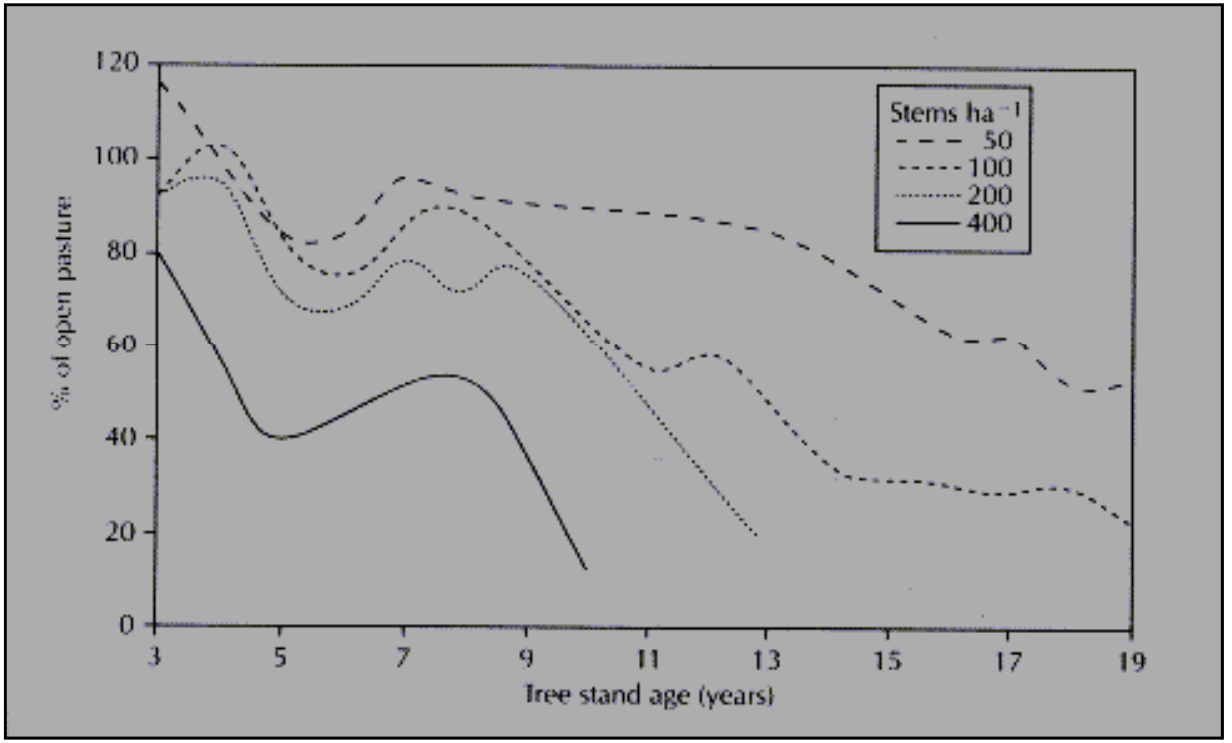
	Full sun	50% shade	80% shade
Total Above Ground Dry Wt. (g)			
Orchardgrass	13^{a}	12^{a}	8^{b}
Ryegrass	13^{a}	11^{ab}	9^{b}
Smooth bromegrass	10^{a}	12^{b}	10^{a}
Tall fescue	13^{a}	12^{a}	7^{b}
Average Leaf Area (cm^2)			
Orchardgrass	16^{a}	23^{b}	21^{b}
Ryegrass	2^{a}	5^{b}	8^{c}
Smooth bromegrass	14^{a}	28^{b}	32^{b}
Tall fescue	14^{a}	30^{b}	30^{b}
Specific Dry Leaf Wt (mg/cm^2)			
Orchardgrass	4^{a}	3^{b}	3^{b}
Ryegrass	6^{a}	4^{b}	3^{b}
Smooth bromegrass	4^{a}	3^{b}	3^{b}
Tall fescue	7^{a}	5^{b}	5^{b}

