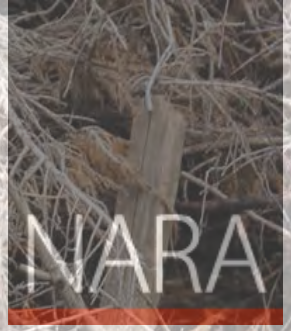

Education at the Speed of Research: Integrating Research and Education for BioEnergy Literacy

Dr. R. Justin Hougham, University of Wisconsin-Extension
Upham Woods Outdoor Learning Center
Alex Nussbaum – Lead Research Naturalist
Taylor Riedl – Research Naturalist
Marc Nutter – Research Naturalist
Sarah Burgess – Research Naturalist
Northwest Advanced Renewables Alliance- Education and Outreach

SUPPLY CHAIN PRODUCTS

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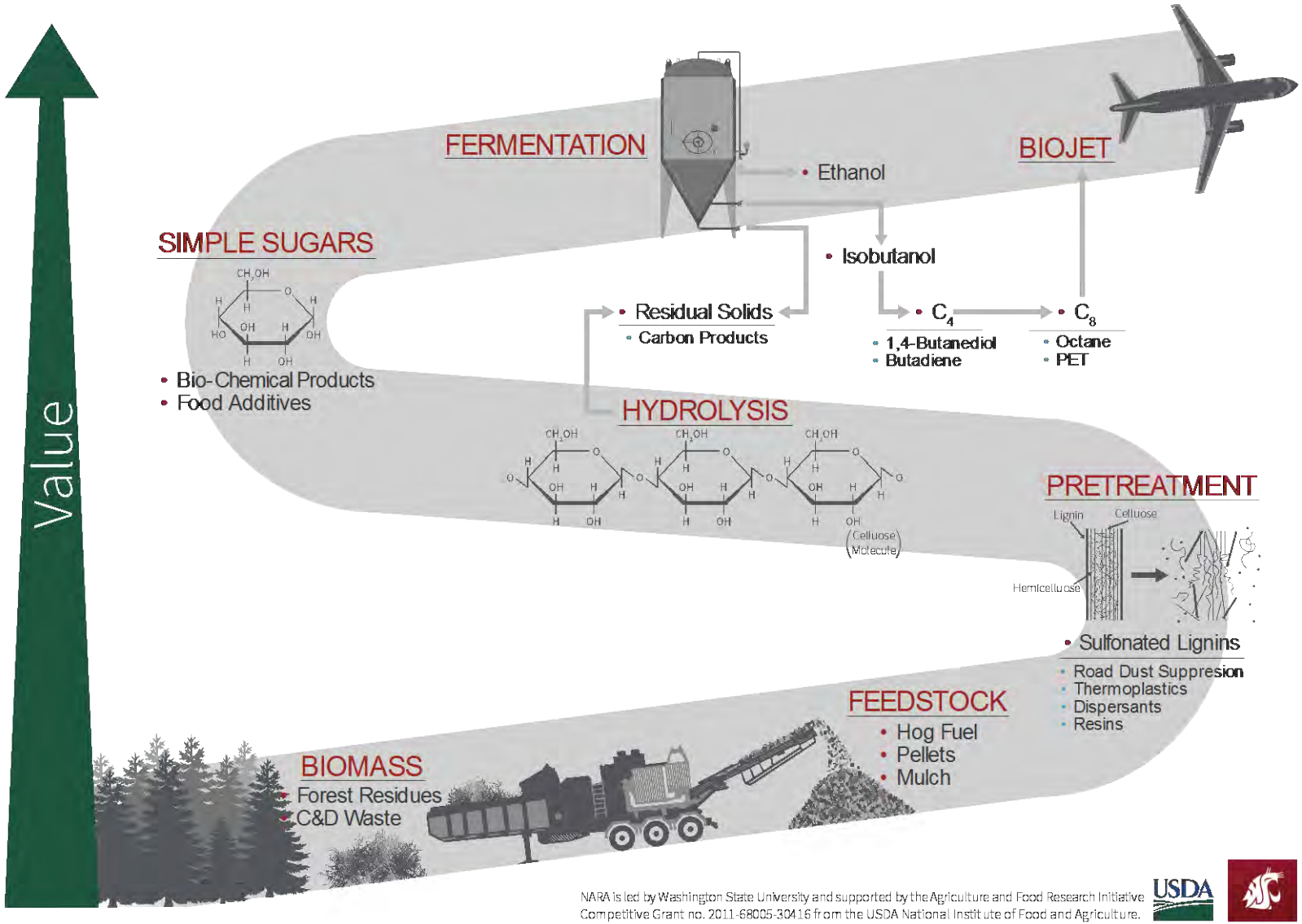
Northwest Advanced Renewables Alliance



NARA is led by Washington State University and supported by the Agriculture and Food Research Initiative Competitive Grant no. 2011-68005-30416 from the USDA National Institute of Food and Agriculture.

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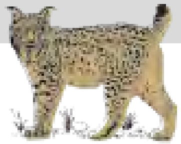
WOOD TO WING

Measuring the environmental impact of converting forest residuals into bio-jet fuel and other co-products.

Converting forest residuals into chemical products such a bio-jet fuel is anticipated to provide numerous benefits to society. As biofuels displace fossil fuels, U.S. energy independence is strengthened and net carbon emissions are reduced. A novel use for forest residuals can stimulate rural economic development and reduce fuel loads in the forest.

NARA funds research to determine how using forest residuals affects forest ecosystems, water and air quality so that regional stakeholders and society can make informed decisions.



WILDLIFE

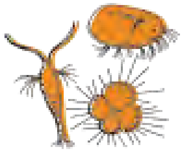
NARA researchers are studying the potential impact of forest residual removal on vertebrate abundance.
http://goo.gl/IbJQRe

AIR QUALITY

NARA is completing a "Life Cycle Assessment" that compares petroleum-based jet-fuel to forest residual-based blended jet-fuel for greenhouse gas emissions, ozone depletion, and smog emissions.
http://goo.gl/90JQIZ http://goo.gl/pYAyLD

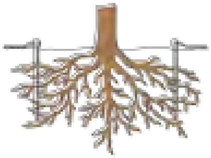
WATER QUALITY

Models to predict water quality, quantity, and the effects on stream channels under various residual harvest scenarios are being developed.
http://goo.gl/4GuwmU



MICROFAUNA

NARA researchers are collecting and examining microbial communities at test spots to understand the effects of forest residual removal and harvesting on microfauna.
http://goo.gl/RprOS3



SOIL NUTRIENTS

NARA is funding research to ensure that soil nutrient pools remain sustainable in working forests when limited forest residuals are removed.
http://goo.gl/[illegible] http://goo.gl/[illegible]

