



BioSUCCEED: Bio-products Sustainability, a University Cooperative Center for Excellence in Education

Keith Schimmel, North Carolina A&T State University

Lucian Lucia, North Carolina State University

Jianzhong Lou, North Carolina A&T State University

Abolghasem Shahbazi, North Carolina A&T State University

Timothy Rials, University of Tennessee





Objectives

- Nature of Sustainable Bioproducts Graduate Education
- BioSUCCEED Initiative
- Open Courseware Issues
- BioSUCCEED Successes at NC A&T





BioSUCCEED

- ...is a platform for the fundamentals & latest knowledge in biomass & bioenergy
- ...distills the work we have been doing in teaching & research into discrete modules for consumption
- ...provides an open-access, modular array of slides for use in academics, industry, government, and private settings





Project Rationale for NC A&T

- Volume of biofuel production in the U.S. doubled last five years
- Energy Independence and Security Act of 2007, biofuel production will quadruple within the next twelve years (36 billion gallons per year in 2022)
- 2007, production and construction in the ethanol industry supported the creation of about 240,000 jobs
- Workforce to serve the growing biofuel industry will be several times higher than this within the next decade
- Most scientists in 1890 universities lack sufficient resources to obtain skills and engage in advanced bioenergy projects and technologies





What is *Biomass*?

Quiz M2.1

- According to the US Department of Energy:

Biomass is any organic material made from plants or animals. Domestic biomass resources include agricultural and forestry residues, municipal solid wastes, industrial wastes, and terrestrial and aquatic crops grown solely for energy purposes.

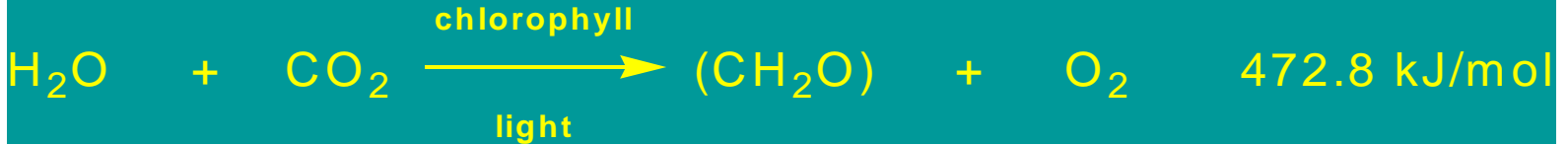
- In general, it is a carbon-containing substance or material that has a biological origin, is renewable, has little to no impact on green house gases, and is degradable.

1. *Which of the following cannot be considered biomass according to the DOE definition: (a) corn stover; (b) poultry; feathers; (c) clay; (d) human hair*
2. *Which of the following can be considered a biomass according to the general definition: (a) petroleum; (b) carbon dioxide; (c) diamond; (d) none of the above*
3. *What can potentially be another name for biomass: (a) biomaterial; (b) biochemical; (c) bioenergy; (d) all of the above*