Adapted from Lin et al. 2001

Effects of trees on pasture production

- In this example, stands were planted at 250, 500, 1000 and 2000 trees per ha and thinned to figure values within 8 years (i.e. 50, 100, 200 and 400 trees per ha) and pruned in four lifts to 5.8 m;
- Pasture production was assessed on area free of pruning;
- Clearly, pasture production decreases with increased density and age
- At higher densities, pasture yields declined rapidly because of canopy closure and lower light penetration;

Understorey dry matter production as a percentage of that found in open pasture



Source: Hawke and Knowles. 1997. Temperate Agroforestry in New Zealand.

Animal Performance

- Shade can reduce of radiant heat by 30% or more
  (Blackshaw and Blackshaw 1994)
- Shade can improve animal performance
  - Grazing
    - Mediterranean climate - Summer temperature 28-38 ^{o}C
      - Cows with shade gained 45 kg more weight

      (Silanikove and Gutman 1992)

    - Louisiana – compared abundant natural shade, scanty natural shade, artificial shade, and no shade
      - Average treatment temperatures 32, 34, 34, 36 ^{o}C, respectively
      - Cow wt gains were greatest with natural shade 1.0-1.29 lbs/d
      - Calves ADG was greatest with shade 1.64-1.85 lbs/d
      - Time spent grazing was greatest with abundant shade

      (McDaniel and Roark 1956)

Animal Performance

Cattle responses following grazing of pastures with or without young trees in Missouri.			
	Without trees	With trees	SEM
Final Cow wt, kg	684	682	18.4
Final Calf wt, kg	158	159	9.2
Cow ADG, kg/d	0.92	0.87	0.15
Calf ADG, kg/d	1.43	1.47	0.02

(Lehmkuhler et al. 2003)

Animal Performance

- Grazing
  - Oklahoma – compared shade from sheds to no shade
    - ADG of steers was 4-30 lbs/steer greater with shade
      - Advantage increased with increased # of hot days
    - Cattle were strongly attracted to areas with shade
    - No shade cattle spent mid-day at water

    (McIlvain and Shoop 1971)

- Feedlot
  - Texas – shade 2.12m^2 and no shade
    - Ambient max. temperature 28-34 ^oC
    - Shade increased final weights by 11 kg
    - DMI was greater for shaded treatment

    (Mitlöhner et al. 2002)

Effects of trees on sheep growth rates

- Livestock growth capacity is reduced with increasing tree age, stocking, and thinning and pruning debris (decline in pasture production);

	Tree age (years)	Final tree stocking (stems ha^{-1})				
		Nil	50	100	200	s.e.d.*
Liveweight changes (g per ewe day^{-1})†	5	38	26	25	17	4‡
	6	63	56	47	40	4‡
	7	27	29	26	15	3‡
	8	18	11	11	−7	4§
	9	24	4	12	19	2§
	10	15	13	−5	−16	2§
Lamb growth rates (g per lamb day^{-1})	7	219	217	220	237	5‡
	8	189	189	189	160	5§
	9	182	175	170	167	8§
	10	185	164	151	157	6§

* Standard error of deviation.
† Over 12 months from a common starting weight.
‡ Analysis based on plot to plot variation.
§ Analysis based on animal to animal variation.

- 200 stems ha^{-1} appears to be the threshold for ewe production, but not so clear for lamb.

Source: Hawke and Percival (1992). Sheep growth rates under pinus radiata agroforestry regimes in New Zealand. Proc. New Zealand Soc. Anim. Product. 52:229-231.