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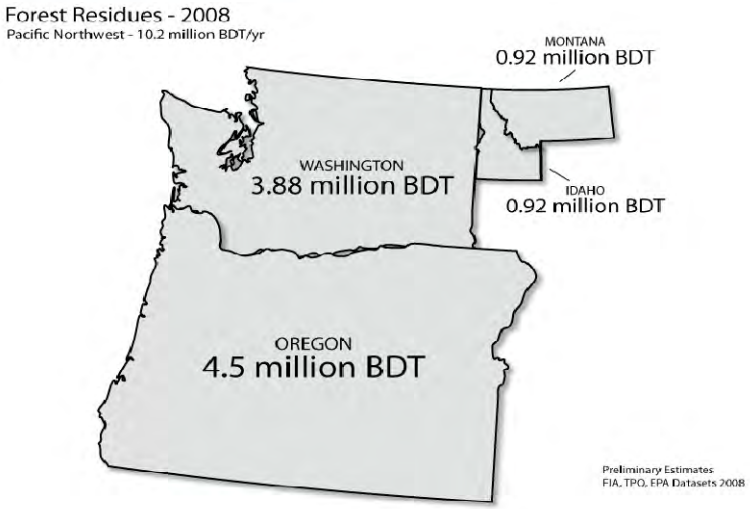
NARA Feedstock --- Wood Waste

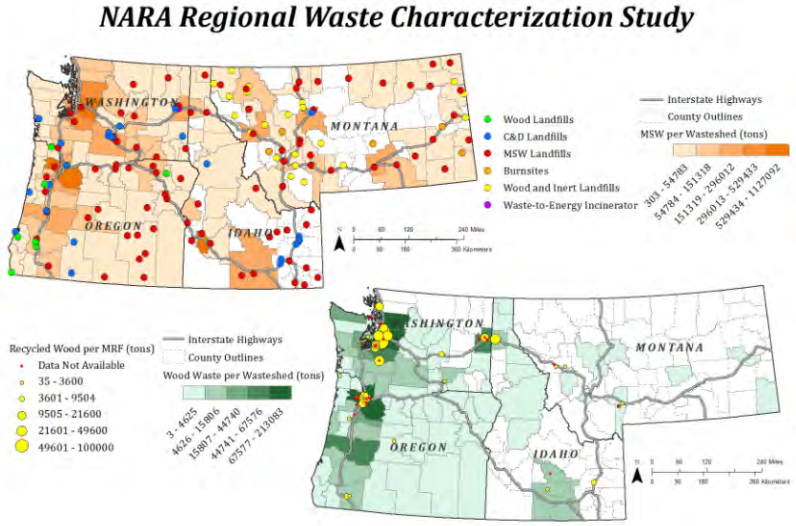
Forest Residues

Treetops and branches remaining on the ground after forest operations or accumulated as a result of natural disturbances such as storm, fire, insects and diseases



Construction & Demolition (C&D)

Nonhazardous painted, treated, and coated wood and wood products resulting from construction, remodeling, repair, or demolition of utilities, structures, and roads[1]



[1] http://www.epa.state.il.us/small-business/construction-debris/

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United States Department of Agriculture
National Institute of Food and Agriculture

NARA

GS Grade School	MS Middle School	HS High School	UG Undergraduate	GR Graduate	PR Professional
MOSS	Facing the Future MOSS	Facing the Future MOSS Imagine Tomorrow with BioFuels	MOSS BioFuels SURE IDeX Salish Kootenai College Western Washington University	MOSS IDeX	MOSS

BIOENERGY IN EDUCATION

Facing the Future

GS MS HS UG GR PR

A NW regional nonprofit developing inquiry based curricula for grades 6-12 on biofuel development.

www.facingthefuture.org

MOSS

GS MS HS UG GR PR

Promotes biofuel literacy to K-12 students, Grad students, and teaching professionals.

uidaho.edu/cnr/moss

BioFuels SURE

GS MS HS UG GR PR

Summer research experience for undergraduates aimed at giving them hands on skills in biofuels and bio-products research.

nararenewables.org/ed

IDeX

GS MS HS UG GR PR

A year long course for UI and WSU students providing supply chain analysis for an emerging wood products to biofuels industry.

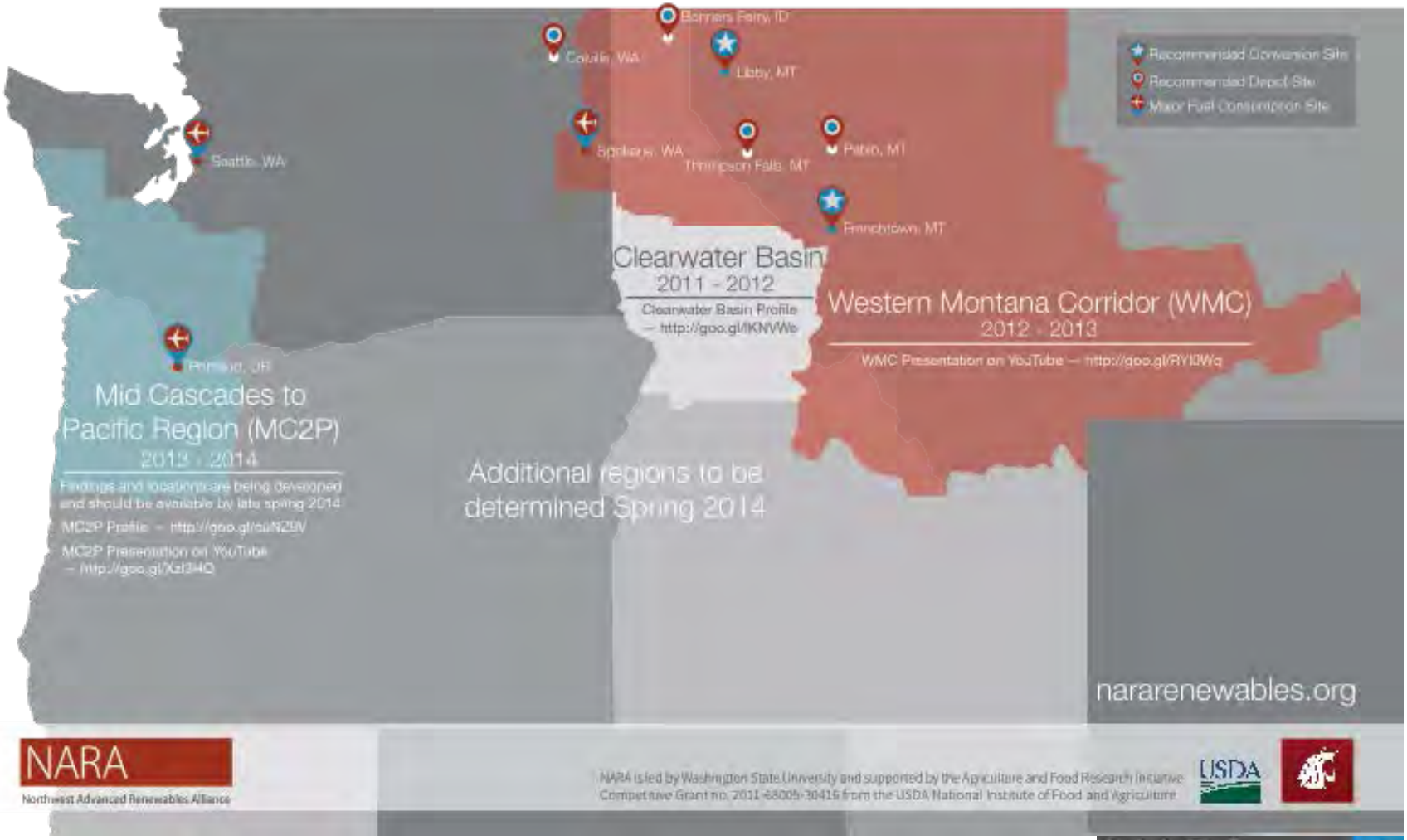
idexstudio.org

NARA

Wood to Wing

Forest Residuals to Biofuel Supply Chains in the Pacific Northwest

Applying research-based findings, NARA and regional stakeholders identify conversion and depot sites in the Pacific Northwest. These site locations provide the best opportunity for economic, social and environmental success to develop a forest residuals to biofuel and co-products industry.