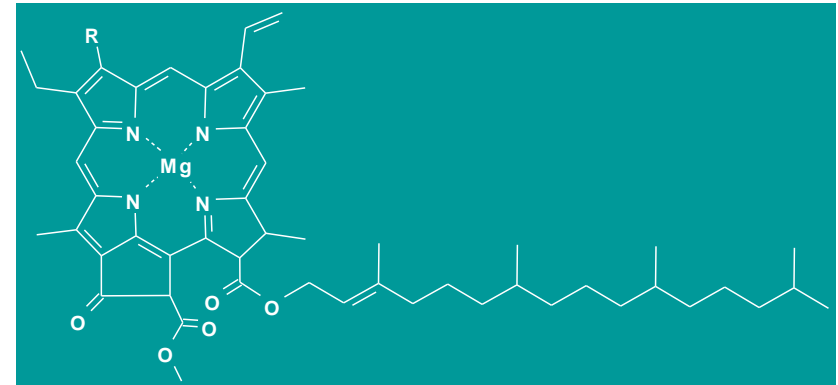
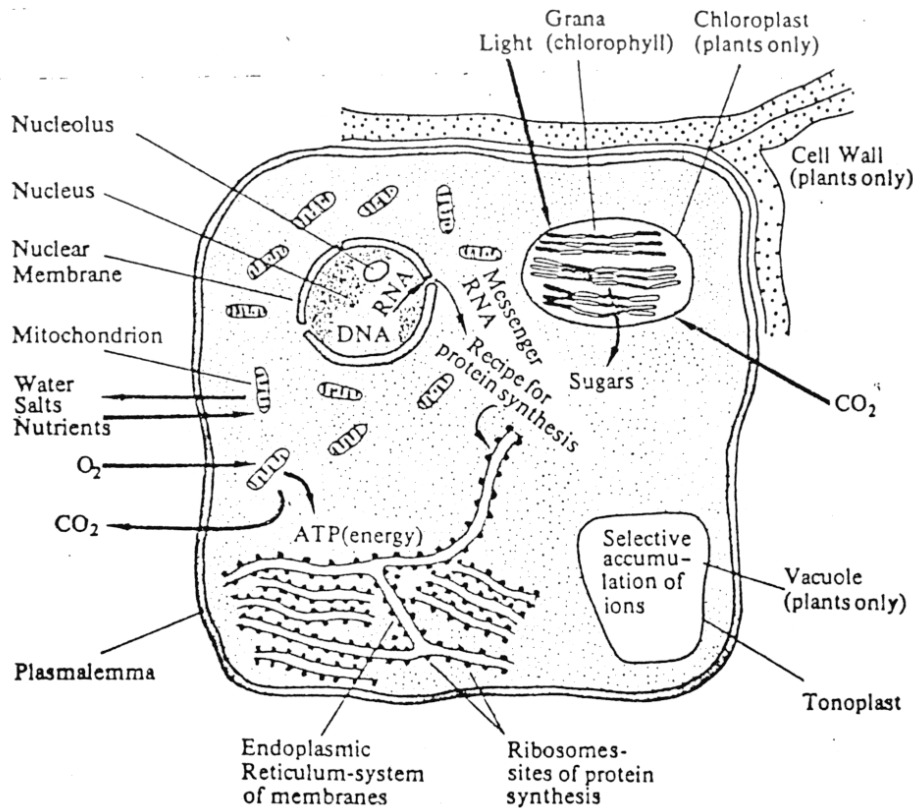


Photosynthesis → Biomass



1g fixed

absorbed



R = CHO
R = CH₃

Chlorophyll a
Chlorophyll b





Biodiesel

- Useful form of liquid fuel
- It is a vegetable oil and fatty acid product (an ester)
- Made from the transesterification of vegetable oil using an alcohol such as methanol (most common): the three fatty acids on the glycerol residue are esterified to 3 molecules of methanol leaving behind glycerin (a tri-alcohol)
- Prof. Chavanne of Belgium invented biodiesel in 1937
- Generally used as B99 blends (1% petrodiesel is added) to avoid molding of fuel

Quiz M2.4

1. *Which has a higher energy value: (a) gasoline; (b) methanol; (c) ethanol; (d) butanol*
2. *What common oils can make biodiesel: (a) soybean; (b) corn; (c) rapeseed; (d) all of the above*
3. *What is an ester: (a) a female's name; (b) an organic product also known as an ether; (c) an alcohol-fatty acid compound; (d) all of the above*





Biomass vs. Fossil Fuel

- In terms of energy, biomass produces less energy than coal
- Coal heating value: 23-28 MJ/Kg
- Biomass heating value: 16-20 MJ/kg, 20-30% lower
- Density of coal 880 kg/m³
- Density of poplar 545 kg/m³; density of switch grass 230 kg/m³