Trees vs. sheds

- Planted or natural trees have a lower radiative heat transfer than sheds
  - a larger low temperature ground area

(Kelly et al. 1950)

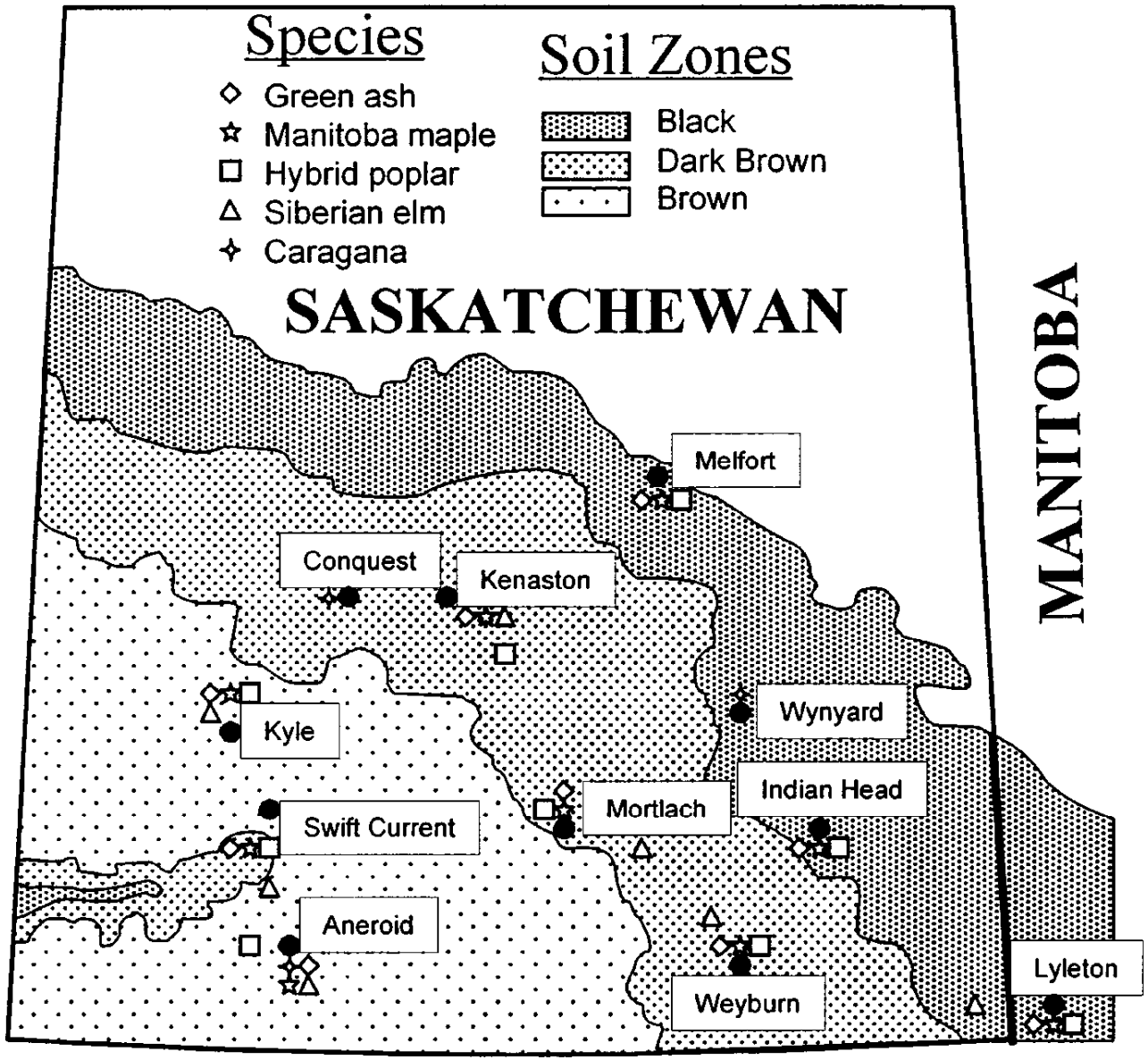
Effects of afforestation on ecosystem C

- Site east of PA
- Siberian larch and white spruce planted on pasture
- Calculated above- and belowground C

Total C pools (Mg/ha) for three vegetation covers			
	Larch	Spruce	Pasture
Vegetation	131	68	1
Soil	150	185	146
Total ecosystem	281	253	147

(Belanger, Unpublished data)

Effects of shelterbelts on carbon storage



(Kort and Turnock 1999)

Table 1. Shelterbelt parameters and biomass contents of shelterbelts in Saskatchewan, Canada.

