Woody Crops for Bioenergy Production in Florida

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Background

A recent analysis of the effect of a hypothetical renewable portfolio standard (RPS) in Florida concludes: "To sustainably achieve 1% to 3% of electricity production from wood sources, logging residues and urban wood waste have to be utilized in addition to merchant-able timber along with an enhanced reforestation program. Reforestation must at least keep pace with forest harvest removals. Beyond 3% of electricity generation from wood sources, short rotation energy crops need to make up a larger share of the fuel mix in addition to all other feedstock sources mentioned above. The study concluded that a 7% RPS (equivalent of 1% to 3% electricity production from wood sources over time) would have little impact to the existing forest products industry and Florida's forest would remain sustainable." "With increased reforestation, afforestation and planting of high-yielding short rotation woody crops on up to 15% of non-forested lands, a 12% and higher RPS could be achieved without depletion of the forest resources of the state, or significant impacts to the existing forest industries." (http://www.fl-dof.com/forest management/fm_pdfs/Final%20Report%20Woody%20Biomass%20Economic%20Study.pdf)

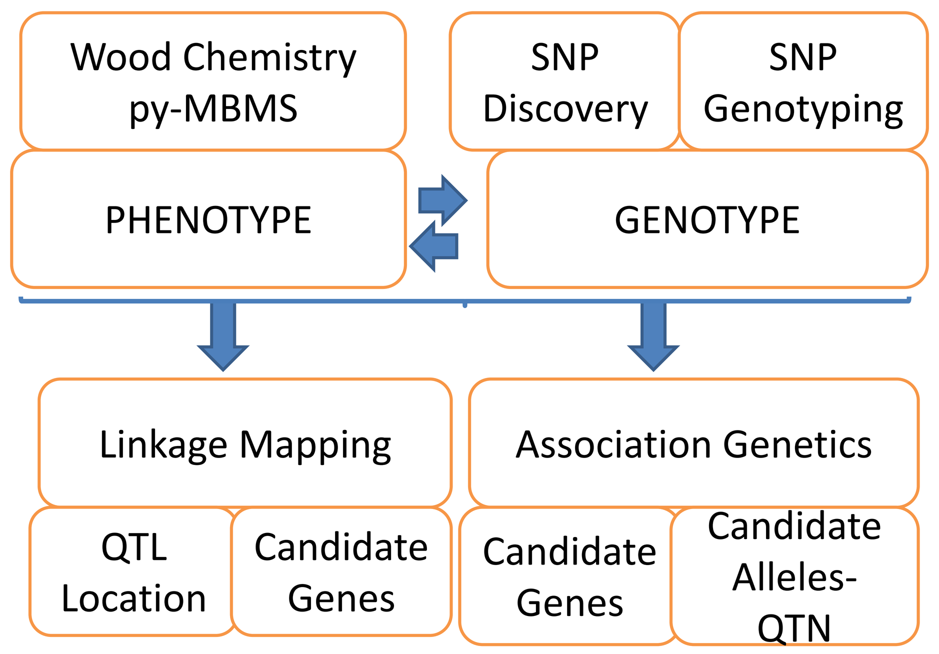
Project Objectives

Forest tree species have a number of favorable advantages for use as a feedstock for bioenergy production. However, commercial use is limited by the feedstock cost and efficiency of conversion to bioenergy and biofuels. We are addressing these limitations by conducting 1) fundamental research with loblolly pine and Populus to identify genes controlling biomass chemical composition and productivity that can be used ultimately to tailor crops for improved conversion efficiencies to biofuels and electricity, and 2) applied short rotation woody crop research with Eucalyptus species, to provide important agronomic practice, yield, and chemical composition information for Florida growers, producers and policy makers.

