AFIF CHAIR IN AGROFORESTRY AND AFFORESTATION
FINAL REPORT
2003-2013

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Overview Summary

This report summarizes the activities of the AFIF Chair position in Agroforestry and Afforestation during the past 10 years. The AFIF Chair was created in July 2003, and this July 2013 represents the end of the 10 year commitment to the development of the AFIF Chair position. My goal is to continue on as Director of the Centre for Northern Agroforestry and Afforestation once the AFIF Chair has ended.

Vision Statement

*To advance the capabilities of farmers for competing in a global economy by diversifying farm income through the incorporation of innovative agroforestry and afforestation practices into farming systems.*

Mission Statement

- To facilitate the coordination and collaboration of scientific research activities, both biological and socio-economic, among the stakeholders in Saskatchewan for using woody plants in agroforestry/afforestation systems on agricultural land for farm diversification, fibre production and other environmental purposes.

- To facilitate the incorporation of the biological and socio-economic knowledge related to agroforestry/afforestation systems into the College of Agriculture and Bioresources curriculum and into extension programs for stakeholders on the land base.

- To network with various agencies to develop Saskatchewan as a knowledge centre in Agroforestry/Afforestation.

Highlights and Accomplishments

Research

1. Obtained over $3.5 million in research funding for various agroforestry and afforestation projects.
2. Trained 8 M.Sc. and 3 Ph.D students and served on 4 M.Sc. and 5 Ph.D. committees related to agroforestry.
3. Published 2 book chapters, 21 journal articles, 10 technical reports and 92 presentations related to AFIF Chair position.
4. Developed a network of hybrid poplar, willow and conifer plantations across the province that continue to be used for demonstration purposes for growers, the general public and for researchers.
5. Have achieved a better understanding of the agronomy of growing trees on agricultural land with respect to herbicides, management practices, pest and diseases and yields.
6. Have developed tree growth models to predict biomass yields for various tree species in Saskatchewan.
7. Have produced maps of carbon sequestration estimates for long term growth of hybrid poplar and willow biomass energy plantations.
8. Hosted numerous field days at the University of Saskatchewan Campus and worked with ForestFirst to hold a Willow Biomass Energy Conference in Saskatoon.

Social

1. Raised awareness of the potential use of trees on agricultural landscapes and benefits to the producer
2. Worked closely with the Agroforestry Unit from ForestFirst (formerly known as the Saskatchewan Forest Centre) to transfer research findings to the grower. Unfortunately, ForestFirst was closed in July 2009 which has reduced our impact on promoting agroforestry in the province.
3. Developed a web page to disseminate agroforestry information

Economic

1. Determined the costs of establishment for hybrid poplar and willow plantations but further research is needed on delivered costs and value of fibre.

Academic

1. Two faculty were hired in the area of agroforestry – Nicolas Belanger (2004-2009) and Anthony Kimaro (2009-2012). These faculty developed an agroforestry course which was highly subscribed by the students in the College of Agriculture and Bioresources.
2. New initiatives are being developed with Anthony Kimaro (who is now with the World Agroforestry Centre (ICRAF) in Tanzania) on an international collaboration to look at enhancing the resilience of agro-ecosystems and livelihood strategies of smallholder farmers in adapting to climate change through Agroforestry in the drylands of Eastern Africa.
Synopsis of the development of Agroforestry in Saskatchewan for 2012

INDUSTRY ACTIVITY

PRT Growing Services (John Kitchen)

Short rotation woody crop activities at PRT Growing Services Ltd. include a variety of technical and business development projects, aimed at increasing the company’s competence in this area. Since 1999, we have implemented small scale demonstration projects, and more recently completed a 75 acre project near Prince George, BC which includes biosolids disposal, short rotation willow and poplar for biomass feedstock, and a biomass boiler for greenhouse heating. We have now harvested small test areas of three-year old willow and poplar with the Ny Vraa JF woody biomass harvester and utilized the fuel in our boiler. We have also added demonstration plots at our locations in Prince Albert, Saskatchewan, Dryden, Ontario and Campbell River, BC. As part of these projects, we have improved planting productivity to commercially viable levels with both six-row and two-row equipment. Winter dieback and weed control remain as issues, however for certain applications we are comfortable with several varieties of willow and poplar and can recommend an integrated weed management plan for growers. Future plans include participation in projects aimed at testing more varieties for performance in cold climates.