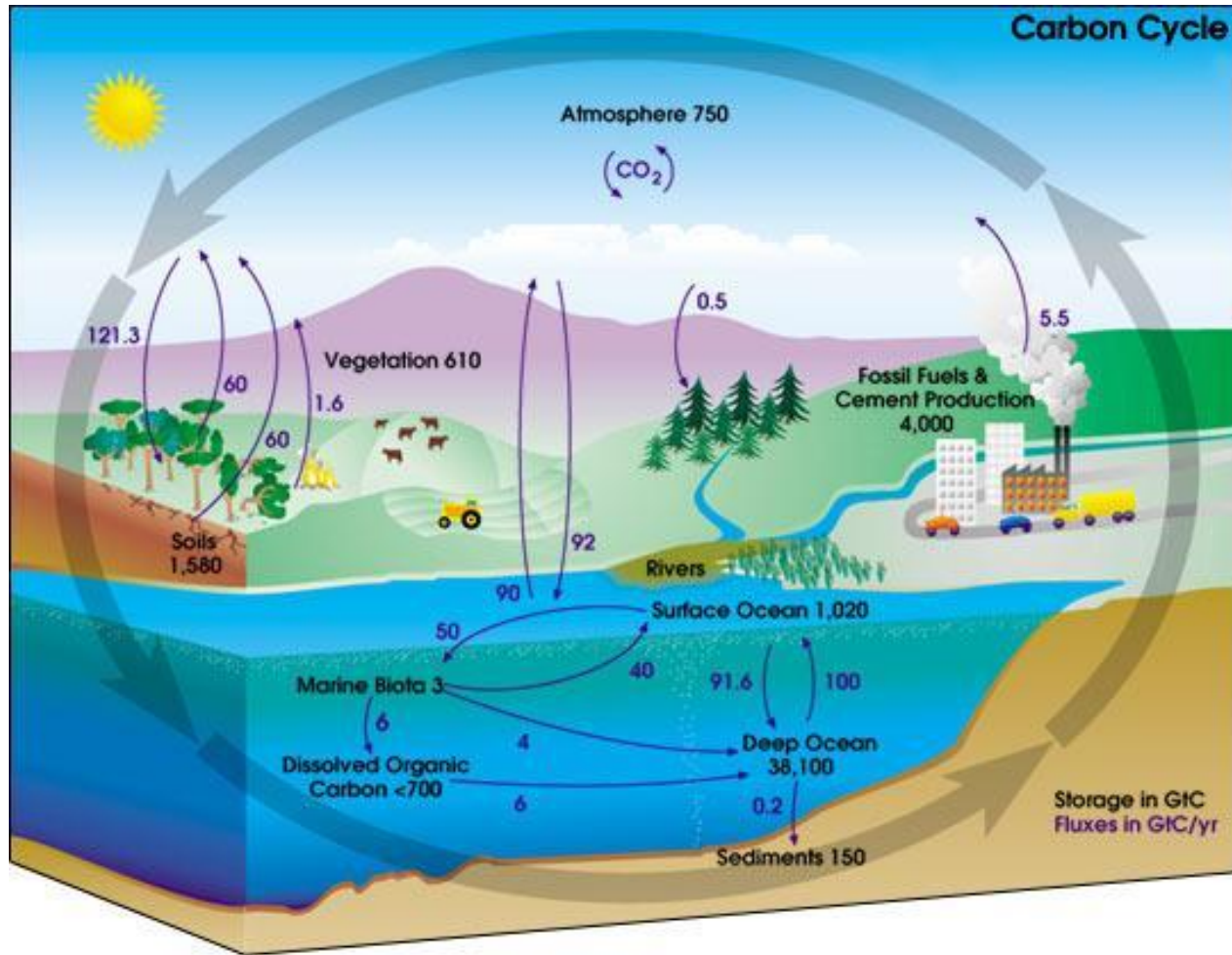
What is Bioenergy?

- Conversion of energy stored in the chemical bonds and natural fibers delivered from biorenewable resources (biomass) into heat and stationary power
- Spans from burning wood to gasifying plant fibers and using the resulting hydrogen in a fuel cell