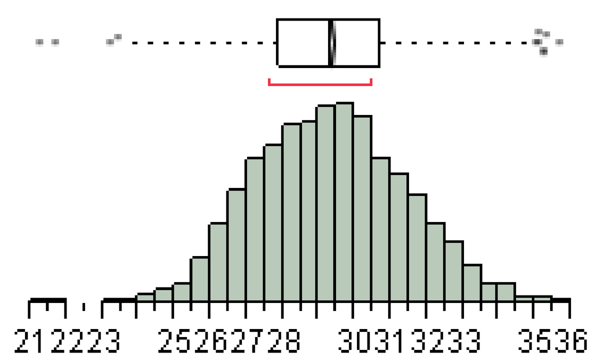
Wood Chemical Composition is Key to Yields

Wood is composed principally of complex carbohydrates, cellulose and hemicelluloses, lignin and extractives, terpenoids. For combustion, gasification and pyrolysis, wood with elevated lignin and terpene contents have greater energy per unit mass. For bioconversion to liquid fuels wood with greater carbohydrates will have greater yields. Thus, understanding the genetic mechanisms controlling the ratio of carbohydrates, lignin and extractives will lead to the development of trees that have greater yields of bioenergy and biofuels. To understand the mechanisms that control wood chemical composition in loblolly pine and Populus, we are conducting mapping studies to identify genes that control cellulose, hemicellulose, liginin and extractive content.

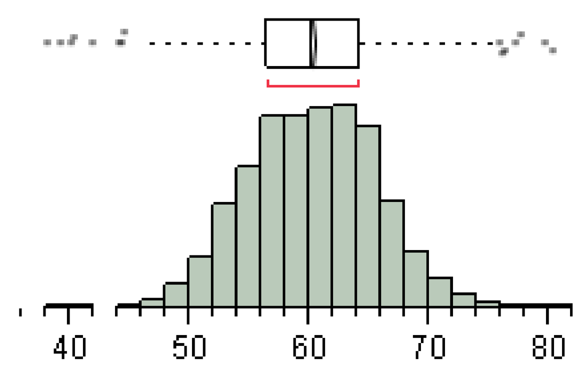
Loblolly Pine: Association Genetics



Phenotype	Method	Measured	# trees
Wood Chemistry	Pyrolysis Molecular Beam Mass Spectrometry	Rings 3 & 4	3888



Phenotypic distribution for % lignin. Lignin content varied from 24.5 to 35.5% with a mean of 29.3%



Phenotypic distribution for wall carbohydrates. Peak intensity varied from 80 to 47.5 with a mean of 60.3.