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SUPPLY CHAIN

FRP

FOREST RESIDUES PREPARATION

Primary feedstock targets include forest residues from logging and thinning operations. We are also considering mill residues and discarded woody material from construction and demolition, in regions where these materials are under utilized.

T

TRANSPORTATION

Feedstocks are transported from the collection site to a conversion facility. Chipping can take place at the loading or in a preprocessing facility.

PT

PRE-TREATMENT

Wood chips are treated to make the sugar polymers (polysaccharides) accessible to degrading enzymes. These processes allow the lignin to be available for separation.

EH

ENZYMATIC HYDROLYSIS

Specific enzymes are added to hydrolyze (cleave) the polysaccharides and generate simple sugars (monosaccharides).

F

FERMENTATION

Specialized yeast convert the monosaccharides into isobutanol.

BCP

BIOJET & CO-PRODUCTS

Aviation fuels can be generated from the platform molecules derived from wood sugars. Lignin can be used to generate co-products such as epoxies, structural materials and bio-based plastics. As an alternative, lignin can be burned to produce renewable energy.

ONE BONE DRY **TON** WOODY BIOMASS + DIESEL + HEAT, WATER, & CHEMICALS = **~600** POUNDS LIGNIN AND **~59** GALLONS ISOBUTANOL OR **~42** GALLONS BIOJET

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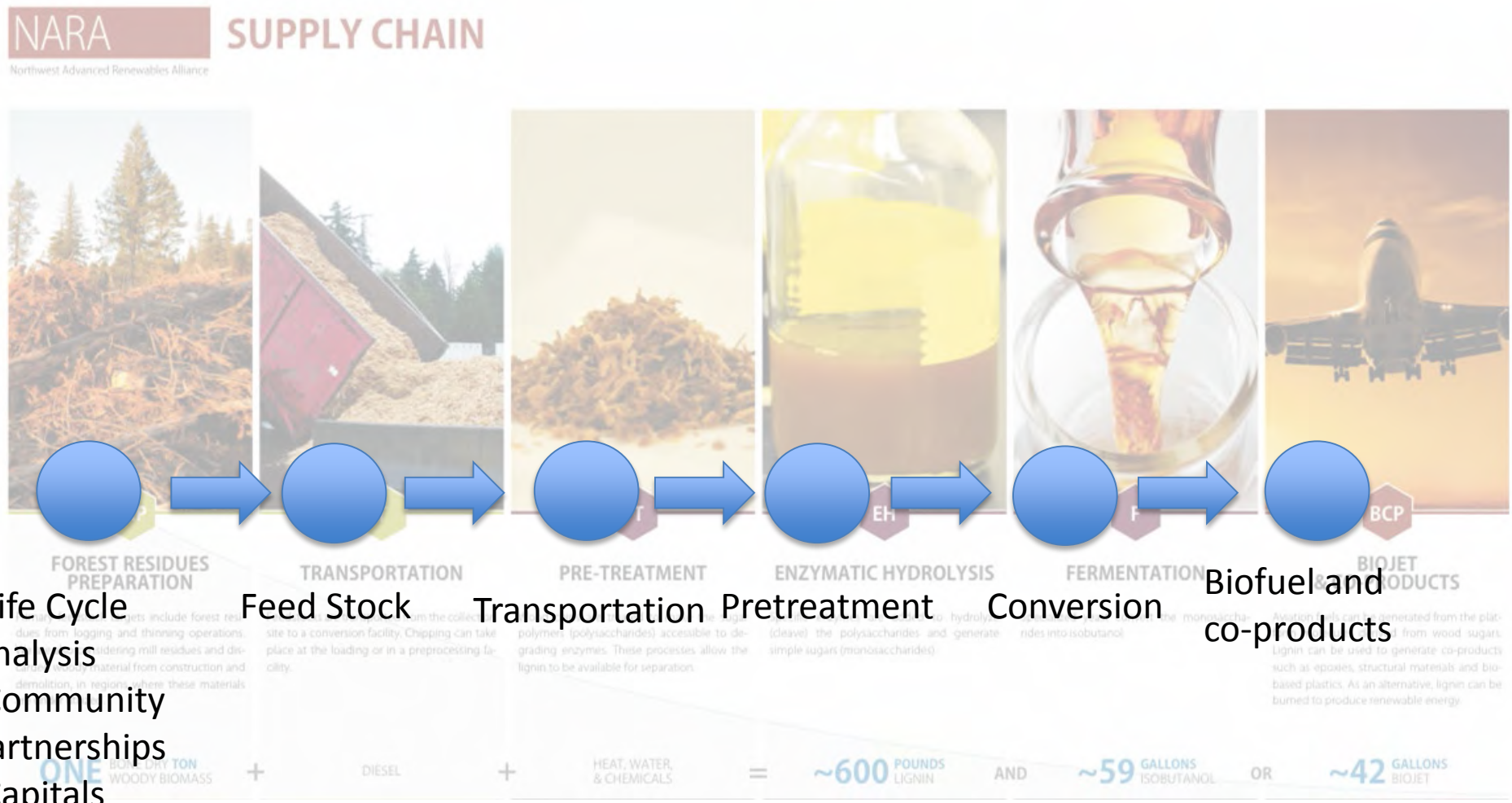
Flow for Education and Outreach of NARA research



-Life Cycle Analysis
-Community Partnerships
-Capitals Framework

Feed Stock

Transportation

Pretreatment

Conversion

Biofuel and co-products

NARA

Flow for Education and Outreach of NARA research

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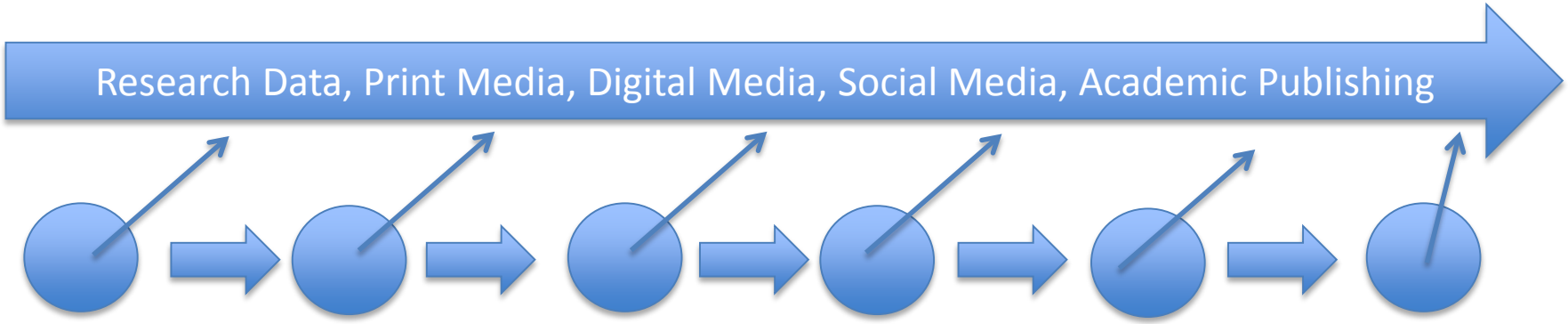