Species	Mean shelterbelt age (yrs)	Mean shelterbelt height (m)	Mean shelterbelt width (m)	Diameter at breast height (cm)	Mean aboveground biomass (kg/tree)
Green ash	53	8.0	3.8	23.1	161.8
Manitoba maple	52	7.3	4.5	39.6	178.6
Hybrid poplar	33	13.8	5.2	44.2	544.3
Siberian elm	37	7.0	4.9	28.6	201.9
White spruce	54	14.1	8.0	24.4	286.9
Scots pine	66	12.1	5.1	23.8	164.1
Colorado spruce	43	11.5	5.6	23.0	202.2
Choke cherry	33	5.3	3.9	N/A	402.6[a]
Villosa lilac	23	3.6	3.1	N/A	334.6[a]
Buffaloberry	20	4.3	4.3	N/A	312.0[a]
Caragana	49	4.2	5.1	N/A	516.0[a]
Sea buckthorn	25	3.4	2.7	N/A	213.0[a]

[a] Aboveground biomass values expressed in terms of kg/10 metres of shelterbelt.

(Kort and Turnock 1999)

Table 3. Aboveground carbon contents[a] of shelterbelts in Saskatchewan, Canada.

Species	Tree spacing (m)	Carbon content (%)	Brown soil		Dark brown soil		Black soil		Mean	
			kg/tree	t/km	kg/tree	t/km	kg/tree	t/km	kg/tree	t/km
Deciduous trees										
Green ash	2.5	48.6	46	18	61	24	130	52	79	31
Manitoba maple	2.5	48.0	58	23	77	31	123	49	86	34
Hybrid poplar	2.5	48.2	269	108	207	83	304	122	260	104
Siberian elm	2.5	49.4	63	25	106	42	130	52	100	40
Coniferous trees										
Colorado spruce	3.5	50[b]	–	–	–	–	101	29	101	29
White spruce	3.5	50[b]	–	–	–	–	144	41	144	41
Scots pine	3.5	50[b]	–	–	–	–	82	24	82	24
Shrubs										
Caragana	0.3	50.1	–	21	–	30	–	27	–	26
Choke cherry	1.0	50[b]	–	–	–	–	–	20	–	20
Villosa lilac	1.0	50[b]	–	–	–	–	–	17	–	17
Buffaloberry	1.0	50[b]	–	–	–	–	–	15	–	15
Sea buckthorn	1.0	50[b]	–	–	–	–	–	11	–	11

[a] Belowground carbon is not included but can be calculated assuming it to be, for deciduous, coniferous and shrub shelterbelts to be 40%, 30% and 50% of the aboveground carbon content, respectively.

[b] Carbon percentages were not measured but were estimated at 50%.

(Kort and Turnock 1999)

Silvopasture carbon and nitrogen storage

- Western Oregon – Douglas-fir
- 3 treatments
  - 11 year-old Douglas-fir/perennial ryegrass/subclover
  - Ryegrass/subclover pasture
  - 11 year-old Douglas-fir plantation
- Measured carbon and nitrogen storage (Sharrow and Ismail, 2004)

Silvopasture carbon and nitrogen storage

	Pasture	Agroforest	Plantation	SE
Carbon (kg/ha)				
Tree	0	12,239[a]	6,949[b]	1,388
Understorey	1,003[a]	1,168[a]	2,231[b]	183
Soil	102,520[a]	95,886[ab]	91,939[b]	3,044
Total	103,523[a]	109,293[b]	101,119[a]	
Nitrogen (kg/ha)				
Tree	0	165[a]	99[b]	20
Understorey	54	62	59	8
Litter	0	3[a]	16[b]	1.4
Manure	19	22	1	4.2
Soil	8,879	8,097	7,600	635
Total	8,915[a]	8,223[ab]	7,688[b]	442

