The impact of Short Rotation Willow on soil nutrients in riparian zones of the Prairie Pothole Region

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Background

- Short Rotation Willow (SRW) has great potential for sustainably supplying bioenergy feedstock on marginal lands in the Prairie Pothole Region (PPR), including riparian zones of sloughs.
- Fast growing SRW crops are known to be nutrient-demanding, hence, the capacity to produce high biomass could induce nutrient depletion and some of the nutrients will be lost from the soil for future use.
- While woody biomass i.e. *Salix* spp. are taking up more nutrients, they are also increasing the recycling potential of some of these nutrients through decreased leaching into the groundwater.
- High evapotranspiration and a highly developed root system of SRW could also reduce the amount of nutrient-rich waters percolating and leaving the soil system in the riparian zones of a wetland.
- However, the ability of SRW to retain nutrients, consume water, and produce high biomass could modify the soil nutrient status, biological activity and biogeochemical cycles of small Prairie wetland systems.

Objective

- The study aims to assess the impact of SRW on soil macronutrient status compared to pasture and annual crop in the riparian zones of PPR wetlands.

Materials and Methods

Field Study Site:

- Field study was conducted under three different land use practices (SRW, annual crop and pasture) at two PPR wetland sites close to the Agroforestry Development Centre, Indian Head, SK (Fig. 1).

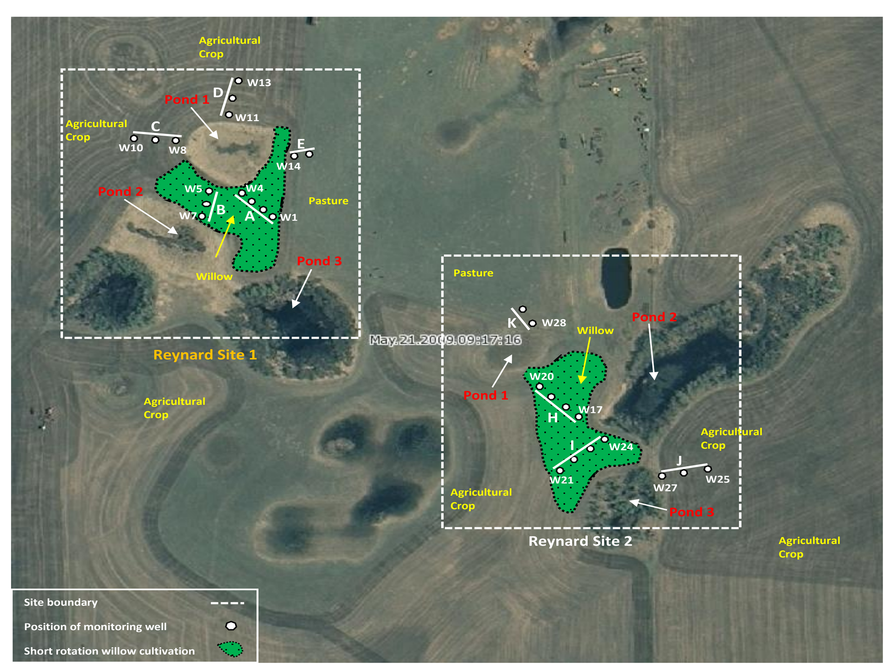

Figure 1. Location map of the study sites in Indian Head, SK

- Willow variety *Salix dasyclados* Wimm. 'India' was planted in June of 2013 without any fertilizers.
- Willow was cultivated side by side with annual oats (seeded May 7–15 and harvested September 5-20 of 2014) and perennial pasture (alfalfa and brome grass mixture, unmanaged for 10-12 years except some small grazing) in the riparian zones.
- Groundwater (monthly) and soil samples (Spring and Fall) were collected along transects during the growing season of 2014 and 2015 (Fig. 1).

Nutrient Analysis:

- Soil available N (as NO_3^- and NH_4^+) were extracted with 2M KCl at the ratio of 1:10 = soil : KCl and available P, K, S were extracted with 1N ammonium acetate at the ratio of 1 : 10 = soil : ammonium acetate.
- Soil and groundwater samples were analyzed for available N (as NO_3^- and NH_4^+) and P (as PO_4^{3-}) colorimetrically using auto-analyzer, K (as K^+) by atomic emission spectroscopy and S (as SO_4^{2-}) by MP-AES.
- Only soil analysis results from the year 2014 are shown here.