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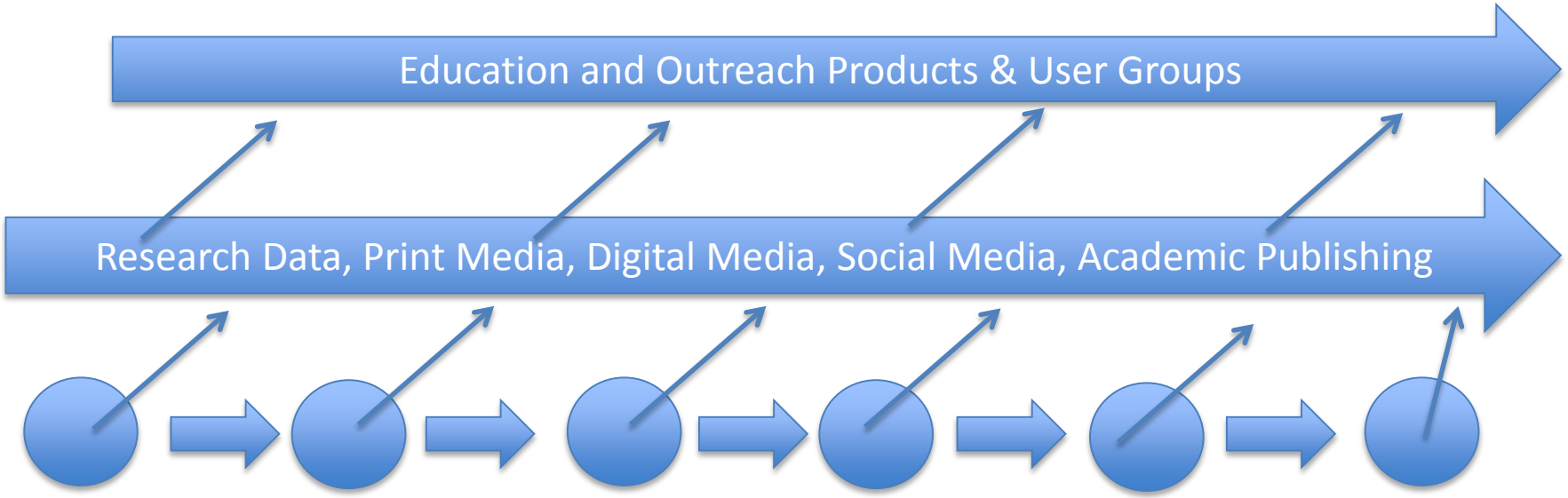

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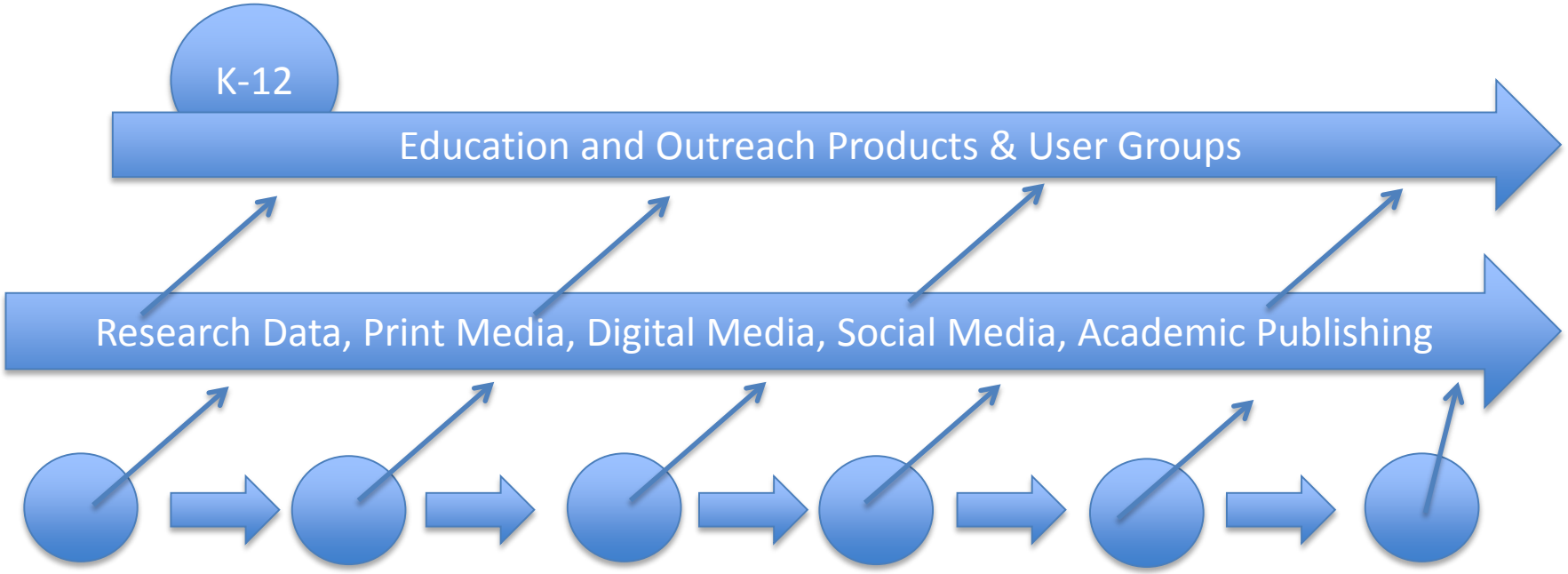