(Adapted from Sharrow and Ismail 2004)

Existing woodlots

- Since settlement in the early 20th Century
  - Substantial increase in brush cover
  - Aspen parkland from central Alberta through Saskatchewan into southern Manitoba and within the various hill formations throughout the Great Plains
  - trembling aspen (*Populus tremuloides*), and balsam poplar (*Populus balsamifera*)
  - Control of fire
- PFRA study (Luciuk et al. 2006)
  - 87 pastures, concerns of aspen encroachment on 32
  - Encroachment is occurring at a rate of 2.2 %/year
  - 70-85% Reduction in carrying capacity between grassland and enclosed forest

Existing woodlots

- Pastures are mainly native grasses or tame forages
- Forage and livestock are managed

But !!!!

  - Trees have been left to go
  - Aspen – deer + cattle do not prefer to graze it
    - Regenerates from root suckers
- Tremendous opportunity to create silvopastures
- Will involve changes to livestock and forage management
  - Rotational grazing
- Thin the canopy
  - Allow trees to grow at optimum
  - Thin to about 35% canopy cover
    - Optimize forage growth

Economical benefits of silvopasture

- Economics is the main driver of silvopasture (not soil improvement as with silvoarable);
- A properly designed combination of trees and livestock can be more profitable than agriculture or forestry alone;
- Douglas fir forest in western Oregon, agroforests produced considerably more aboveground phytomass than either pastures or forest monocultures
  - 1.6 ha (0.96 ha forest + 0.64 ha pasture) of monocultures would be needed to equal the productivity of 1 ha of agroforest

(Sharrow et al. 1996)

Economical benefits of silvopasture

- Silvopasture is a multi-product system and thus, reduces the risk of monetary loss due to unfavourable markets or politics;

- Long-term income of timber coupled with yearly income of livestock or hay offers more continuity over a full rotation than would classical plantation forestry.

- Ponderosa pine forest in Arizona, the optimum profit came by combining timber harvest and grazing
  (Clary et al. 1975)

Other environmental and social benefits

- Wildlife habitat
  - Cover for deer
  - Foraging opportunities for local and migrating birds
    - Greater diversity of bird species
- Increased biodiversity
  - Soil fauna, insects, plant species, mammals
- Water and air quality
  - Reduced soil erosion, surface runoff, subsurface flow of nutrients
- Intangible social benefits
  - Aesthetics
  - intergenerational turnover of farm (more important than erosion control and wind protection (Raedeke et al. 2003)

The New Zealand experience

- Started in the 60s as a result of plantation forestry (Monterey and radiata pine)
- Under typical management, stands are kept open by thinning (200-350 stems per hectares);
- Grazing with sheep and cattle is a way to use undergrowth and obtain early returns (especially where trees were planted on pasture)
- Plantation estate is 1.6 million ha (7% of the land) with 90% being radiata pine; 9.3 million ha of pasture and crop land. In 1996, about 80,000 ha were planted on farmland and this is augmenting fast.

source: **www.ag-network-chile.net/Radiata%20Pine.htm**

Silvopasture in New Zealand (cont.)

- New species such as poplars are attracting producers
- 3 AF systems in New Zealand:
  (1) tree farming (mostly on pasture) under a direct sawlog regime,
  (2) grazing in plantation forests and
  (3) shelterbelts
- Probably what Saskatchewan could achieve within the next 20 years with pines (red) and larches as an alternative for radiata pine.