Conservation Learning Centre (CLC) (Larry White)

The poplar clonal trials (Hybrid and Balsam) are on-going, as are the alley cropping, riparian planting and the biomass plantings. Scientists from AESB at Indian Head collected some of the Balsam clones for analysis of wood quality this year. The CLC did take out about a 10 acre field of hybrid poplar due to weed issues as it had not been properly tended for the past three years which was due to timing issues and some of it caused by the very wet conditions experienced in the past three years. It is uncertain whether this field will be re-planted. We did another successful Sinbar 80 trial in 2012 to gather more data to support a minor use registration for willow crops. The raspberry and Haskap plantings continue as well.

GOVERNMENT AGENCIES

Ministry of Economy (Larry Stanley)

The bioenergy industry seems to have been put on hold at the moment while companies concentrate on the re-start of the lumber, OSB and pulp industry. Prince Albert Pulp Mill is operating their biomass boiler using hog from the Meadow Lake Pulp Mill and the heritage pile at PA. Meadow Lake Tribal Council has prepared a feedstock availability report for their proposed biomass boiler project. The report made note of all available material within defined distances from the proposed generation site, including scrub brush on agriculture lands, agriculture crop residual and purpose grown plantations (hardwood and softwood).
Agroforestry Development Centre (Bill Schroeder)

Woody crop research at the AAFC Agroforestry Development Centre has continued along three streams, breeding and development of new poplar and willow clones, designing agroforestry systems for biomass production and end use applications for woody biomass. Significant progress has been made in breeding new willow and poplar genotypes. In 2012 12 new willow clones were selected and three new polar clones released. Controlled crossing of both poplar and willow continues. Development of willow biomass systems progressed significantly in the past year mainly quantifying biomass yield from naturally growing willows on the periphery of wetlands and use of domesticated willows for nutrient interception and biomass production in riparian buffers. A post-doctoral fellow, Dr. Jaconette Mirck has collected considerable data to support the concept of willow ring harvest. Also a University of Regina M.Sc. candidate is studying the impact of biomass harvest around wetlands on avian populations and diversity. Finally, beginning in March 2012 the ADC Laboratory/Greenhouse complex is being heated by a 300kw biomass burner. With this system we have offset 90 percent of the natural gas used in the previous heating system. The feedstock for the burner is willow harvested from willow rings using a Bio-Baler. We are collecting data on heating efficiency of feedstock as well as harvest, handling and processing costs.

Saskatchewan Research Council (Mark Johnston)

The Saskatchewan Research Council (SRC) continues to manage a number of agroforestry research and demonstration projects at the Conservation Learning Centre, located south of Prince Albert. Many of these projects are in partnership with the Agroforestry Development Centre in Indian Head. They include an ecobuffer, alley cropping demo, hybrid poplar clonal trial, balsam poplar common garden and willow biomass demos.

The SRC is collaborating with the U of S on the field work for the Agriculture Greenhouse Gas Program project; “Shelterbelts as an Agroforestry Management Practice for the Mitigation of Greenhouse Gases”. As well, SRC is providing monetary contributions to the Poplar Council of Canada (PCC) Environmental Services Working Group for a white paper on the environmental services of poplar and willow. SRC is also involved in the PCC “Pesticide Working Group”.

University of Saskatchewan

Chemical Engineering

Kurt Woytiuk and Bill Campbell (M.Sc.)

In 2012, the fluidization group made further progress on the torrefaction and gasification of willow and wheat straw. Preliminary work was presented at the 2012 Symposium on Energy from Biomass and Waste in Venice, Italy. Mr. Campbell is currently in the detailed design phase of a continuous torrefaction system that will be used in the
thermal treatment of agroforestry products and agricultural residues for energy production. The continuous device is scheduled to be completed in 2013. Mr. Woytiuk is currently refining a system for contaminant measurement from the gasification of biomass. The system will be used to evaluate means of contaminant reduction in syngas. Finally, Mr. Campbell has begun investigation into a new non-invasive, online analyser for biomass using spectral methods.