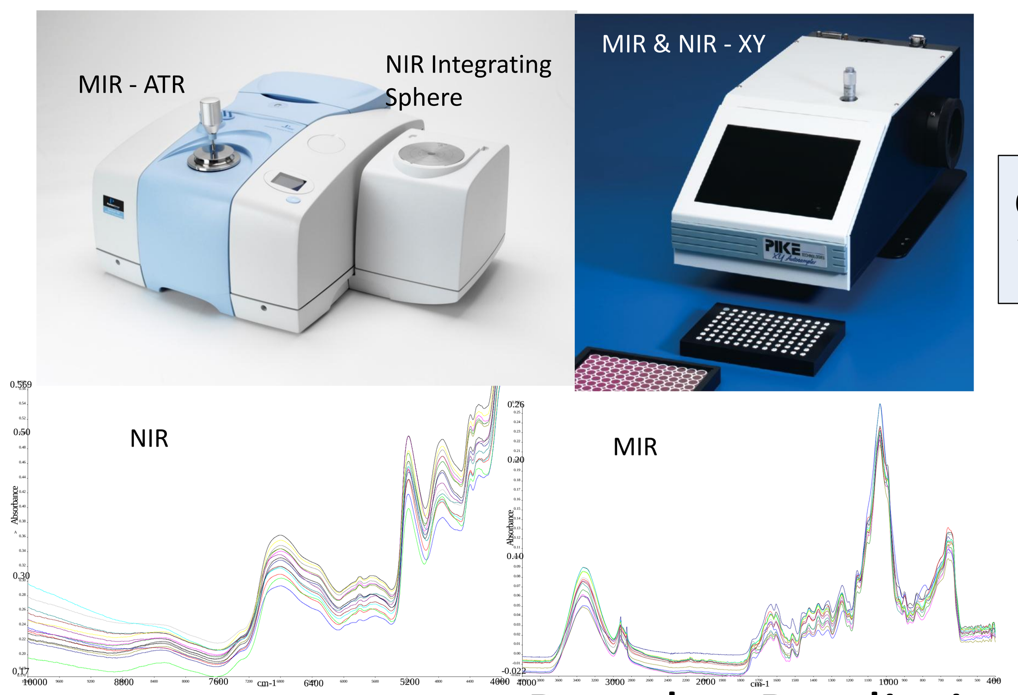
Carbohydrate Genes

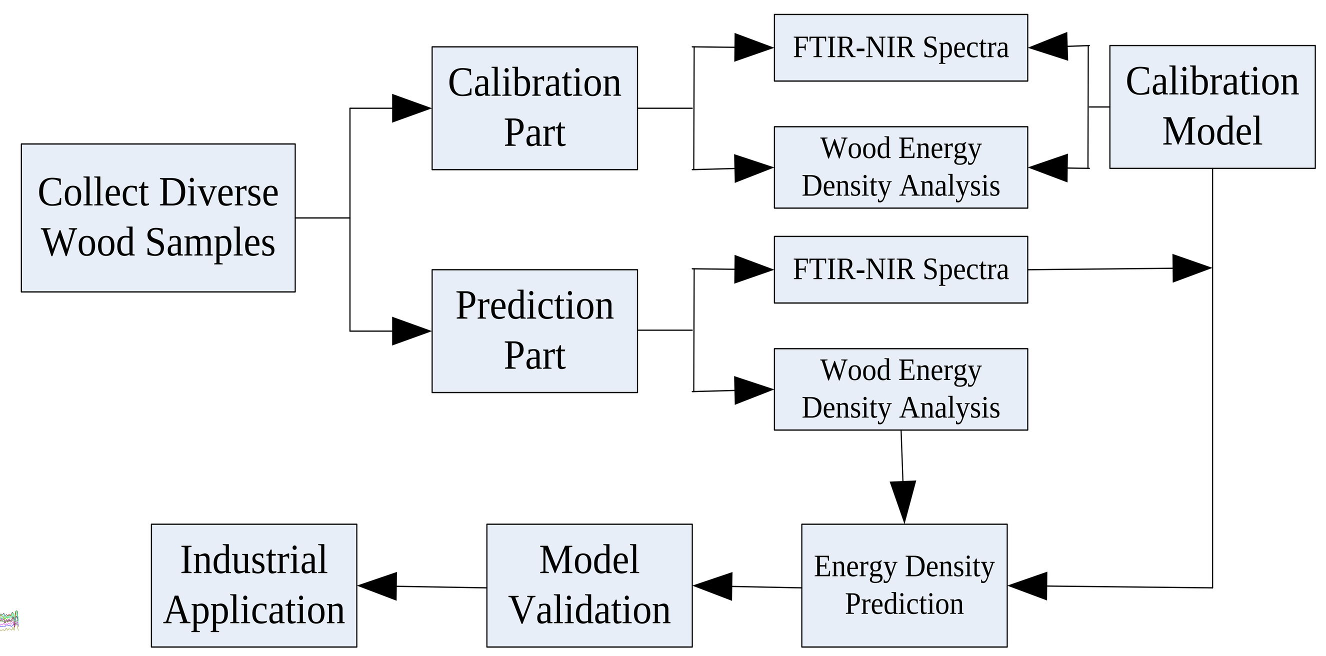
Effect (% of phenostev)	Annotation	Single Peak Significant
9.3	glycoside hydrolase family 28 protein	114
7.2	hypothetical protein OsJ_08791	114
8.2	hypothetical protein OsJ_36445	114 & 144
7.4	No Hits Found	114 & 144
6.1	No Hits Found	-
10.6	ASC1-like protein/putative resistance protein	144
6.5	short-chain dehydrogenase, putative	144
7.4	heat shock protein 70 (HSP70)-interacting protein, putative	144
8.6	Acetylornithine aminotransferase, mitochondrial; Short=ACOAT	144
8.1	hypothetical protein OsJ_05018	-