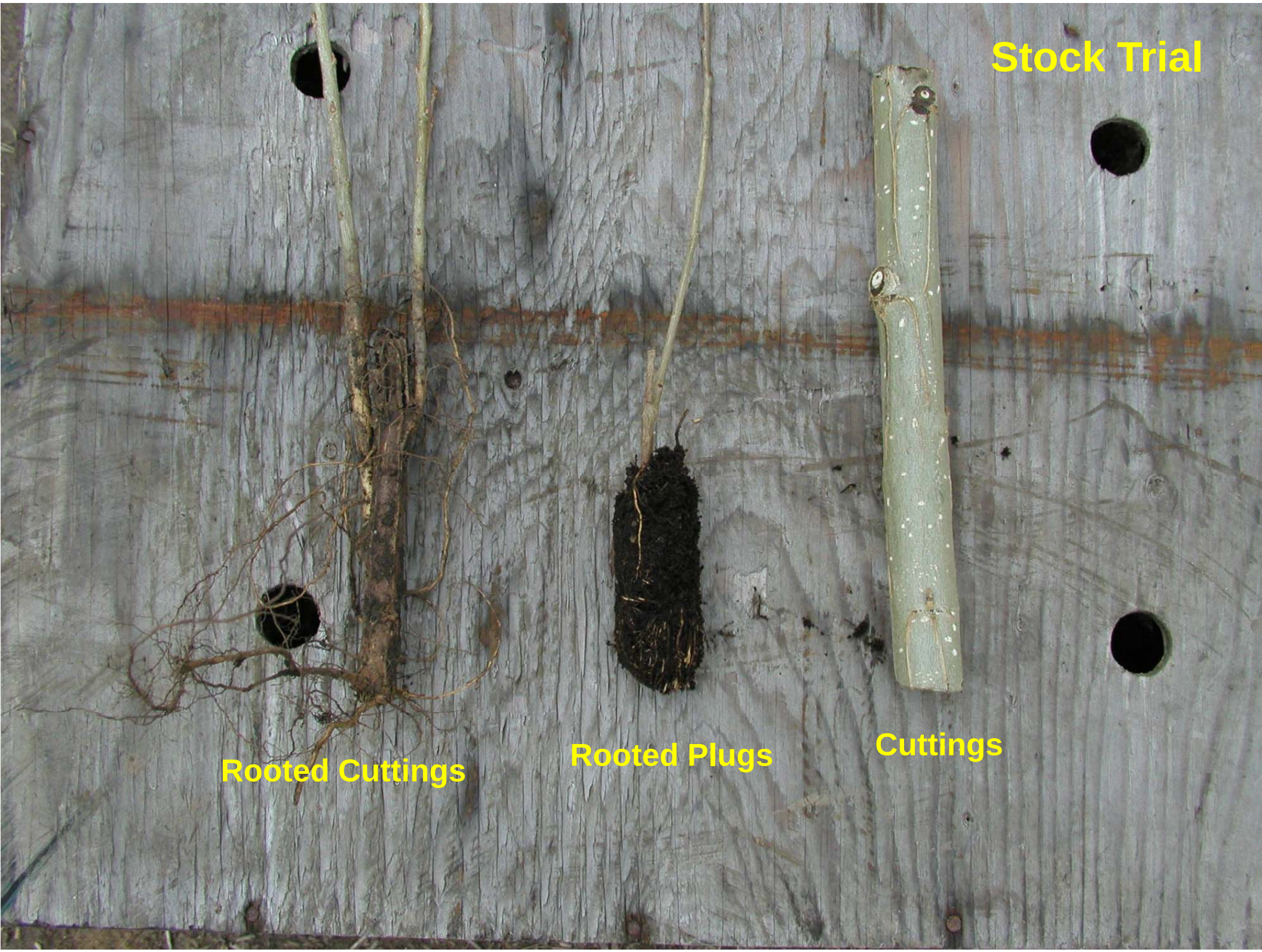
Radiata pine plantation on sandy site

source: **www.ffp.csiro.au/alrtig/radiatapine.htm**

Hybrid Poplar Growth Trials in Saskatchewan

Hybrid Poplar Stock Trial

Objective: To determine the effect of different stock types on plantation establishment and growth
Location and Establishment Date: Two sites near Meadow Lake in 2002
Clones: Walker poplar
Treatments: Three stock types: cuttings, rooted cuttings and rooted plugs
Management: Previous land use was alfalfa and pasture for the two sites; Treflan/Sencor mix was used at each site and then a combination of glyphosate and mowing in first four years
Funded by: NSERC in collaboration with Mistik Management Ltd., PRT Nurseries, AAFC-PFRA Shelterbelt Centre and farm cooperators D. Cubbons and W. Culbert