Bioenergy Production and Storage through Carbon Cycle





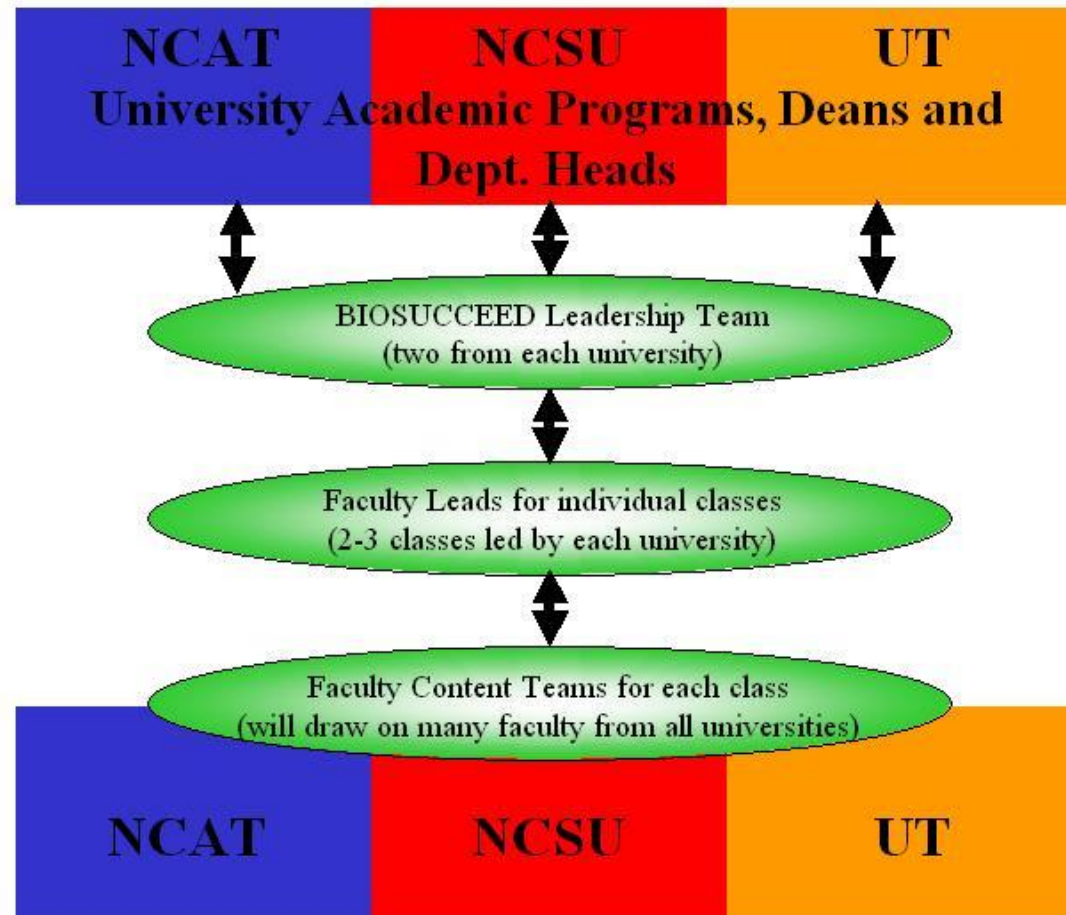
Biomass Environmental Issues

- Effects from burning biomass (formation of CO₂ and other air pollutants)
- Effect from using plant sciences and biotechnology to improve food/feed
- Effects from using chemicals that help plants grow or keep the crops safe
- Effects of machinery used in planting, growing, storing, and transporting biomass
- Effects of agricultural practices on soil erosion





Organizational Structure





Fundamentals of Biomaterials Science (NCSU LEAD)

- This course offers a fundamental definition of the concepts of “biomaterials” and “biomass” and their relevance in our society. It provides an in depth study of the **core physical, chemical, and biological principles that underlie the synthesis and modification of biomaterials** and associated biopolymers into novel materials.





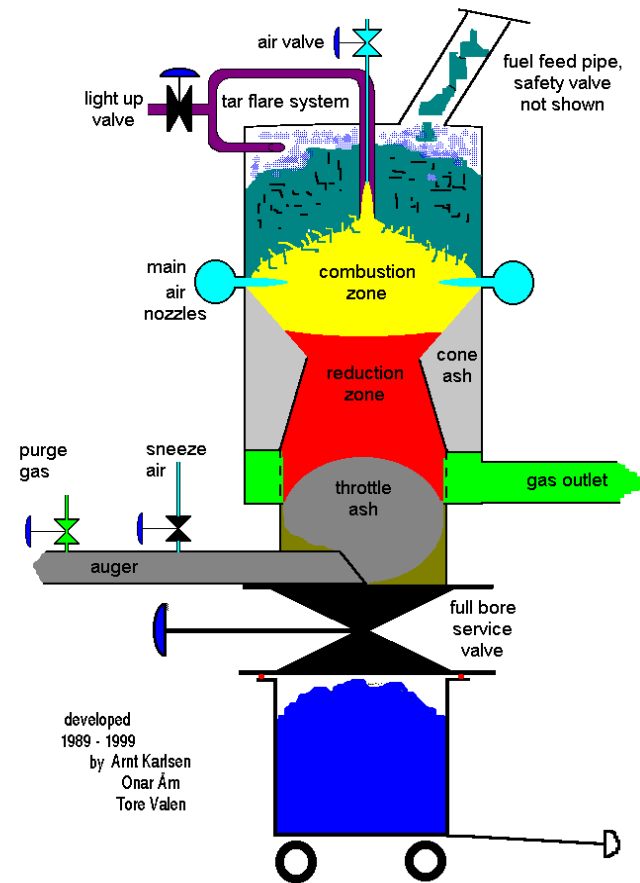
Biomaterials Characterization (NCAT LEAD)

