Comparison of Switchgrass with Woody Invasive Shrubs as Cellulosic Ethanol Sources in MI

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Background:

Switchgrass biomass is broadly viewed as a high potential source of cellulosic ethanol that is renewable, reduces the carbon footprint, and does not directly jeopardize food stocks. Southwest MI has a cool and moist climate conducive to the rapid growth of several C3 invasive shrubs. Switchgrass is a sun-loving, heat tolerant C4 plant.


Common Buckthorn (CB)


Glossy Buckthorn (GB)


Autumn Olive (AO)


Switchgrass (SW)

Objectives:

•Compare the potential for using biomass from invasive shrubs as a feedstock for ethanol production with that of Switchgrass

•Evaluate the suitability of harvesting invasive shrubs (pictured at right) as a perennial crop in 1-3 year timeframes, thereby preventing seed dissemination

Methods:

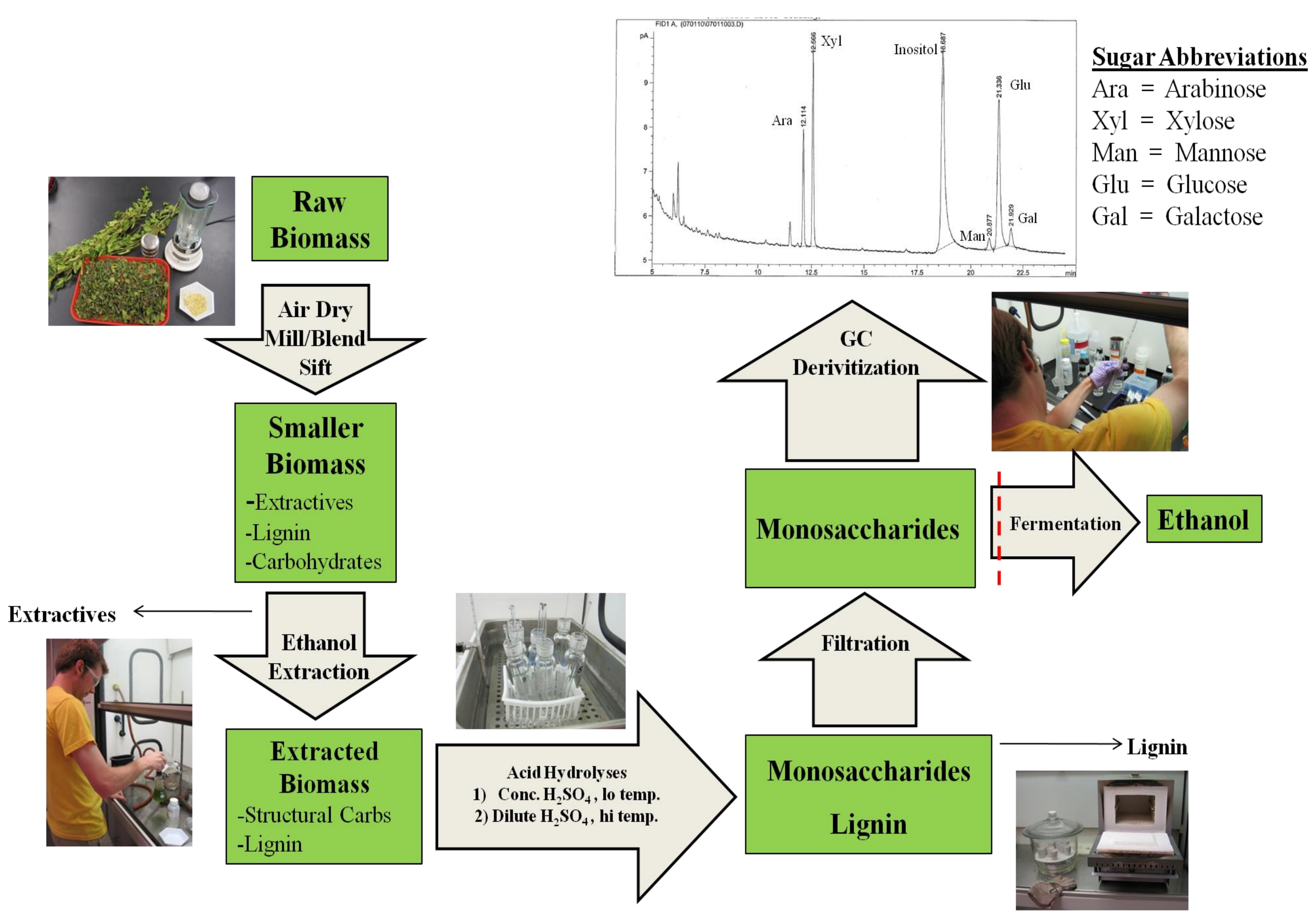
•Collected woody invasive and SW biomass from Calvin College and Pierce Cedar Creek Institute in SW Michigan