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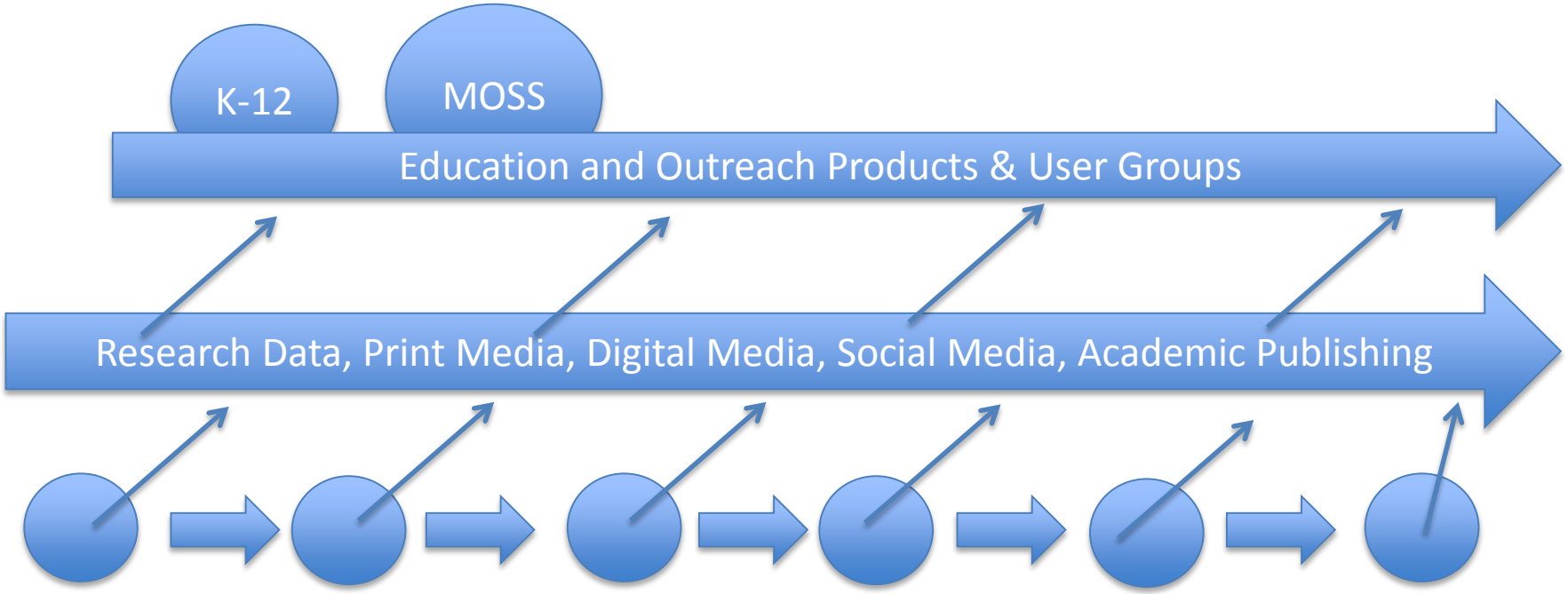

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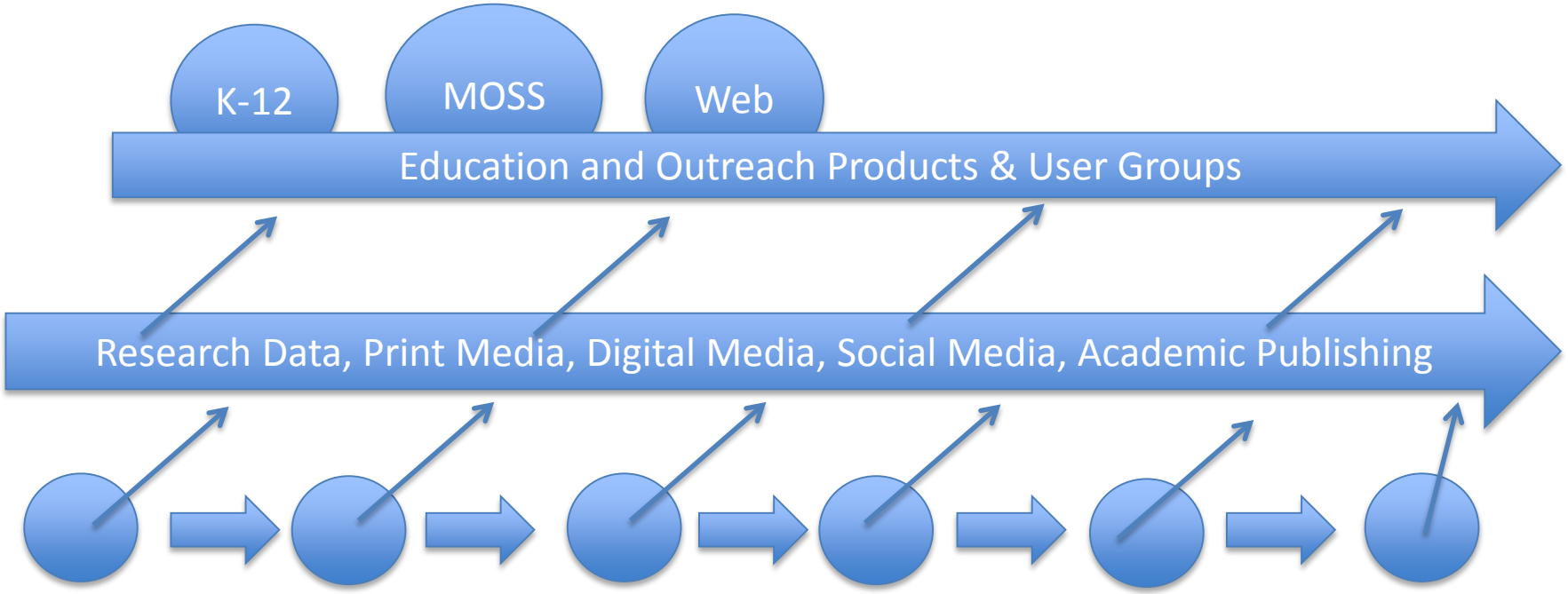

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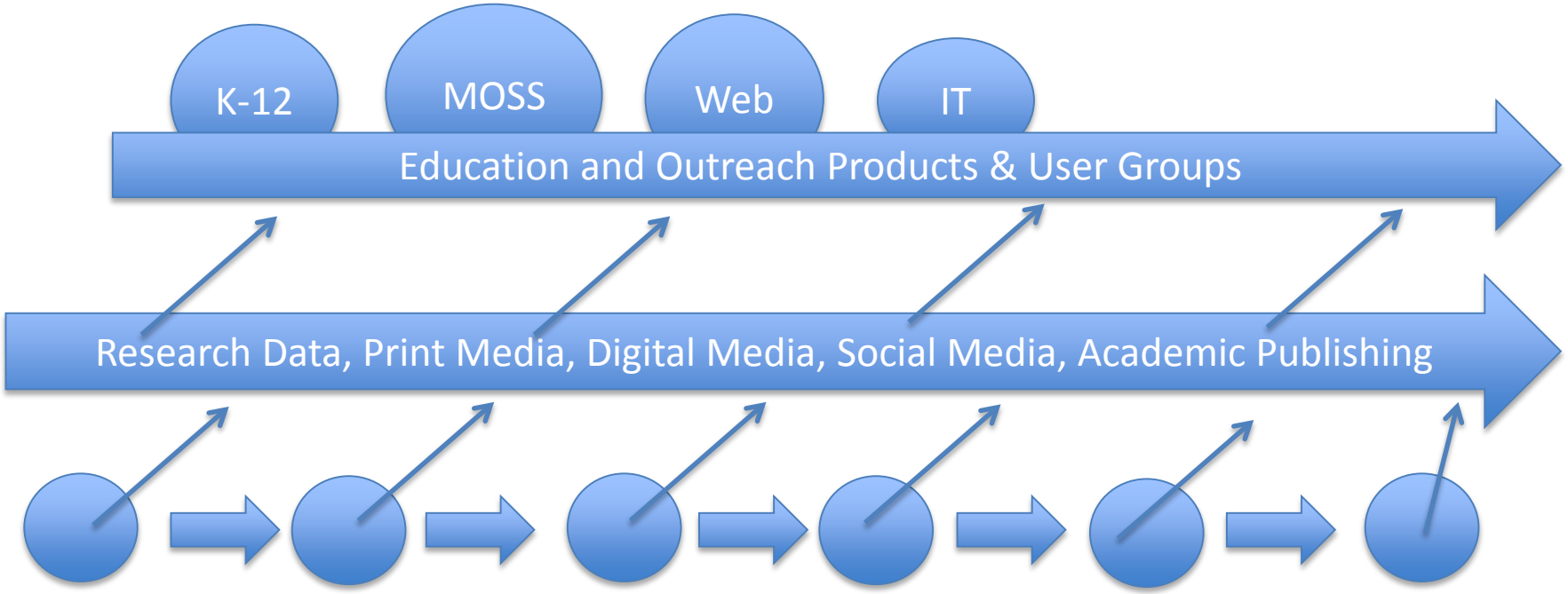