Lignin Genes

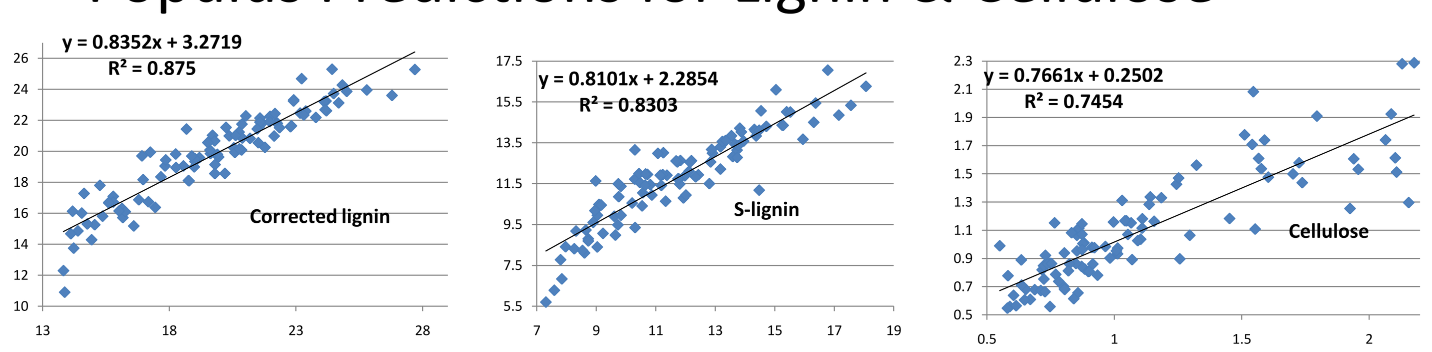
Effect (% of phenostev)	Annotation
7.3	unknown
4.2	Os08g0518100
4.1	amino acid permease
3.5	serine-threonine protein kinase, plant-type, putative
3.5	No Hits Found
3.3	PREDICTED: hypothetical protein
4.8	unknown
3.7	Activating signal cointegrator, putative
4.2	GTP binding protein, putative
5.2	mitochondrial Acetylornithine aminotransferase
4.0	unnamed protein product
3.8	predicted protein
4.3	conserved hypothetical protein
4.1	PREDICTED: hypothetical protein

High Throughput Wood Chemistry Estimation





Populus Predictions for Lignin & Cellulose



Short Rotation Field Trials Established with Three UF/IFAS *Eucalyptus grandis* cultivars

Location	Site	Soil	Age (mo)	Response	G1	G2	G3
South	Citrus beds	Poorly drained sand	9	Height (m) Survival (%)	3.3 92.3	3.3 89.4	3.5 91.3
South	Agricultural land	Sandy muck	8	Height (m) up to 6.1			
Central	Mined land (Reclaimed site)	Sandy	7	Height (m) Survival (%)	0.5 100	0.5 100	0.7 100
Central	Mined land (Clay settling area)	Clay	7	Height (m) Survival (%)	0.9 100	1.8 100	1.3 100
Central	Citrus grove windbreak	Well drained sand	15	Height (m)	4.3	4.4	5.0
North	Former Pine Plantation	Sandy clay	5	Height (m) Survival (%)	0.5 100	0.6 100	0.5 96

Conclusions

We have identified candidate genes in pine and Populus that appear to control cellulose and lignin amounts. We are following up on these genes in pine and Populus with the long-term goal of developing high lignin trees that can be converted with high efficiency to bioenergy with combustion, gasification and pyrolysis or high carbohydrate trees that can be converted efficiently to biofuels and valuable co-products via biochemical conversion.

We have developed validated predictive models to estimate wood chemical composition in Populus.

We have established six new field plantings of *Eucalyptus grandis* cultivars developed by UF. These cultivars survived well in south and central Florida as expected. They have excellent height growth on various soils and we will be measuring their growth to quantify yields.

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