•Followed the National Renewable Energy Laboratory's (NREL) protocol for *Determination of Structural Carbohydrates and Lignin in Biomass* and the ASTM test method for *Determination of Carbohydrates in Biomass by Gas Chromatography* to quantify woody invasive and Switchgrass chemical composition

•Estimated theoretical ethanol yield of each species using the online NREL Theoretical Ethanol Yield Calculator

Potential for using biomass from invasive shrubs for cellulosic ethanol

NREL /ASTM Process



Results:

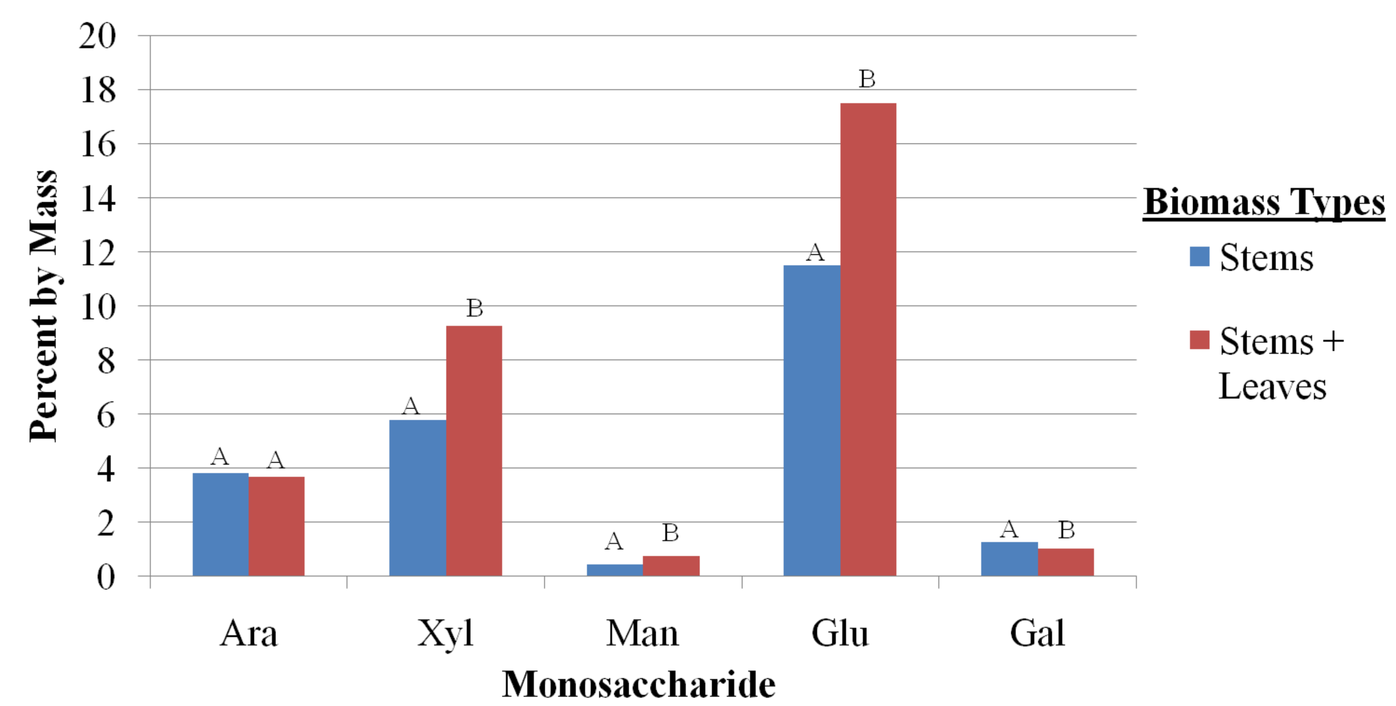


Figure 1: Woody invasive monosaccharide composition varies according to biomass type

•Question: When to harvest biomass, before or after leaf drop?