- The objective of this course is to describe the ***analytical and spectroscopic techniques and tools available for examining molecular and macroscopic structural features of naturally occurring materials with emphasis on the lignocellulosic substrate.*** The students will be able to understand the way these methods are applied toward addressing chemical, physical and macroscopic properties of biomaterials.



Thermal Conversion Processes (NCSU LEAD)

- This learning outcome of this course is the development of an understanding of the available **methods and processes that are necessary to convert biomass into usable chemicals and energy as part of a biorefinery concept.** This work will focus on the application of chemical and thermal processes that can convert biomass to specific end products or to complex mixtures of materials such as syngas or pyrolysis oils.



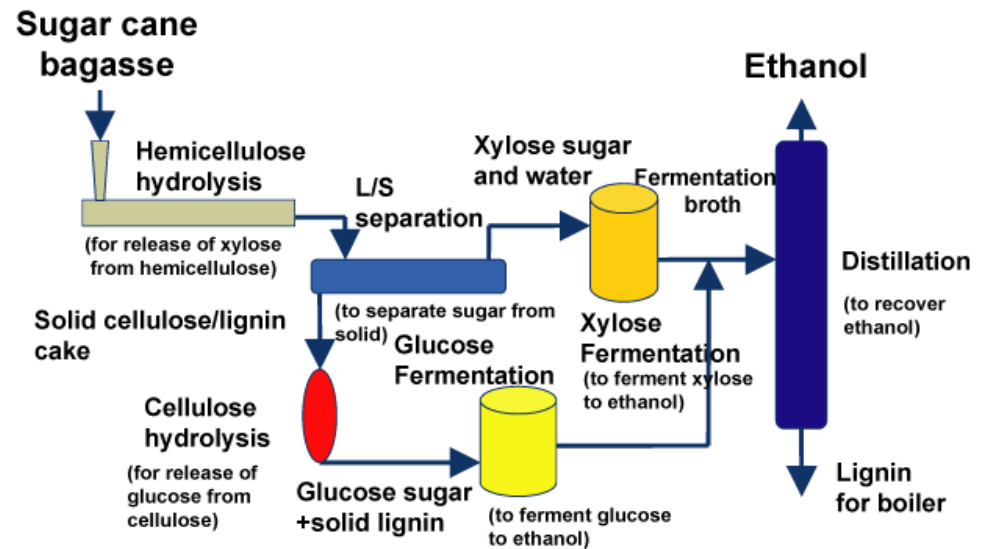
Downdraft Gasifier



Biological Conversion Processes (NCAT LEAD)

- The learning outcome focuses on the *unique advantage of biomass over fossil carbon feedstocks where biological processes can be used to very selectively carry-out some transformations*. This class also highlights challenges of bioconversions in terms of cost, dewatering, and limited thermal and pH ranges.