Other Noteworthy News Developments

“The USDA Farm Service Agency (FSA) has announced the tenth new Biomass Crop Assistance Program (BCAP) project area in Clinton, Essex, Franklin, Herkimer, Jefferson, Lewis, Oswego, Oneida and St. Lawrence counties in northern New York State for the production of shrub willow. Up to 3,500 total acres are approved for the shrub willow plantings in central and northern New York State. These producers are eligible to receive establishment and annual payments to grow shrub willow for biomass conversion to bioenergy. FSA has reserved up to $4.28 million for enrollments in this Project Area. Shrub willow is a short rotation woody crop and can produce large amounts of woody biomass through coppicing harvests that allow for repeated cuttings of wood from each shrub. The technology that will be employed reflects 25 years of research and development spearheaded by the State University of New York College of Environmental Science and Forestry’s willow biomass program. The 3,500 acres will be planted in 2013 and 2014 to provide a steady supply of this biomass material to the biomass conversion facilities. Land preparation for the contracted acreage will take place in 2012 and 2013. To support shrub willow producers in the project area, FSA will enter into 11-year contracts with the eligible producers to grow the willow biomass crops on cropland enrolled in BCAP contracts. These participants will be required to maintain the willow during the 11-year contracts at their own expense, but will receive an annual rental payment. Producers must have a production agreement with a qualified biomass conversion facility, such as the project sponsor, ReEnergy Holdings LLC, which has three bioenergy generating facilities in the region committed to the project area - ReEnergy Lyonsdale (20 MW), ReEnergy Chateaugay (22 MW) and ReEnergy Black River (60 MW). The signup periods for producers in project area counties are scheduled to run from June 18 through Sept. 14, 2012.”
(source: http://www.esf.edu/willow/bcap.htm)
RESEARCH PROGRAM

Details outlining the establishment and location of these studies can be found at www.saskagroforestry.ca under research and trials.

CONIFER TRIALS

The four conifer trials will be remeasured in 2014 for their 10 year measurements.

HYBRID POPLAR

Stock Trial (established 2002)

The hybrid poplar stock study at Meadow Lake as part of the NSERC Strategic Grant program has finished its 9th growing season. The trees were all measured again this past fall (2012) for height and diameter. Data from 2012 are presented for height (Fig. 1) and tree volume (Fig. 2) for the two sites.

![Graph showing Walker poplar heights for rooted cuttings (RC) and rooted plugs (RP) at the Alfalfa and Pasture sites near Meadow Lake.](https://example.com/graph.png)

Figure 1. Walker poplar heights for rooted cuttings (RC) and rooted plugs (RP) at the Alfalfa and Pasture sites near Meadow Lake.
Figure 2. Walker poplar volumes for rooted cuttings (RC) and rooted plugs (RP) at the Alfalfa and Pasture sites near Meadow Lake.

**Clone X Fertilizer Trial (established 2003)**

No fertilizer was applied to this clone trial again this year as three years (2003-2005) of repeated fertilization did not yield any growth increases for this study. The site was not managed for weeds this year and 10th year tree measurements were collected in the fall 2012.

Figure 3. Mean poplar clone heights at the Alfalfa site near Meadow Lake averaged across fertilizer treatments.
Figure 4. Mean poplar clone heights at the Pasture site near Meadow Lake averaged across fertilizer treatments.

Figure 5. Average tree volume at age 10 by clone and site.
**Spacing Trial (established 1997)**

The three spacing trials at Meadow Lake, Henribourg and Birch Hills were remeasured the fall of 2012. Tree volumes range from 175 m³/ha at Meadow Lake, 110 m³/ha at Henribourg to 76 m³/ha at Birch Hills for the 8X8' spacing (Figures 6-10). The tree heights (Fig. 6) and DBH (Fig. 7) for Meadow Lake and volumes (Figs. 8-10) for each spacing and location are presented below:

![Figure 6](image6.png)

Figure 6. Mean Walker poplar tree height for the three tree spacings (8X8′, 10X10′ and 12X12′) at the Alfalfa site near Meadow Lake.