•When leaves are included in biomass processing, sugar yields generally increase, indicating harvesting before leaf drop is optimal for maximizing ethanol yield

•Trade-off: allowing leaves to drop may contribute to increasing soil organic carbon

•Conclusion: Harvest with leaves

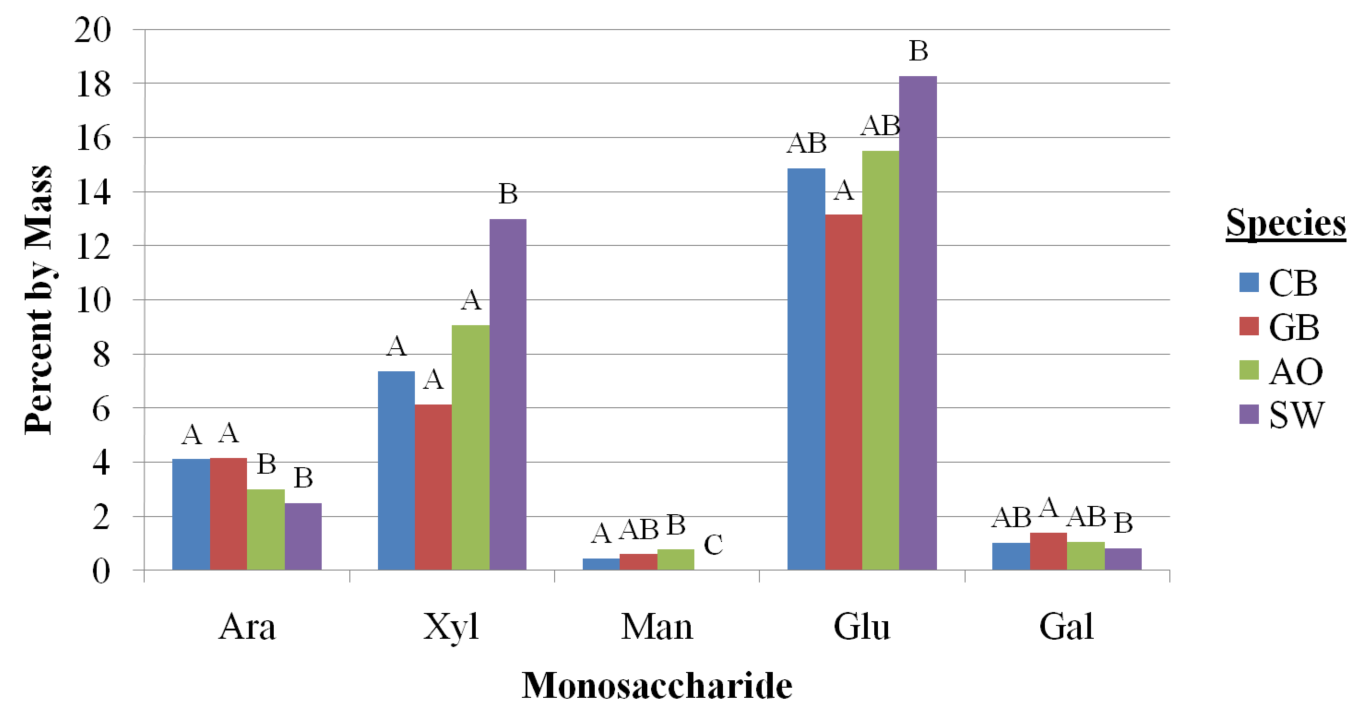


Figure 2: Comparison of monosaccharide compositions of 3-year-old woody invasive and 1-year-old swtichgrass biomass

•Xylose & Glucose convert most efficiently to ethanol

•These two monosaccharides are present in the greatest proportions in all species

•Switchgrass has the greatest relative proportions of xylose and glucose among all species, suggesting that it would produce a greater amount of ethanol per unit of mass

