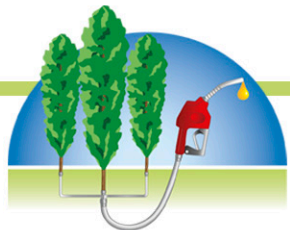


# Bioenergy Science and Engineering as Components of Agricultural Ed Curricula

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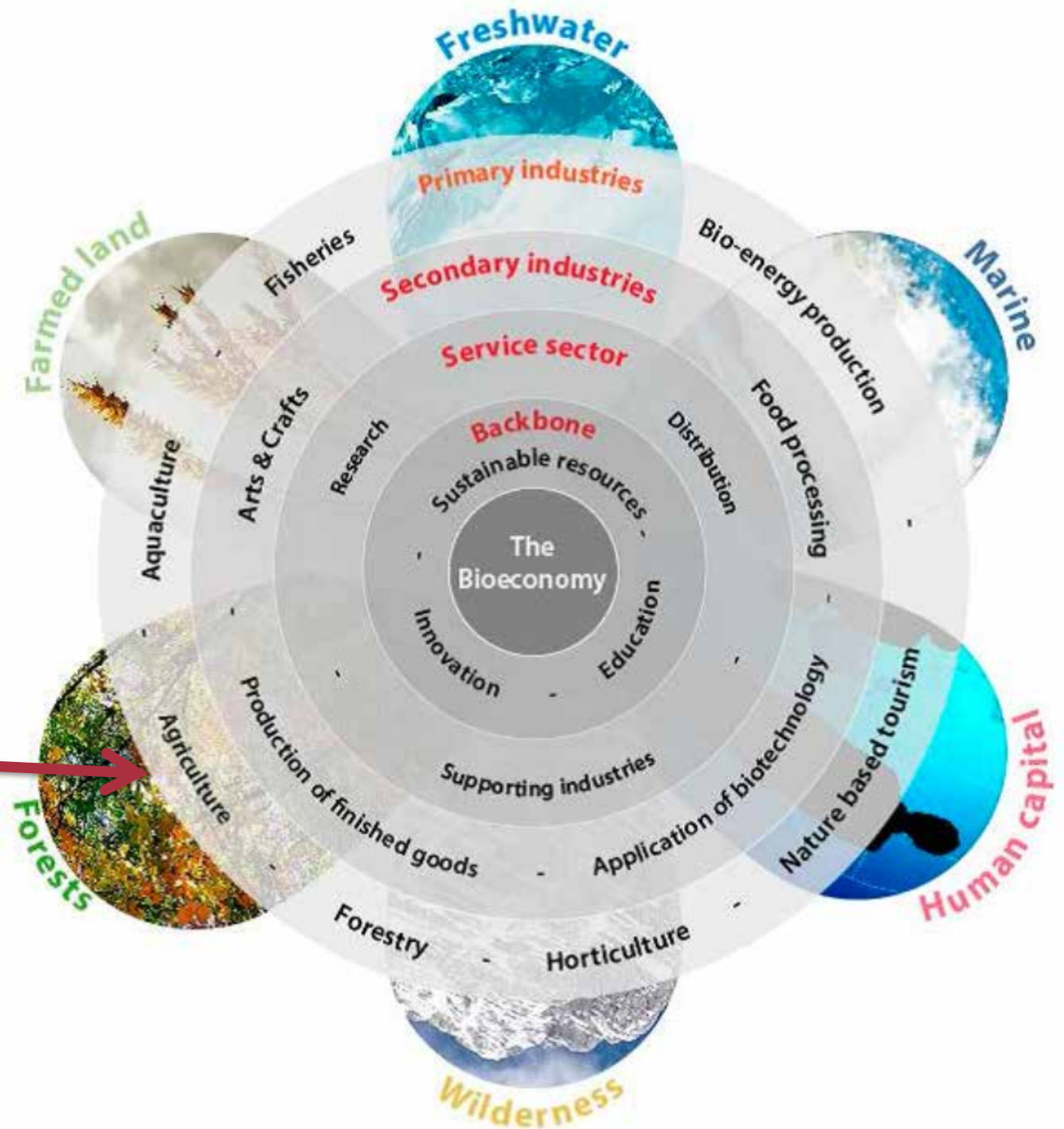
Advanced **Hardwood Biofuels** Northwest  
[hardwoodbiofuels.org](http://hardwoodbiofuels.org)