![Figure 7](image7.png)

Figure 7. Mean Walker poplar tree DBH for the three tree spacings (8X8′, 10X10′ and 12X12′) at the Alfalfa site near Meadow Lake.
Figure 8. Mean Walker poplar tree volume for the three tree spacings (8X8’, 10X10’ and 12X12’) at the Alfalfa site near Meadow Lake.

Figure 9. Mean Walker poplar tree volumes for the three tree spacings (8X8’, 10X10’ and 12X12’) at Henribourg.
WILLOW

**Willow and Hybrid Poplar Short Rotation Species (established 2006)**

The short rotation woody crop study with the Canadian Forest Service and Forest First has finished its fifth growing season. This study is investigating different willow clones to evaluate their performance for biomass energy. Students from the Chemical Engineering Department have been using biomass material from this plantation for their research in gasification and torrefaction.

**Willow Clonal Trial (established 2007)**

As part of the willow NSERC Strategic project and ADF grants, a 30 clone trial was planted in 2007 at the University plot of land at Circle and 14th Street. The clones were obtained from our collaborating partners at SUNY in New York. Six of the best clones from this list of 30 clones were also planted at PRT Nurseries in Prince Albert, a farm in Birch Hills and at the SaskPower Shand greenhouse in Estevan. All four sites were instrumented with weather stations and soil temperature and moisture probes. The measurement plots were harvested in the spring of 2011 except for the Estevan site which was under water for several months due to flooding. After the measurement plots were harvested, the remaining willow was cut down so that the next rotation could start growing. 2013 represents the 3rd growing season and it is our goal if we can find funding to harvest the measurement plots in the spring of 2014 to obtain second rotation.

Figure 10. Mean Walker poplar tree volumes for the three tree spacings (8X8’, 10X10’ and 12X12’) at Birch Hills.
biomass yields to validate our modelling work. The data from these plots is being used in a North America wide analysis of willow yields by the research group at SUNY.

Ryan Hangs is finishing his Ph.D thesis this year which will contain the most comprehensive research on willow in western Canada. Preliminary research from Ryan shows that a 4 year rotation of willow will result in small deficits of P, K and Mg and larger losses of Ca; however, the losses represent a small fraction of the extractable soil pools (Table 1).

Table 1. Preliminary nutrient budget (kg ha\(^{-1}\)) for willow in Saskatchewan for one 4-year rotation (Source: Hangs, 2013).

<table>
<thead>
<tr>
<th>Budget Variable</th>
<th>N</th>
<th>P</th>
<th>K</th>
<th>S</th>
<th>Ca</th>
<th>Mg</th>
</tr>
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<tbody>
<tr>
<td>Extractable Soil Nutrients</td>
<td>79.6</td>
<td>66.1</td>
<td>1332</td>
<td>579</td>
<td>18524</td>
<td>4574</td>
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<tr>
<td>INPUTS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mineral weathering</td>
<td>0</td>
<td>0.2</td>
<td>14.4</td>
<td>0</td>
<td>39.4</td>
<td>12.4</td>
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<tr>
<td>Soil Mineralization</td>
<td>181.2</td>
<td>0</td>
<td>0</td>
<td>110.6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Atmospheric Deposition</td>
<td>22.6</td>
<td>6.5</td>
<td>25.8</td>
<td>31.4</td>
<td>47.6</td>
<td>17.4</td>
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<tr>
<td>TOTAL</td>
<td>203.8</td>
<td>6.7</td>
<td>40.2</td>
<td>142.0</td>
<td>87.0</td>
<td>29.8</td>
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<td>OUTPUTS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coppiced stems</td>
<td>5.4</td>
<td>0.8</td>
<td>3.0</td>
<td>0.6</td>
<td>10.9</td>
<td>1.7</td>
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<tr>
<td>Harvested Stems</td>
<td>60.2</td>
<td>8.9</td>
<td>44.7</td>
<td>10.1</td>
<td>125.4</td>
<td>16.4</td>
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<tr>
<td>Leaching</td>
<td>6.6</td>
<td>0.4</td>
<td>1.1</td>
<td>20.2</td>
<td>44.7</td>
<td>32.2</td>
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<tr>
<td>TOTAL</td>
<td>72.2</td>
<td>10.1</td>
<td>48.8</td>
<td>30.9</td>
<td>181</td>
<td>50.3</td>
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<tr>
<td>Input-Output</td>
<td>131.6</td>
<td>(3.4)†</td>
<td>(8.6)</td>
<td>111.1</td>
<td>(94)</td>
<td>(20.5)</td>
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<tr>
<td>TRANSFERS</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Leaf Litter</td>
<td>82.7</td>
<td>15.5</td>
<td>115.5</td>
<td>25.7</td>
<td>264.9</td>
<td>42.6</td>
</tr>
<tr>
<td>Stools and Roots</td>
<td>158.6</td>
<td>41.8</td>
<td>61.2</td>
<td>40.4</td>
<td>53.6</td>
<td>41.1</td>
</tr>
<tr>
<td>Litter Decomp</td>
<td>21.1</td>
<td>47.5</td>
<td>10.5</td>
<td>110.9</td>
<td>18.4</td>
<td></td>
</tr>
<tr>
<td>Fine Root Turnover</td>
<td>50.4</td>
<td>12.3</td>
<td>17.8</td>
<td>11.8</td>
<td>15.5</td>
<td>12.1</td>
</tr>
</tbody>
</table>