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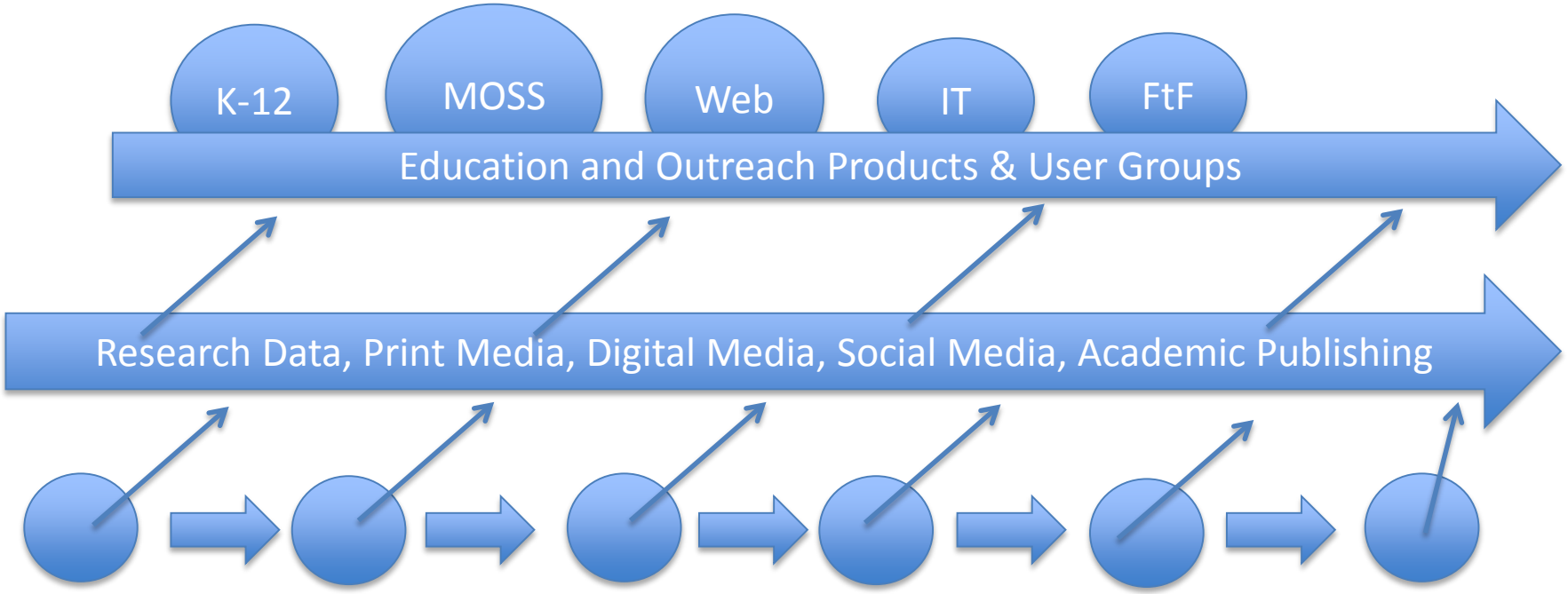

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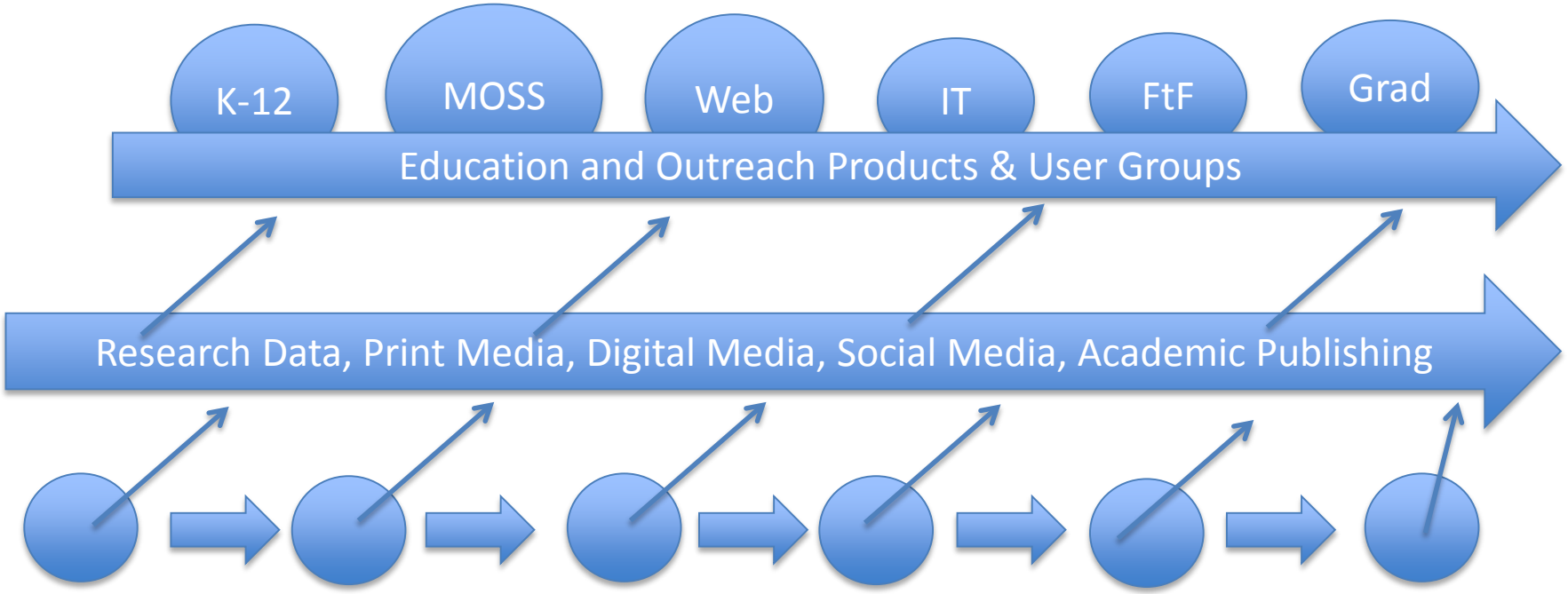