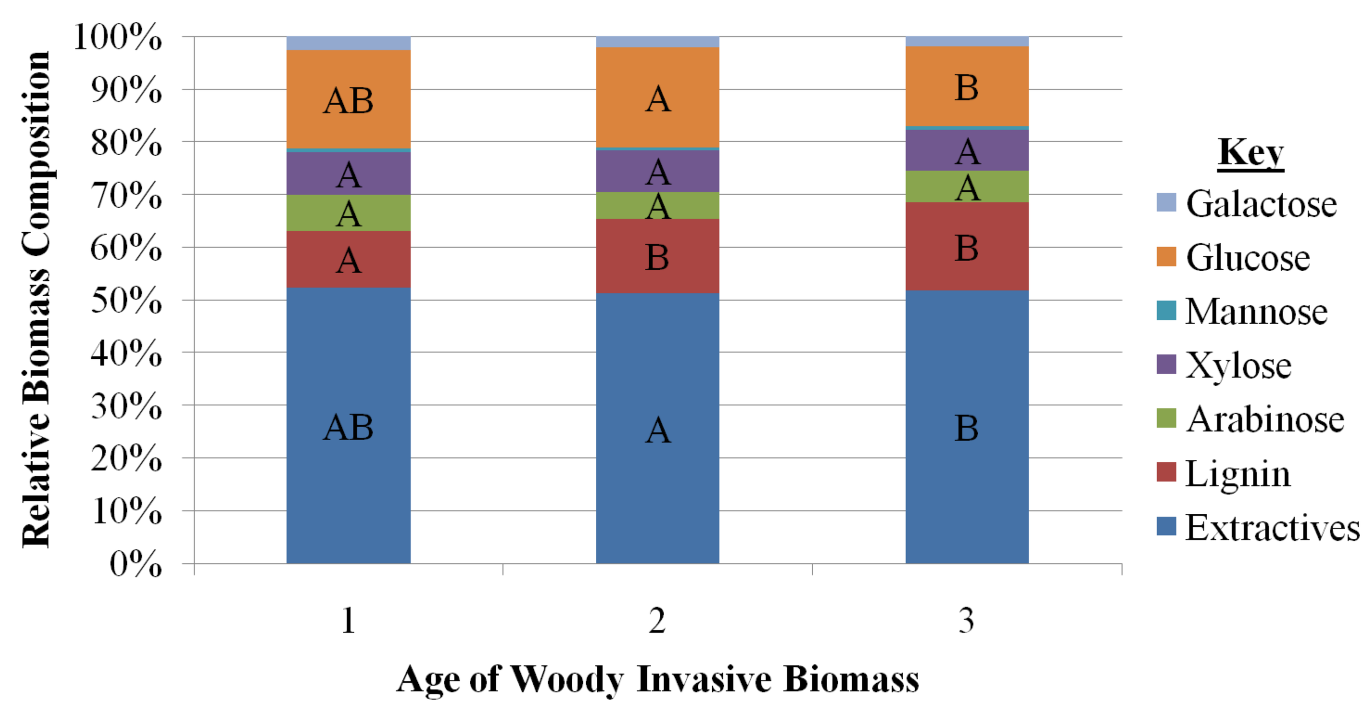


Figure 3: Relative composition of woody invasive biomass varies little with age

•Question: Should biomass be harvested after 1, 2, or 3 years?

•Need to know how much monosaccharide composition changes over time

•Xylose content did not change significantly

•Glucose content dropped significantly in third year

•Conclusion: Harvest after 1 year

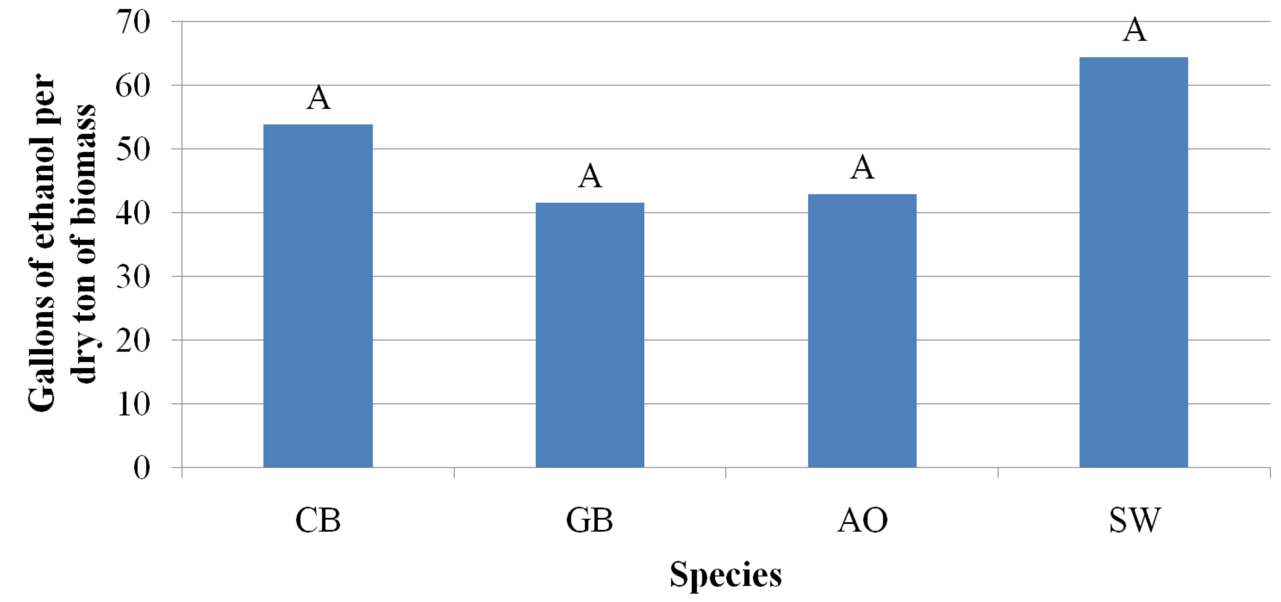


Figure 4: Theoretical yields of ethanol differ by species

•Question: Does the theoretical ethanol yield from 1-year-old, whole-plant biomass differ according to species?