Celunol Corp. Ethanol from Biomass Process





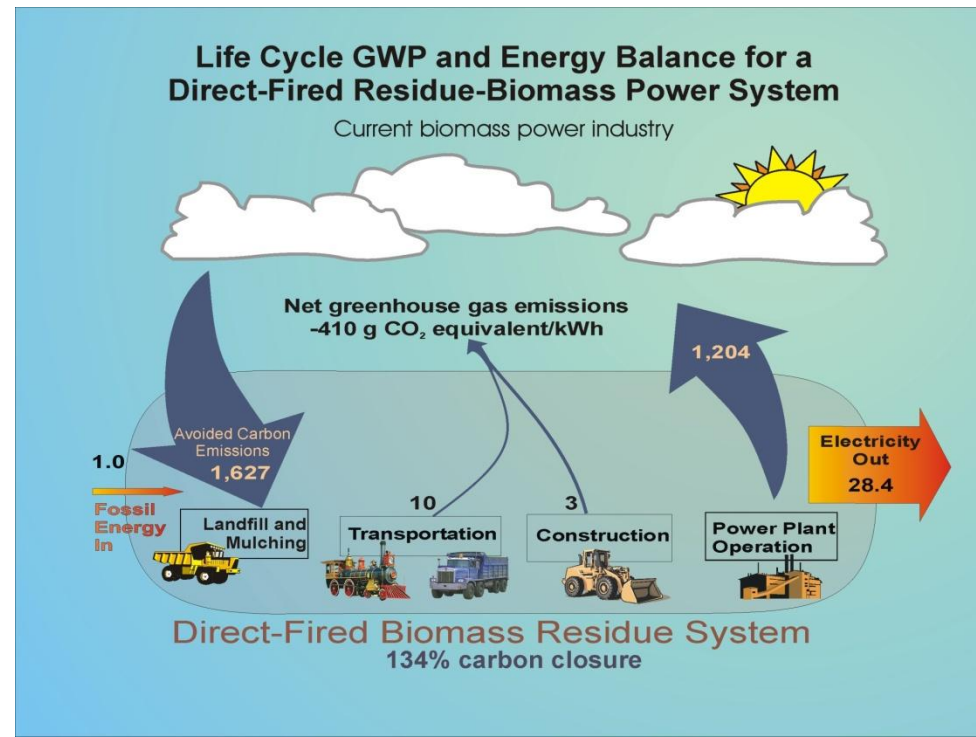
Solid State Composites (UT LEAD)

- This course involves the ***physics and engineering required for the manufacture of biocomposites from biomass.*** It focuses on the micromechanics of the new composites by an emphasis on the physics of interfacial binding and the physical and mechanical properties of biobased plastics and fibers.