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# Context



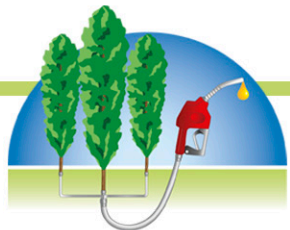
# Motivation

- World energy consumption is predicted to increase by 56 percent between 2010 and 2040 ([www.eia.gov](http://www.eia.gov))
- Biomass constitutes 50% of U.S. renewable energy production (US Energy Administration, 2013)
- 1001 American adults surveyed: 51% can't name one renewable fuel
  - ethanol (6%)
  - wood (2%)
  - “biofuels” (2%)
  - biodiesel (1%)
  - garbage (1%) (Bittle, Rochkind, & Ott, 2009)
- 1% of students scored above 80% on an energy survey (Dewaters & Powers, 2008)
- Currently there is a severe deficiency in programs and classes dedicated to bioenergy (Ransom & Maredia, 2012)



# Initial Study – Delphi

- Bioenergy experts n=21(8) – Bioenergy or energy education researchers
- “What should be taught for Bioenergy K-12?”
- Mixed-methods Delphi study
  - Qualitative round 1 – Concept identification
  - Quantitative round 2 – Concept narrowing
  - Quantitative round 3 – Concept priority

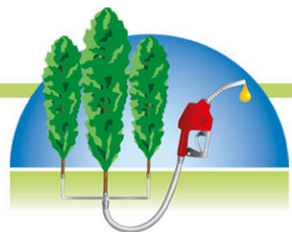


# K-12 Bioenergy Concepts

Concept	Rating	SD
<b>Energy Requirements:</b> Quantity and type of energy needed	4.88	.35
<b>Energy Consumption:</b> Current and historical energy sources	4.88	.35
<b>Climate Change:</b> Historical record and consequences	4.88	.52
<b>Nature of Engineering:</b> Role of engineering in bioenergy	4.62	.52
<b>Energy Fundamentals:</b> Work, energy, conversions	4.63	.52
<b>Lifecycle Assessment:</b> Environmental impacts cradle to grave	4.50	.52
<b>Photosynthesis:</b> How light energy is stored in plants	4.38	.46
<b>Conversion Principles:</b> Types of conversions	4.38	.52
<b>Chemical Cycles:</b> Water, carbon, nitrogen cycles	4.25	.35
<b>Ecosystems:</b> Ecology and human impact	4.25	.52

# Follow-on Study

- Ag education –Develop future bioenergy innovators, potential for bioenergy integration
- Research questions:
  - Which are bioenergy concepts are included Western US agricultural education standards?
  - Which states implement bioenergy at the highest level?