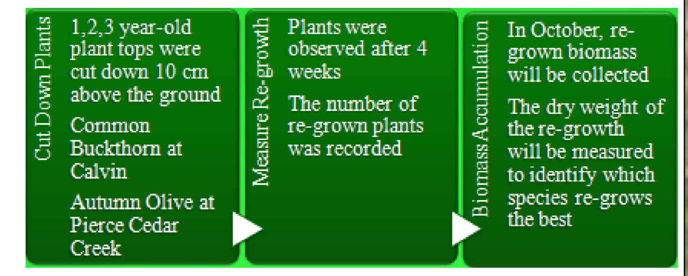
•Convert percent-weights of monosaccharides to gallons of ethanol using NREL Theoretical Ethanol Yield Calculator

•Ethanol yields from each species are not significantly different

•Conclusion: More important how much biomass can be produced annually (dry tons of biomass/unit area/year)

Potential for using biomass from invasive shrubs for cellulosic ethanol:

~100% re-grow after cutting.



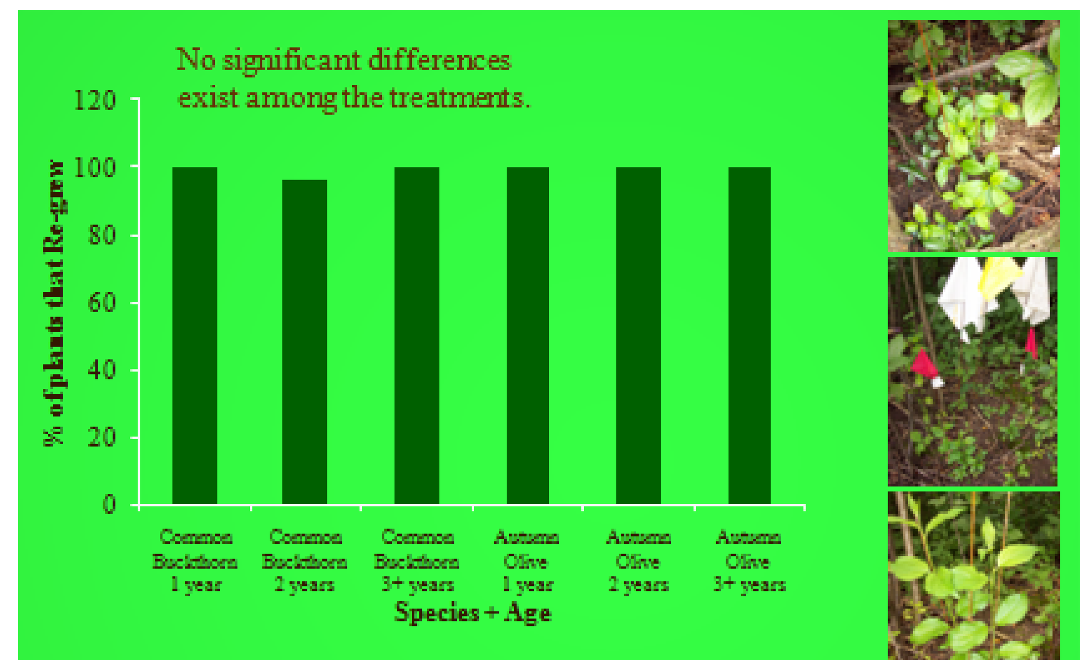


Figure 1. Re-growth rates of Common Buckthorn cut down at Calvin and Autumn Olive cut down at PCCI in June.

Conclusions:

•Ethanol yield from woody invasive species was optimized when biomass from one year of growth was harvested before leaf drop. Early harvest would likely slow soil enrichment from the accumulation of organic matter, however.

•Maximum ethanol yield did not depend on biomass source, but rather on the quantity of biomass capable to grown per unit area.

•Biomass harvest frequency could take place at least annually without jeopardizing the ability of invasive shrubs to re-sprout.

•Establishment of a controlled long-term field study will serve to confirm these results and allow future analysis of the potential of woody invasive shrubs to produce biomass and increase soil carbon.

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