Results

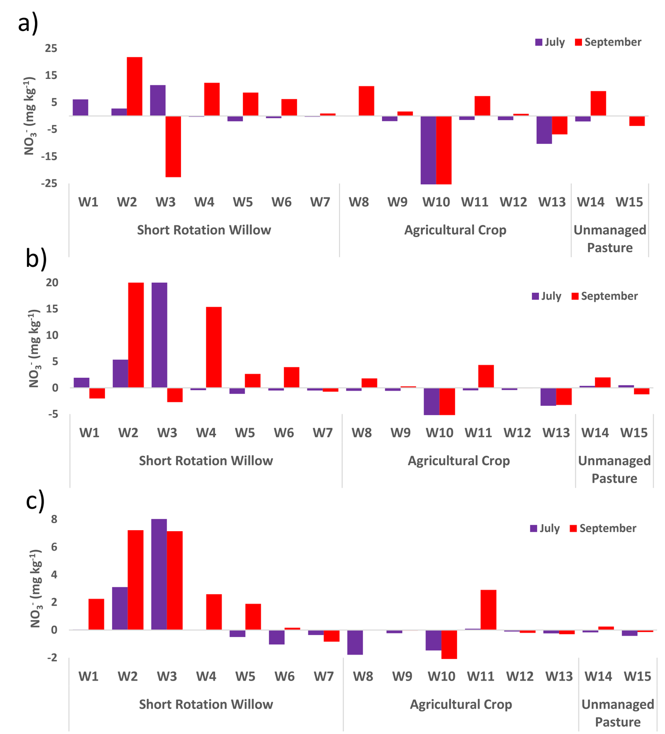

Figure 2. Net change in soil available N as NO_3^- from the month (May) in site 1 at a) 0-15cm b) 15-30cm and c) 30-60cm depth

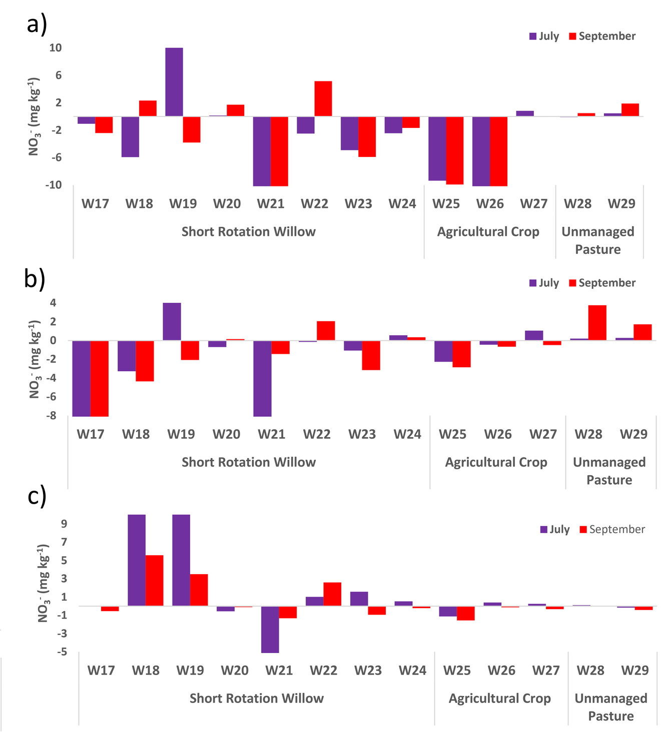

Figure 3. Net change in soil available N as NO_3^- from the base month (May) in site 2 at a) 0-15cm b) 15-30cm and c) 30-60cm depth