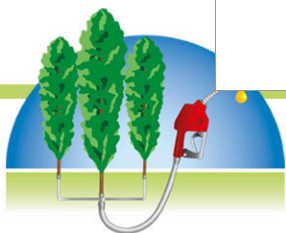
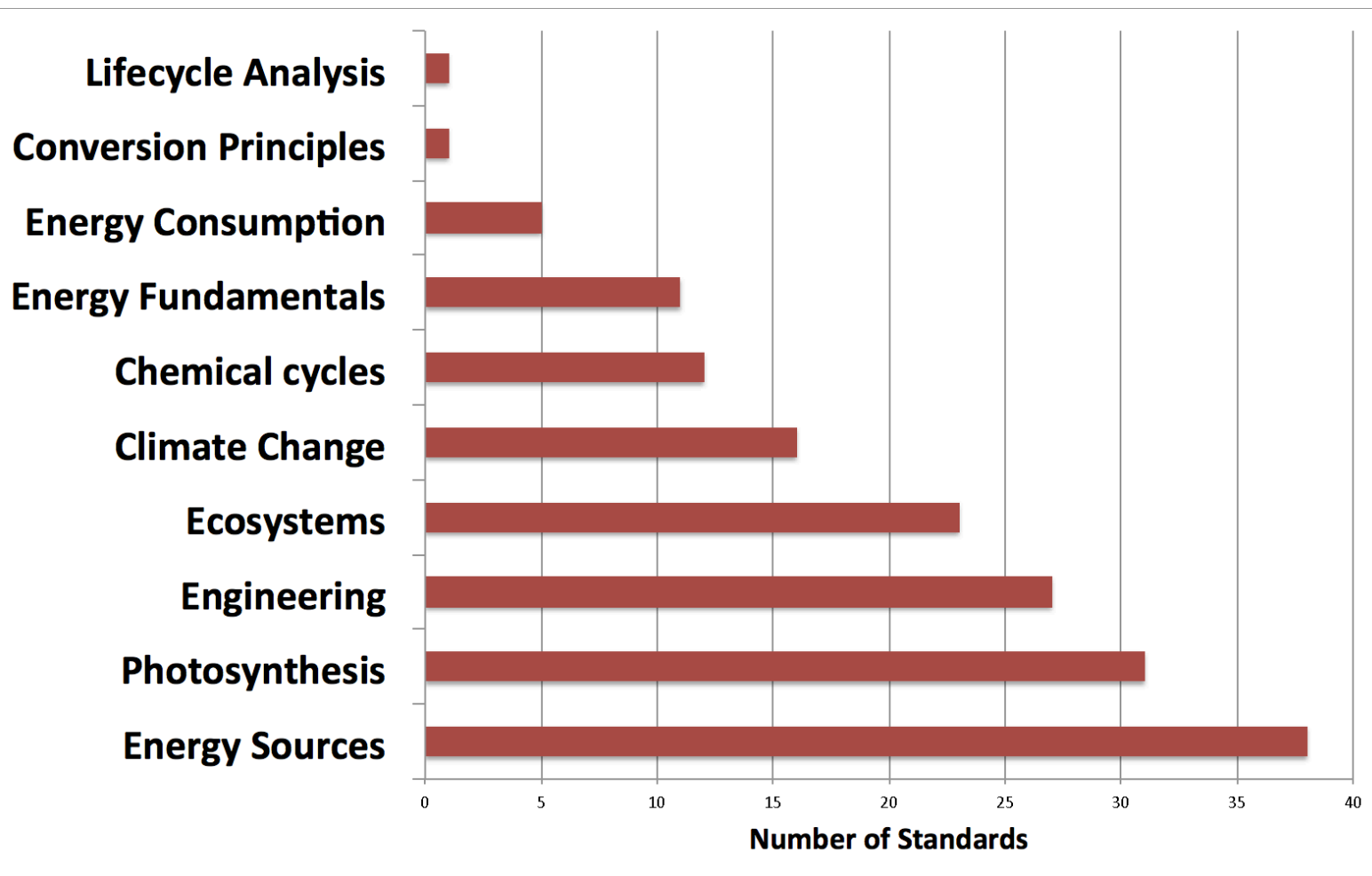


# Methods

- Internet search for state-level Ag Ed standards
- 24 Western states / ID 12 with Ad Ed standards
- Cross reference to national repositories: Education Commission, Advance CTE
- Identified 17,850 standards / 743 average state
- Manual and electronic keyword search for bioenergy concepts