Stock Trial
Rooted Cuttings
Rooted Plugs
Cuttings

Year 5 Tree Measurements

	Alfalfa			Pasture		
	Cutting	Rooted Cutting	Rooted Plug	Cutting	Rooted Cutting	Rooted Plug
Mean Ht (cm)	89	389	409	93	380	347
Mean DBH (cm)	2.1	4.1	4.2	0.9	3.9	3.5
Max Ht (cm)	440	660	610	350	690	560

Hybrid Poplar Spacing Trial

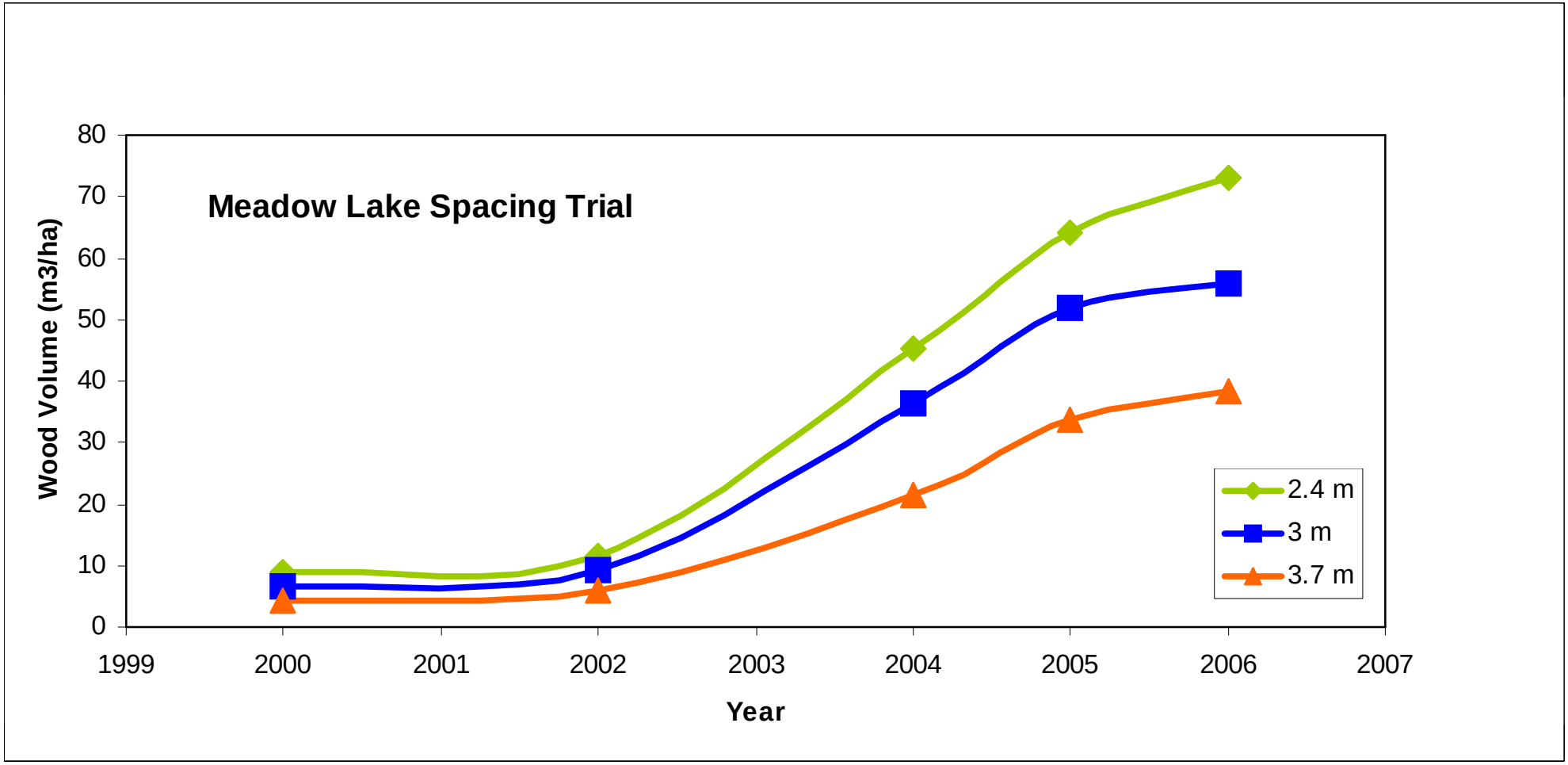
Objective: To determine the effect of different tree spacings on tree growth characteristics
Location and Establishment Date: Meadow Lake in 1997
Clones: Walker poplar, rooted cuttings
Treatments: Spacings of 2.4 X 2.4, 3.0 X 3.0 and 3.7 X 3.7 m and each plot was 0.3 ha and replicated three times
Management: Previous land use was alfalfa; Treflan/Sencor mix used for weed control only in year 1; trees pruned to 2 m height at age 4 for half of each plot
Funded by: AAFC-PFRA Shelterbelt Centre and Mistik Management Ltd and farm cooperator D. Cubbons