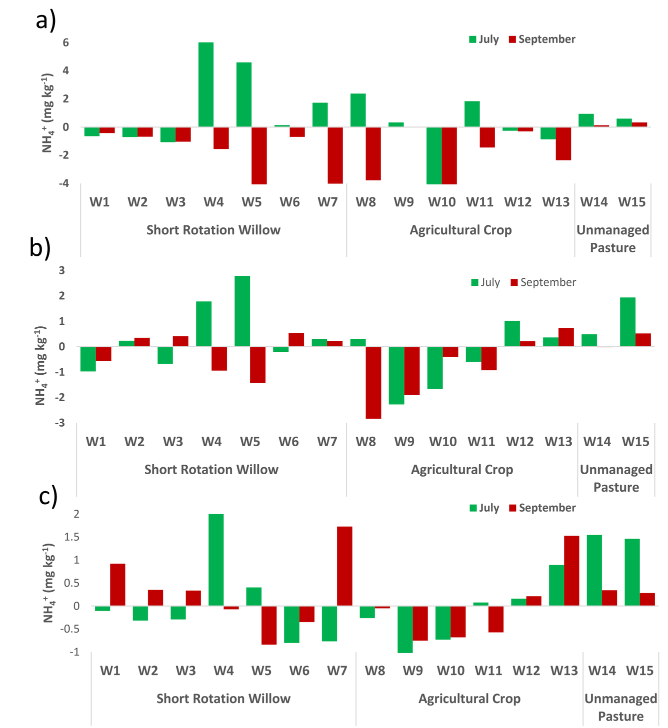

Figure 4. Net change in soil available N as NH_4^+ from the base month (May) in site 1 at a) 0-15cm b) 15-30cm and c) 30-60cm depth

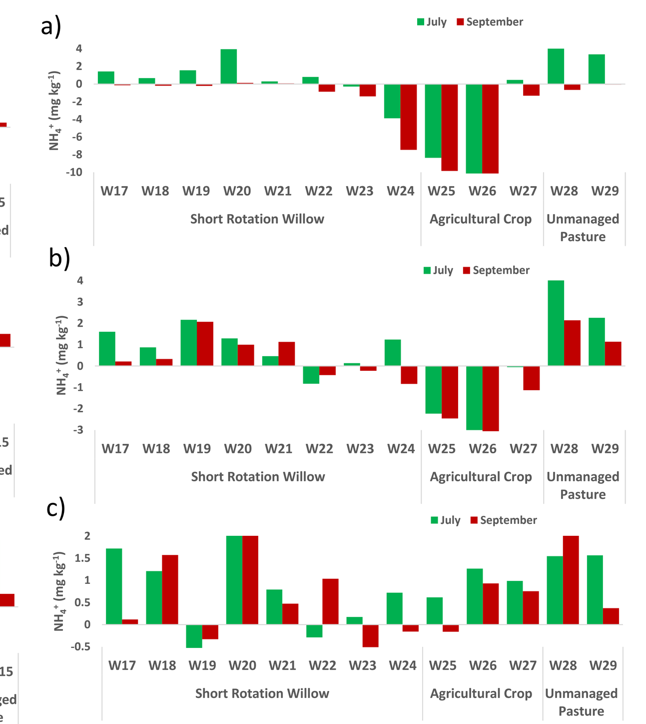

Figure 5. Net change in soil available N as NH_4^+ from the base month (May) in site 2 at a) 0-15cm b) 15-30cm and c) 30-60cm depth

- In site 1, the net change in soil NO_3^- -N under SRW tended to be more positive in all depth compared to annual crop with minimal change under pasture. In site 2, a decreasing trend in NO_3^- -N was observed in upper layers (0-15 and 15-30cm) compared to lower depth (30-60cm) under both SRW and annual crop where it showed a slight increasing trend (Fig. 2 & 3).
- However, a greater negative change (decline) was observed in the depth of 0-15cm under annual crop (Fig. 1 & 2) which indicates the higher uptake and demand of NO_3^- -N during the growing season.
- The change in soil NH_4^+-N was variable in magnitude and trend under SRW in both site 1 and 2. However, the changes in soil NH_4^+-N were negative (decline) under annual crop in all the depth in site 1 and 2, except 30-60cm at site 2 (Fig. 4 & 5).
- The magnitude of change (decrease) in NH_4^+-N under annual crop was higher in the upper soil layer (0-15cm) compared to deeper (30-60cm) due to the fibrous root distribution within the upper soil layer (Fig. 4 & 5).
- NH_4^+-N showed a positive change under the unmanaged pasture (Fig. 4 & 5). The rate of uptake of N by grass may not exceed the maximum rate of mineralization under alfalfa-brome grass mixture.