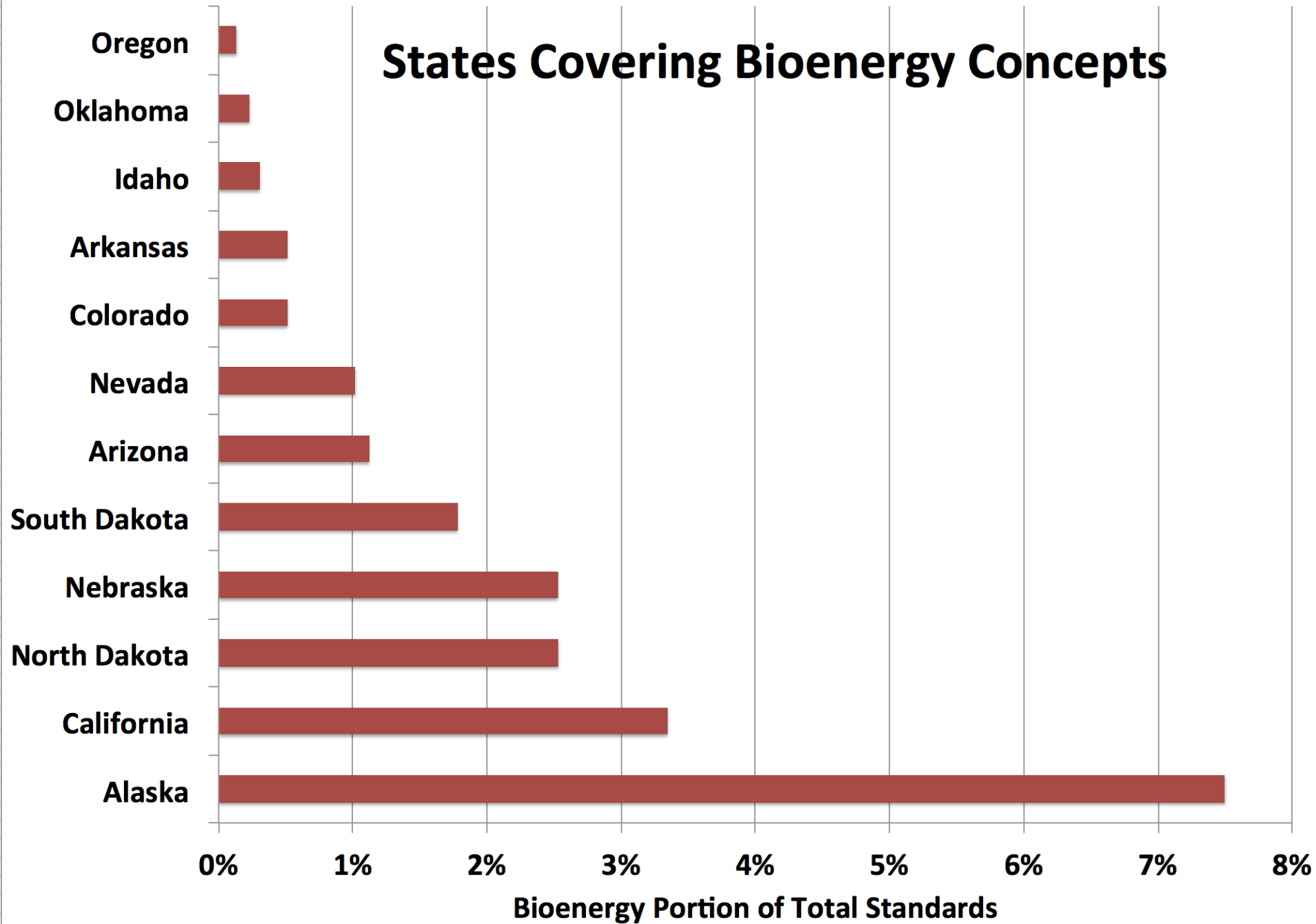


# Bioenergy Concepts in State Ag Ed Standards



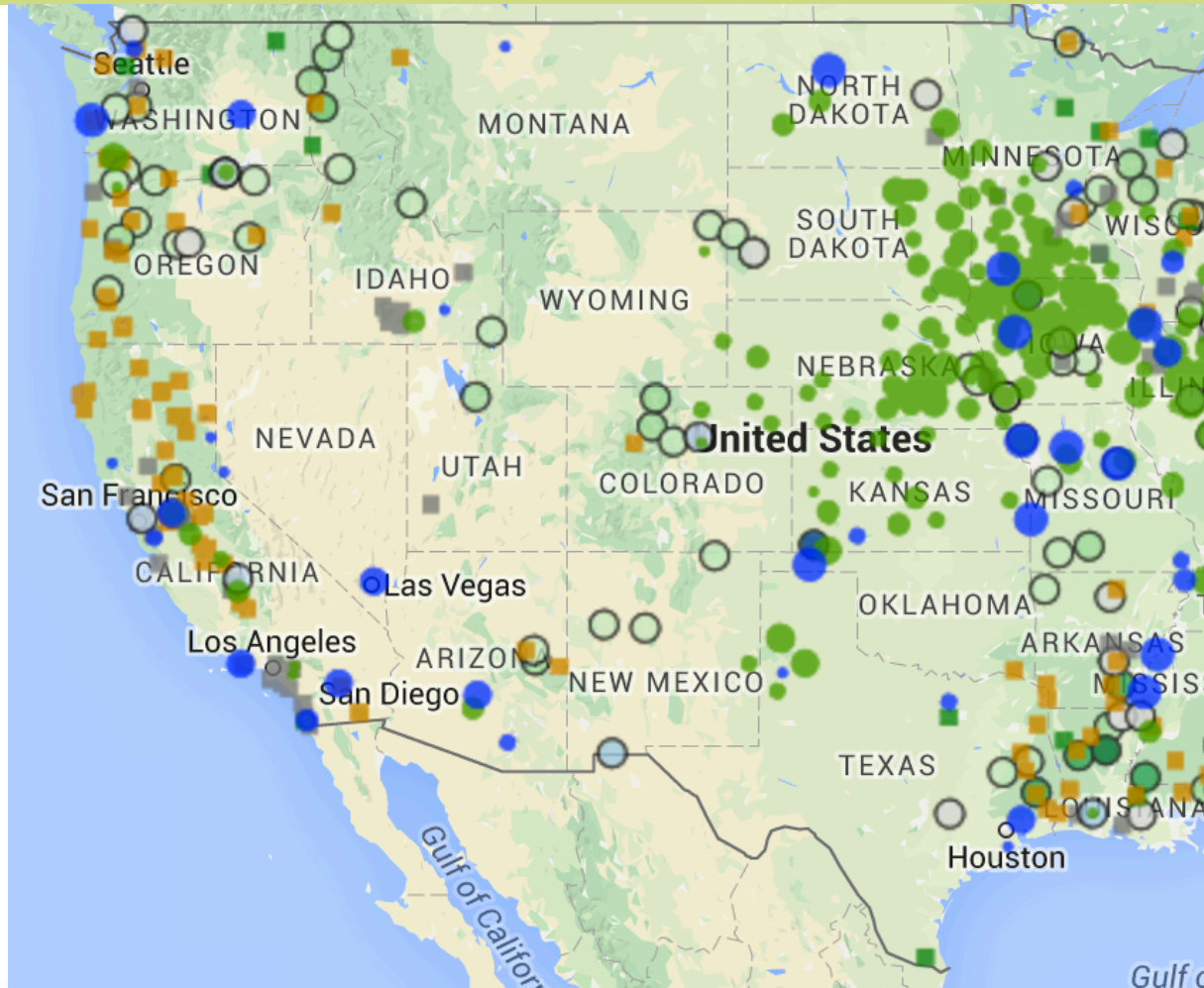


# States Covering Bioenergy Concepts



No Ag Ed Standards: Wyoming, Washington, Utah, Texas, New Mexico, Montana, Missouri, Minnesota, Louisiana, Kansas, Iowa, Hawaii

# Bioenergy Facilities



Ethanol  
Biodiesel  
Biorefinery  
Wood

NREL.org



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# Example Standards

- Conversions
  - “Compare various methods for using animal waste and the environmental impacts associated with each method.”
- Energy Sources
  - AZ – “Compare fossil fuels and biofuels and how they are affecting the environment”
- Energy Consumption
  - NV – “Explain the trade-off of population growth, greater energy demands ... on the environment”



# Example Standards

- Energy
  - CA – “Analyze the way in which human activities influence energy cycles...”
  - NV – “Investigate the first and second laws of thermodynamics”
- Chemical Cycles
  - NV – “Diagram and explain the nitrogen, phosphorus, carbon, and water cycles”
  - NE – “Describe natural biogeochemical cycles”



# Implications

- All basic bioenergy concepts are covered in at least one Western state's agricultural education standards.
- All states with Ag Ed Standards included bioenergy concepts.
- Opportunity for states to expand bioenergy content and explicitly include bioenergy in standards
- Recommend development of bioenergy curriculum for Ag Ed
- Recommend professional development program in bioenergy for Ag Ed teachers



# Thank You

- Contact
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