-Life Cycle Analysis
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Feed Stock

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Pretreatment

Conversion

Biofuel and co-products

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Education and Outreach Connections

1 NARA Supply Chain

1) Forest Residues Preparation
2) Transportation
3) Pretreatment
4) Enzymatic Hydrolysis
5) Fermentation
6) Biojet + Co-products

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Long Term Soil Productivity

LCA
Sustainability
and
Context

NARA

Stakeholder Outreach Efforts

NARA

Stakeholder Outreach Efforts

NARA

Stakeholder Outreach Efforts

NARA

Stakeholder Outreach Efforts

NARA

Stakeholder Outreach Efforts

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Education and Outreach Connections

② Research Products

1) Research Data
2) Academic Publishing
3) Social Media
4) Print Media
5) Digital Media

① NARA Supply Chain

1) Forest Residues Preparation
2) Transportation
3) Pretreatment
4) Enzymatic Hydrolysis
5) Fermentation
6) Biojet + Co-products

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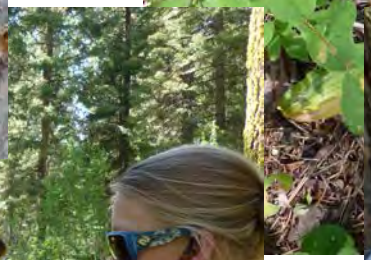
Outdoor Science Schools

MOSS Graduates Field testing curriculum



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Students using curriculum

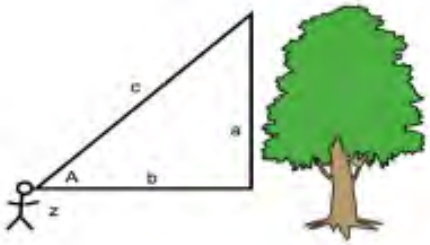
NARA

Field testing curriculum

Explore:

Complete the following steps.

1. Determine the height of your tree.



Distance from base of tree out on meter tape so you can see the top of the tree (b): _____ m

Angle on clinometer from ground to top of tree (A):_____ degrees

Distance from ground to observer's eyes (z):_____ m

Height of tree = H = ((tanA x b) + z

H = _____m

2. Measure the circumference of the tree.

Circumference of tree:_____cm

3. Determine the amount of Carbon in the tree

Using the "How Much Carbon Is in a Tree" chart

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McCall Outdoor Science School

JET FUEL CALCULATIONS

HEIGHT OF TREE → m

CIRCUMFERENCE OF TREE → m

CARBON IN THE TREE → kg

"How Much Carbon is in a Tree?" Chart

JET FUEL MILES TREE CONTAINS → miles using whole tree

"How Far Can I Fly?" Chart

÷ 2 = miles actually used

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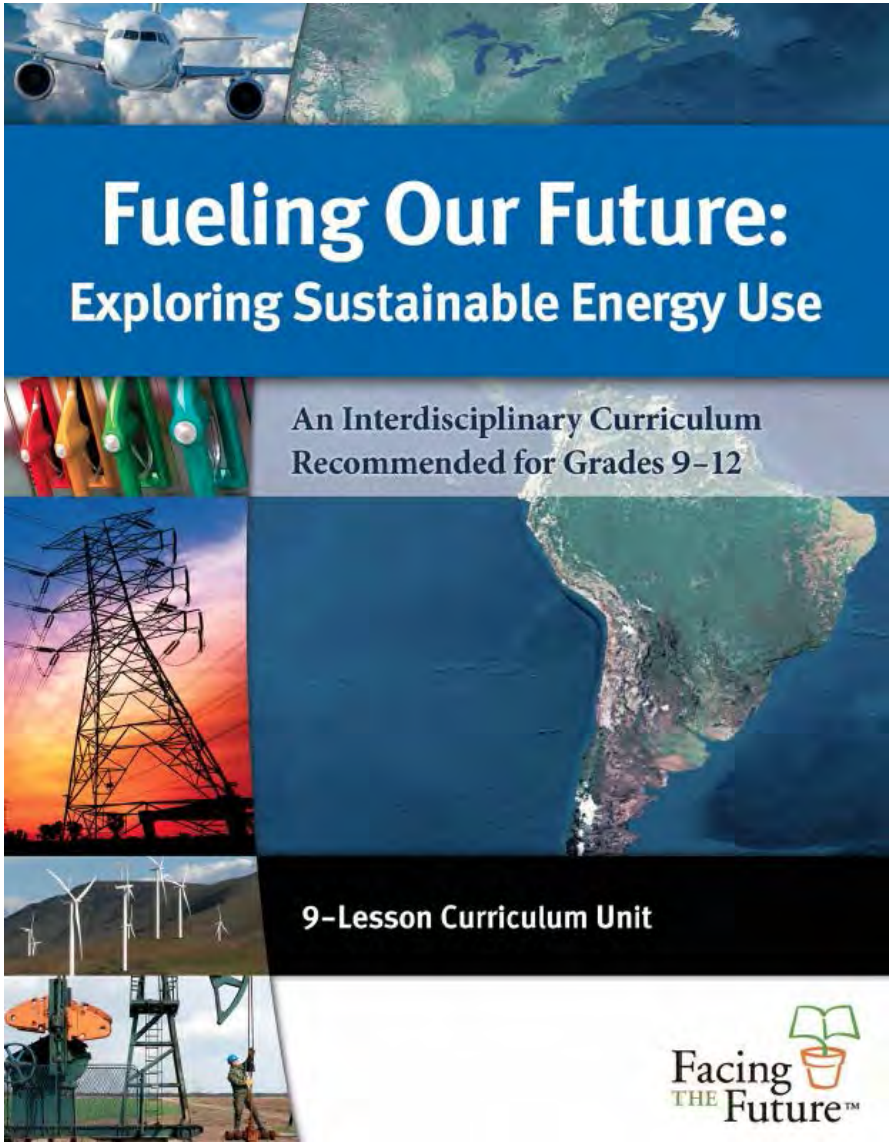

Name Date Class

Scenario: Sustainable Flight in the Pacific Northwest

The federal government has mandated that an increasing amount of biofuel be mixed into jet fuel over the next few years in order to reduce the amount of crude oil used in the nation. The federal government has established regional councils to help identify the most sustainable biofuel feedstock(s) for different regions in the nation. You have been selected to be a part of the Pacific Northwest Regional Biofuel Council. This region includes Washington, Idaho, Montana, and Oregon. Over the next few days, you will:

- identify and understand the reasons for developing aviation biofuels,
- conduct research on different kinds of biofuels and consider their impacts on the environment,
- represent a specific stakeholder at a negotiation, identify other stakeholders' perspectives, and create a policy that identifies a sustainable fuel mix for the Pacific Northwest region,

so that you can answer the following question:

What are the most sustainable biofuels that can be produced in the Pacific Northwest for aviation?