Two other spacing trials, with Walker poplar have been established by the Shelterbelt Centre, one at Henribourg in 1997 with Weyerhaeuser (replicated 5 times) and one at Birch Hills in 1999 with a farmer cooperator (replicated 4 times). The Henribourg trial was undersown with grass and mowed while the Birch Hill trial was treated with Treflan/Sencor in the initial year and glyphosate in later years.

Density Spacing Studies

Tree growth parameters for the three spacing trials in Saskatchewan. Meadow Lake and Henribourg are 10 yrs old and Birch Hill is 8 yrs old.

Parameter	Site	Spacing (ft)		
		8 X 8	10 X 10	12 X 12
Height (m)	Meadow Lake	10.9	10.8	10.8
	Henribourg	9.3	9.4	8.9
	Birch Hills	7.0	6.6	7.8
DBH (cm)	Meadow Lake	10.5	11.8	12.1
	Henribourg	8.4	9.2	9.2
	Birch Hills	7.1	7.6	9.1
Volume (m^3/ha)	Meadow Lake	70.9	54.2	39.1
	Henribourg	46.2	34.0	23.1
	Birch Hills	27.1	18.2	19.2


Meadow Lake Spacing Trial
Wood Volume (m3/ha)
80
70
60
50
40
30
20
10
0
1999
2000
2001
2002
2003
2004
2005
2006
2007
Year
2.4 m
3 m
3.7 m

Conclusion

- Silvopasture is a system that can work in Saskatchewan

- Should be considered for 2 reasons

  1) potential for increased livestock/forage production

  2) generate additional value in timber or other forest products

  However, the principles of silvopastures (although well known) have not been tested here in Saskatchewan

- Potential profitability, social acceptability and environmental benefits of silvopastures in an era of environmental farm planning make them a viable option for the future

Conclusion

- High level of management is needed
  - Forage, trees and livestock
    - Mixture of tame forages with legumes
    - Rotational grazing
    - Pruning of trees
    - Leave appropriate levels of residual leaf area – 8 to 10 cm
    - Cannot graze the areas when wet

- Additional research is needed to fully develop a silvopasture system in Saskatchewan
  - “Ecological heterosis” – forage, trees and livestock
  - Tree species and spacing
  - Levels of grazing and timing


Questions