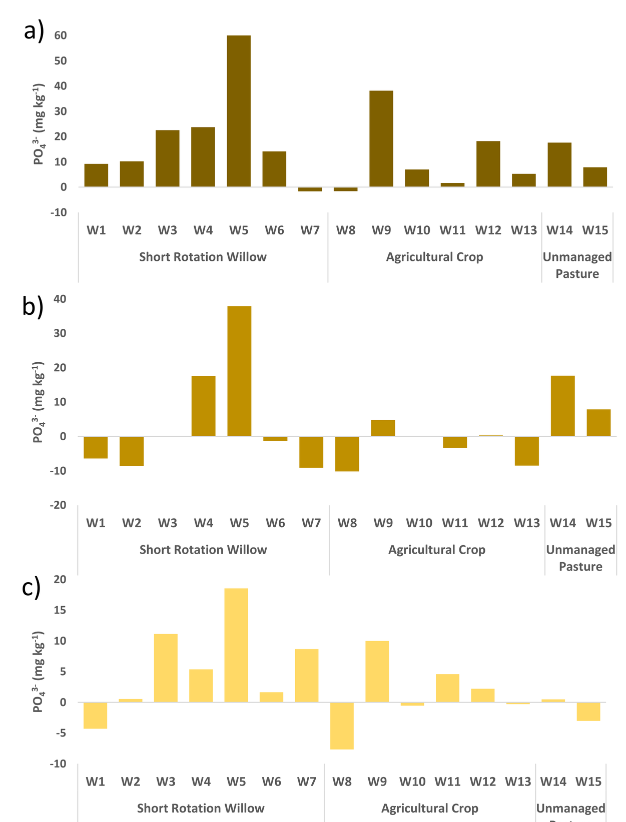

Figure 6. Net change in soil available P as PO_4^{3-} from May to September in site 1 at a) 0-15cm b) 15-30cm and c) 30-60cm depth

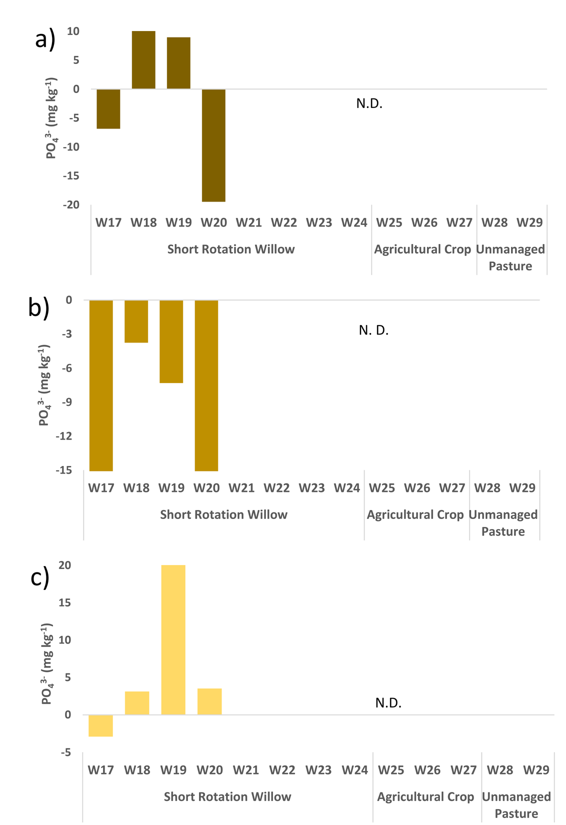

Figure 7. Net change in soil available P as PO_4^{3-} from May to September in site 2 at a) 0-15cm b) 15-30cm and c) 30-60cm depth