† loss of nutrient
Agricultural Greenhouse Gas Program (AGGP) Project

This project will provide science-based knowledge of shelterbelt systems as an agroforestry practice to develop strategies to help farmers decide on what are the best options (including BMPs) for mitigating GHGs when planting shelterbelts. Shelterbelts include farmyard and field shelterbelts, forest belts, eco-buffers and natural shelterbelts. The anticipated knowledge will include: 1) development of technology for identifying species/age in shelterbelts using remote sensing techniques, 2) an inventory of tree/soil C pools and GHG emissions for different species and soil zones across Saskatchewan, 3) development of tree growth models to predict C accumulation over time, 4) predictions of C cycling for shelterbelts with time, 5) understanding how past climate has impacted tree growth and predictions of how growth might be impacted by future climate change scenarios, 6) an assessment of the sustainability of shelterbelts as a C accumulator and an economic analysis at a farm level, and 7) protocol development for measuring, monitoring and verifying C in shelterbelts. Information will be disseminated on shelterbelts and technology transfer to aid farmers with their decisions in adoption of shelterbelts for GHG mitigation using BMPs. Carbon modeling and inventory of shelterbelts will collectively determine the magnitude of shelterbelt impacts on C sequestration in Saskatchewan and the potential impact as a GHG mitigation strategy today and with future climate scenarios. New strategies and designs of shelterbelts for GHG mitigation and environmental purposes will be examined to maximize benefits to farmers and the environment. This project involves researchers from U of Saskatchewan, SRC, U of Regina and Mount Allison University and is funded by AAFC.

Over 40 farmers have been visited to collect information from their shelterbelts for the project and another 80+ farms will be visited this year. Several mapping projects have been done based on the historical record of tree distribution for Saskatchewan (Fig. 12). Maps have been created to determine potential age and location of shelterbelts across the province (Fig. 13) as well as expected distribution of shelterbelts on the landscape since 1925 (Fig. 14).
Figure 12. Historical distribution of trees shipped from the Agroforestry Development Centre in Indian Head.
Figure 14. Potential age and location of hybrid poplar shelterbelts in the province as derived from the PFRA tree orders database (1946-2009).
Figure 15. Maps showing the expected distribution of shelterbelt establishment (1925-2009) in the province.
Committees related to Agroforestry:

Member, Board of Directors for Poplar Council of Canada 2011

Other Activities

Met with Dr. Marian Marinescu of FP Innovations about the development of a technical and economic study of biomass co-firing with coal. I provided them with yield data from our plantations to help with their analysis.

Forestry/Agroforestry Summit

I will be participating in a forestry/agroforestry summit that is being planned for October to discuss the research needs of the forestry/agroforestry community and how they might be addressed by researchers in the province.
Summary of Theses (Supervised)

I have supervised or co-supervised 12 graduate students and participated on eight other student committees related to research in agroforestry the past 10 years.