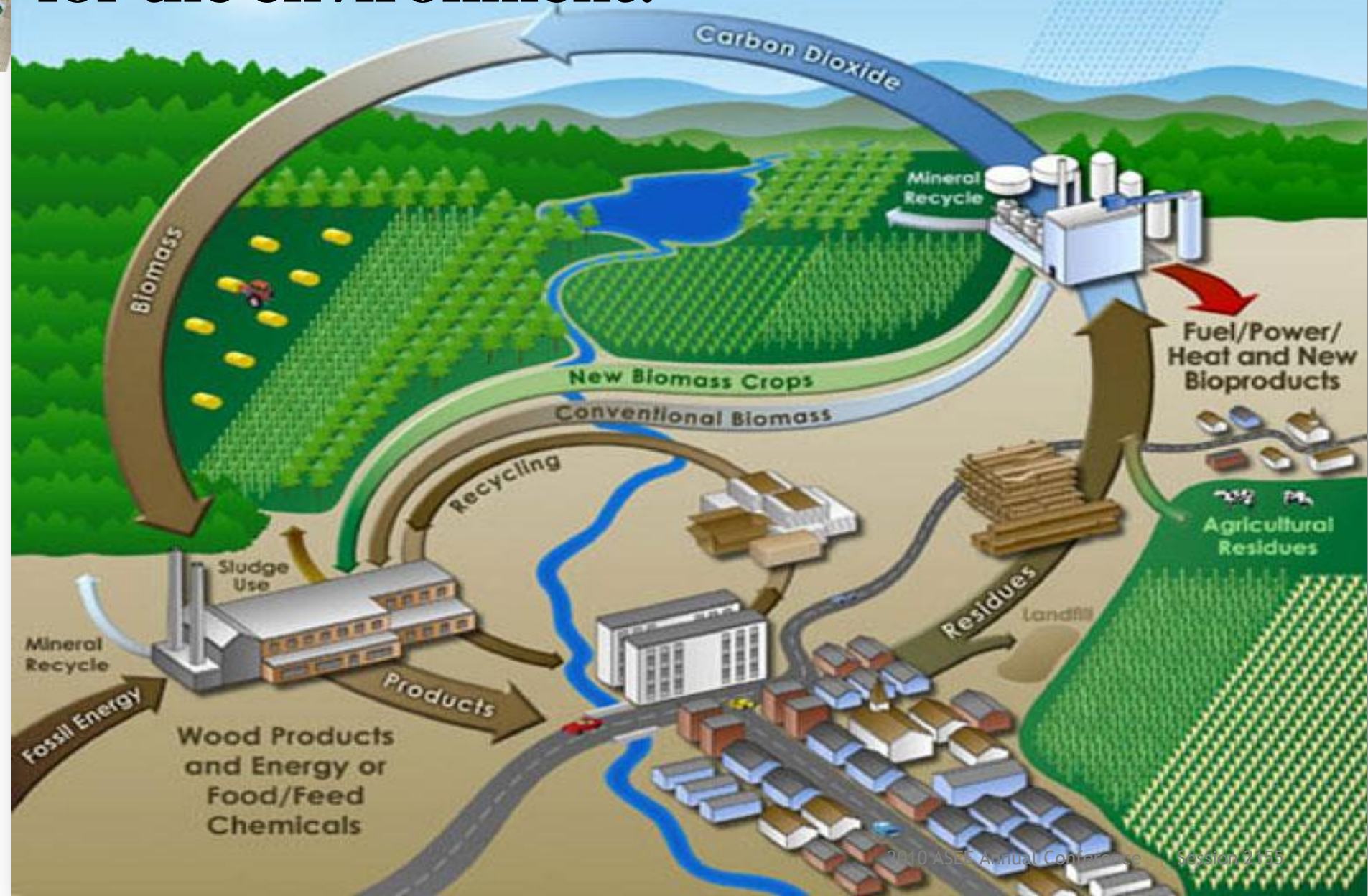


Environmental & Policy Studies of Biomass Use (UT LEAD)

- The objective of this course is to elucidate ways in which **biomass technological principles impinge upon policy issues, including lifecycle analysis (LCA), management issues, and public policy development**. Learning modules will be built around the study of various realistic cases, integrating principles that were explained more fully in the other courses in the series.



Is using biomass as a source of energy good for the environment?





Open Source Course Issues

- Faculty sensitivity to sharing intellectual property – Mixed response from project faculty
- Proper permissions for use of intellectual property
- Appropriate format – Flexible, easy to modify by user
- Sustainability – Mechanism for continuous improvement and updating





NCA&T Successes

- NC A&T has over the past few years begun to focus upon the development of interdisciplinary graduate programs and initiated this past fall within its interdisciplinary Energy and Environmental Systems graduate program a concentration in Sustainable Bio-products
- Concentration capitalizes on NC A&T's agriculture, science, and engineering research strengths
- BioSUCCEED initiative will help NC A&T enhance its graduate course offerings in Sustainable Bio-products at a faster rate





BioSUCCEED Metrics

- Number of other universities that adopt some or all of the classes
- Number of students who have taken classes developed by the program and have graduated
- Sample Survey Questions <http://www.surveymonkey.com/s/ZMNRQXL>:
 - » Based on the information that you have seen and understood in BioSUCCEED, its work, and any documentation related to it, what difference in the marketability and employability will there be for the following categories of personnel after completing the coursework/materials in BioSUCCEED and offshoots of it?
 - » Has either BioSUCCEED or some offshoot of it influenced your ability to improve or enhance your job performance/pay/advancement or those of people within your circle of influence?
 - » Should the concept of BioSUCCEED be pursued in post-secondary learning establishments?





Communication Resources

- Web-site: www.ncsu.edu/biosucceed/
- Facebook:
<http://www.facebook.com/group.php?gid=396008630920>
- Blog: <http://biosucceed.blogspot.com/>





Conclusions

- First phase of the BioSUCCEED effort has been accomplished with course notes developed and posted on the BioSUCCEED website
- New courses approved at the three partner universities are being taught
- Preliminary data indicate that students on the three partner campuses are being positively impacted by the BioSUCCEED activities
- Impact outside of the partners is not clearly established at this point
- BioSUCCEED does appear to be a viable model for providing up to date course information in an emerging field of study





Acknowledgments

- *“Higher Education Challenge Grant with CREES/USDA” (Cooperative Grant No. 2006-38411-17035)*
- Gregory Smith, Program Officer USDA