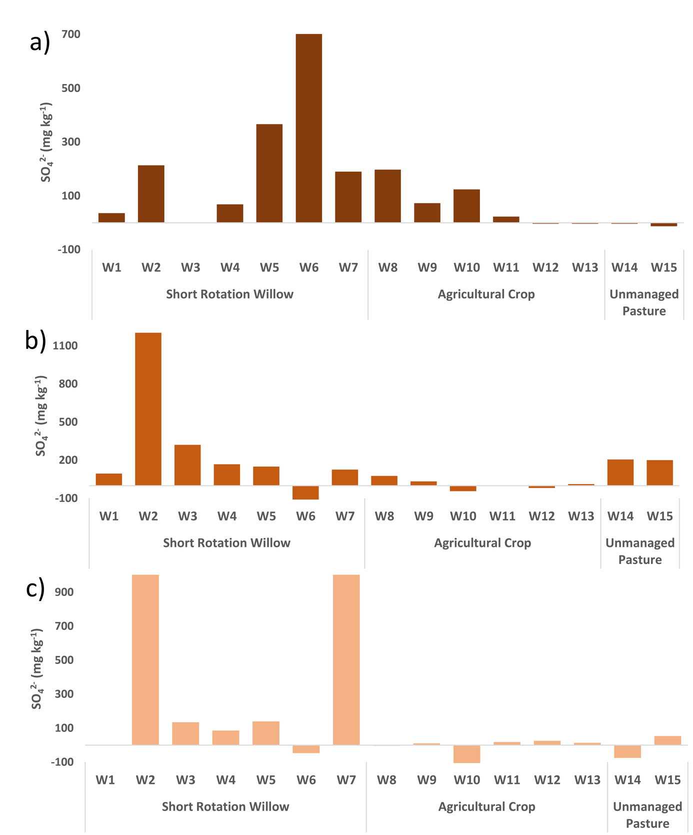

Figure 8. Net change in soil available S as SO_4^{2-} from May to September in site 1 at a) 0-15cm b) 15-30cm and c) 30-60cm depth

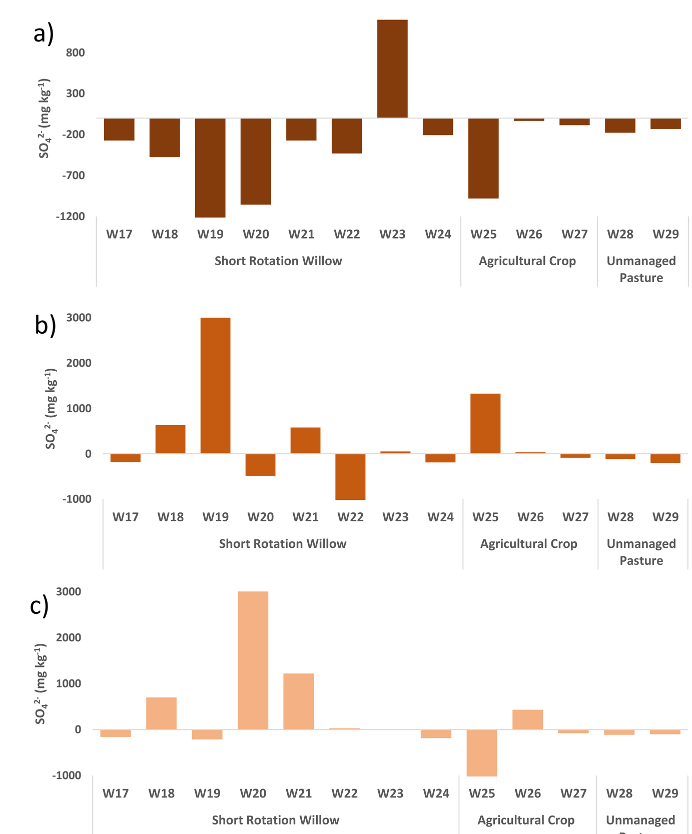

Figure 9. Net change in soil available S as SO_4^{2-} from May to September in site 2 at a) 0-15cm b) 15-30cm and c) 30-60cm depth

- Overall net change (i.e. from May to September) soil available P (as PO_4^{3-}) concentration increased (except at depth 0-15cm of site 2) during the growing season of 2014 in all depths under all land use practices (Fig. 6 & 7).
- The magnitude of the P uptake during the first year of SRW plantation are not much higher (as seen for N) due to not fully developed root systems.
- Net change in soil available S as SO_4^{2-} also showed an increasing trend in most depths, except 0-15 cm at saline site 2 (Fig. 8 & 9).
- The magnitude of change in available S was greater under the SRW compared to annual crop and pasture.