Completed


S. Konesni. M.Sc. Fertilization of Willow Bioenergy cropping systems in Saskatchewan. 2010


B. Sing., Ph.D. Nutrient Uptake by Hybrid Poplar in Competition with Weed Species Under Growth Chamber and Field Conditions Using the Soil Supply and Nutrient Demand (SSAND) Model. 2008


J.J. Gunderson., M.Sc. The Effect of Hydrocarbon Contamination and Mycorrhizal Inoculation on Poplar Fine Root Dynamics. 2006 (Co-supervised with J.D. Knight)


In Progress
A. Oesi. M.Sc. Carbon cycling in agroforestry systems in Tanzania

C. Amadi. Ph.D. Role of shelterbelts in mitigating greenhouse gases

G. Dhillon. Ph.D. Soil carbon sequestration and dynamics in the shelterbelts of Saskatchewan
Summary of Theses (On Committee)

Completed

J. Ens. Ph.D. The effect of willow (Salix spp.) plantations on nutrient availability and greenhouse gas emissions in the Canadian prairies. 2012


Z. Hosseini-Nasabnia. M.Sc. Characterization of Fungal Communities Associated to Willow SRIC Plantations in the Canadian Prairies Ecozone Using PCR-Based Molecular Methods. 2012. (Food and Bioproducts Science)

A.H. Corredor. M.Sc. Molecular profiling of fungal functional groups associated with rhizosphere of Salix. 2011 (Food and Bioproducts Science)


In Progress

K. Woytiuk. Ph.D. Chemical characteristics of willow for biofuels (Chemical Engineering)

T. Olowokudejo. Ph.D. Remote sensing of shelterbelts in Saskatchewan (University of Regina)

R. Hangs. Ph.D. Environmental Constraints Influencing the Viability of Short-Rotation Willow Plantations in Saskatchewan

J. Rempel. M.Sc. Costs and benefits associated with on-farm shelterbelts in Saskatchewan. (SENS)
### Summary of Research Funding

Funding specifically obtained for research dealing with agroforestry and afforestation where I was the principle investigator totaled $3,527,969 during the 10 years of the AFIF Chair. The breakdown of these research grants are as follow:

<table>
<thead>
<tr>
<th>Source</th>
<th>Amount</th>
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<tbody>
<tr>
<td>NSERC programs</td>
<td>$1,562,391</td>
</tr>
<tr>
<td>AAFC</td>
<td>$1,579,110</td>
</tr>
<tr>
<td>ADF</td>
<td>$195,580</td>
</tr>
<tr>
<td>SK Forest Centre</td>
<td>$190,888</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$3,527,969</strong></td>
</tr>
</tbody>
</table>

Projects where I was a co-investigator totaled $466,784. These amounts do not include any in-kind contributions. Thus approximately $4 million were directed to research in the area of agroforestry and afforestation in the province of Saskatchewan.
Summary of Published Articles Related to AFIF Chair

Book Chapters (2)


Journal Articles (21 published, 2 submitted):


Technical Reports (10)


**Summary of Presentations (92 presentations)**


of Willow Plantations. IEA Task 30 Meeting, August, University of Guelph, Guelph, Ontario.


K.C.J. Van Rees, 2006. Saskatchewan Agroforestry Opportunities, Saskatchewan Institute of Agrologists Workshop, October 26, Saskatoon, Saskatchewan.


I would like to thank the Ministry of Agriculture and the Agri-Food Innovation Fund for providing the funding for this chair position in agroforestry and afforestation the past 10 years. It has been a blessing to be involved with a wonderful group of individuals from across this province who have a special interest in growing trees on the prairie landscape. I may never have ventured south of the boreal forest to get involved in utilizing trees on agricultural landscapes if not for a breakfast meeting at Dennys with Bill Schroeder (AESB) and Mike Martell (Mistik Management Ltd). I would also like to thank the members of my Steering Committee who have provided support and advice during my tenure as AFIF Chair as well as to the College of Agriculture and Bioresources for their support. Lastly, I would like to thank the summer assistants, graduate students, postdocs and especially my technician Doug Jackson who have played a huge role in the research we have undertaken to understand how to successfully grow woody crops on agricultural land in the province of Saskatchewan.