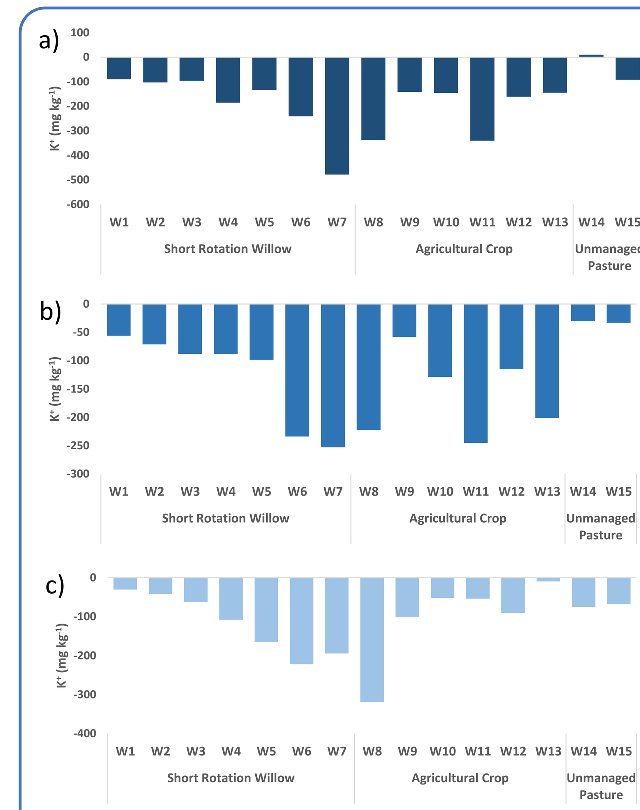

Figure 10. Net change in available K from May to September in site 1 at a) 0-15cm b) 15-30cm and c) 30-60cm depth

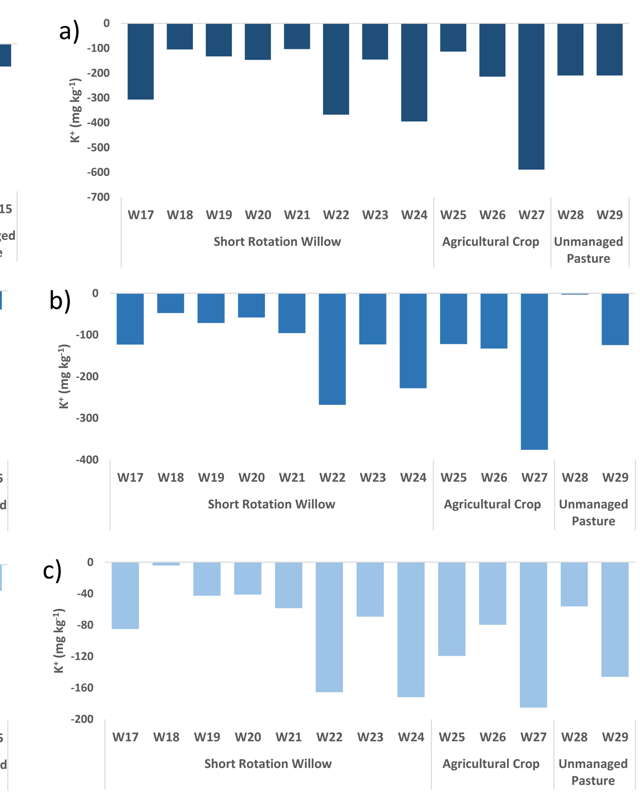

Figure 11. Net change in available K from May to September in site 2 at a) 0-15cm b) 15-30cm and c) 30-60cm depth

- The K in groundwater showed an increasing trend (data not shown here) under all the land use practices, whereas available K in soil decreases in all the depth under all the land use practices (Fig. 10 & 11). This might be due to the higher demand of K during the development phase of SRW.
- However, there were no clear differences found among the land use practices.
- It has been suggested by several studies that, over the long term period, SRW can represent a carbon sink; however, in the short term, it can induce K depletion (Ens et al., 2013).

Conclusions

- First year soil analysis data showed relatively high N, P and S concentrations both in groundwater and soil, which can be justified by the relatively high nutrient concentrations of Prairie wetlands in combination with a not yet fully developed root system in the deeper soil layer, though SRW has high demand for N and P for their biomass growth.
- However, an increasing litter layer of SRW may provide a continued supply of N, P and S through the degradation of organic matter in future rotations.
- These preliminary data show that SRW have some influential change in soil nutrient concentration especially in soil available K during their first growing period; however, to see an inter-annual variations we have to wait for the soil nutrient analysis results from 2015.

References

Ens, J., R. Farrell and N. Bélanger. 2013. Early Effects of Afforestation with Willow (*Salix purpurea*, "Hotel") on Soil Carbon and Nutrient Availability. Forests 4: 137-154.

Acknowledgements

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