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Education and Outreach Connections

3 Education and Outreach Products & User Groups

1) K-12
2) Outdoor Science Ed
3) Webinars and Workshop
4) Collegiate Course Work

2 Research Products

1) Research Data
2) Academic Publishing
3) Social Media
4) Print Media
5) Digital Media

1 NARA Supply Chain

1) Forest Residues Preparation
2) Transportation
3) Pretreatment
4) Enzymatic Hydrolysis
5) Fermentation
6) Biojet + Co-products

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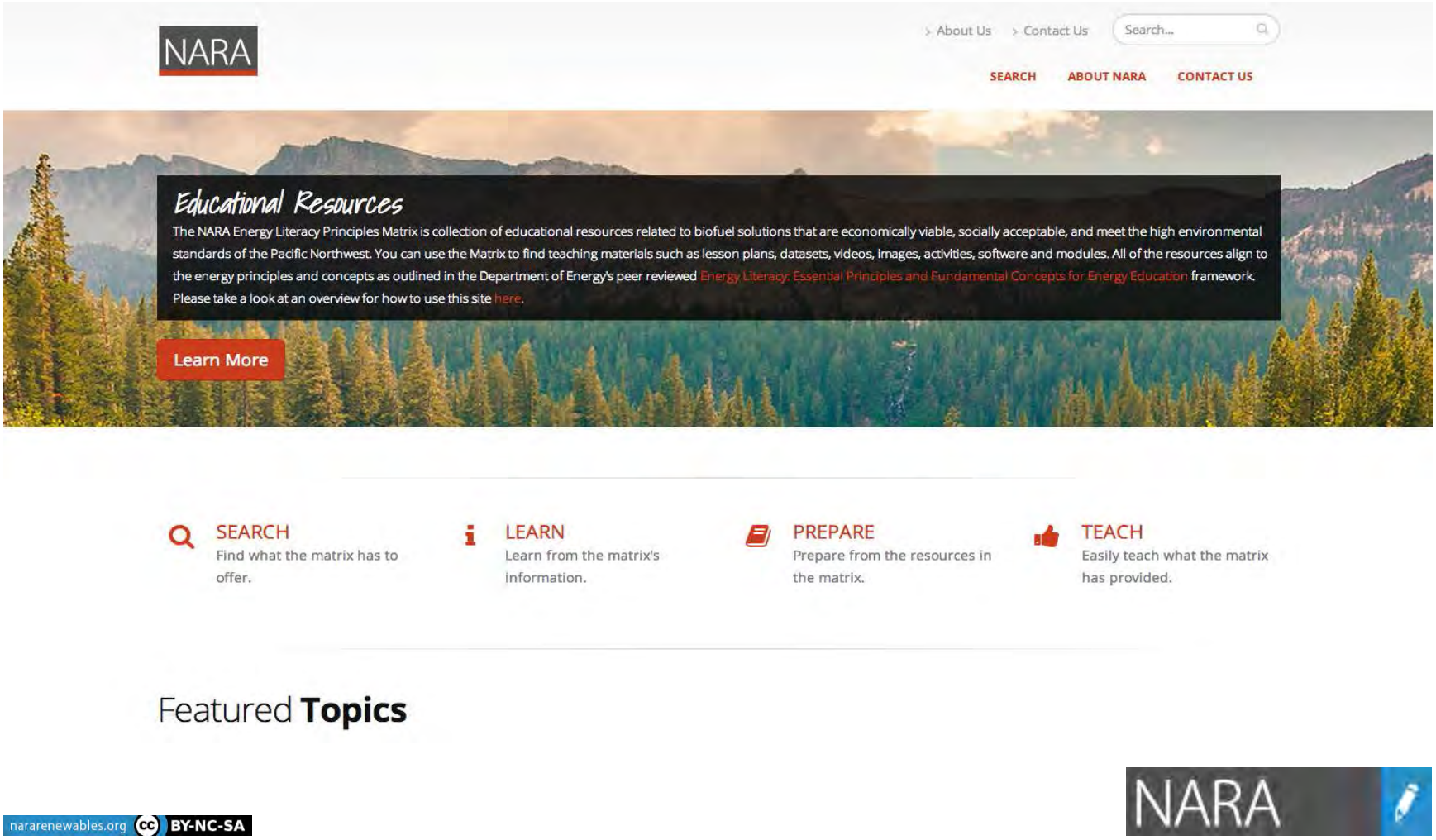
EnergyLiteracyPrinciples.org



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Energy Literacy Framework

ENERGY | Renewable Energy

Energy Education & Workforce Development

Energy Education & Workforce Development
SEARCH
Search Help

EERE » Energy Education & Workforce Development

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- K-12 Lesson Plans & Activities
- Energy Literacy
  - Energy 101
- Education & Professional Development
- Fellowships, Postdoctoral Research Awards, & Scholarships
- Competitions
- Green Your School
- EERE Office Activities
- Multimedia
- Related Links
- Contacts

Energy Literacy: Essential Principles and Fundamental Concepts for Energy Education

What is Energy Literacy?

Energy Literacy is an understanding of the nature and role of energy in the world and daily lives accompanied by the ability to apply this understanding to answer questions and solve problems.

An energy-literate person:

- Can trace energy flows and think in terms of energy systems.
- Knows how much energy they use, for what purpose, and where the energy comes from.
- Can assess the credibility of information about energy.
- Can communicate about energy and energy use in meaningful ways.
- Is able to make informed energy use decisions based on an understanding of impacts and consequences.

What is the Energy Literacy Framework?

Energy Literacy: Essential Principles and Fundamental Concepts for Energy Education is an interdisciplinary approach to teaching and learning about energy. The framework identifies seven Essential Principles and a set of Fundamental Concepts to support each principle. The guide does not seek to identify all areas of energy understanding, but rather to focus on those that are essential for all citizens K-Gray. It presents energy concepts that, if understood and applied, will help individuals and communities make informed energy decisions.

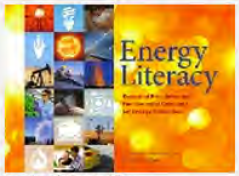
Who led the development of the Energy Literacy document?

The *Energy Literacy* document is the culmination of public listening sessions and thousands of experts from diverse fields of study contributing to a dialogue about what an energy literate person should know and understand. This included over 20 recognized educational partners and 13 federal agencies that comprise the U.S. Global Change Research Program Partner agencies.

How should we approach energy literacy?

Energy Literacy looks at energy through the lens of natural science as well as social science. Energy issues require an understanding of civics, history, economics, sociology, psychology, and politics in addition to science, technology, engineering and mathematics. A comprehensive study of energy and curriculum designed using *Energy Literacy* should be interdisciplinary and use a

Like 84 Pin it 18



Download the guide:
High Resolution
Low Resolution
Word File

Request a copy by mail

Energy Literacy Alignment Tool

Use this Excel file to assess how many Fundamental Concepts your activity or curriculum addresses or use it as a tool for building a curriculum which addresses the entire range of Fundamental Concepts.

Preview: 7 Energy Literacy Principles

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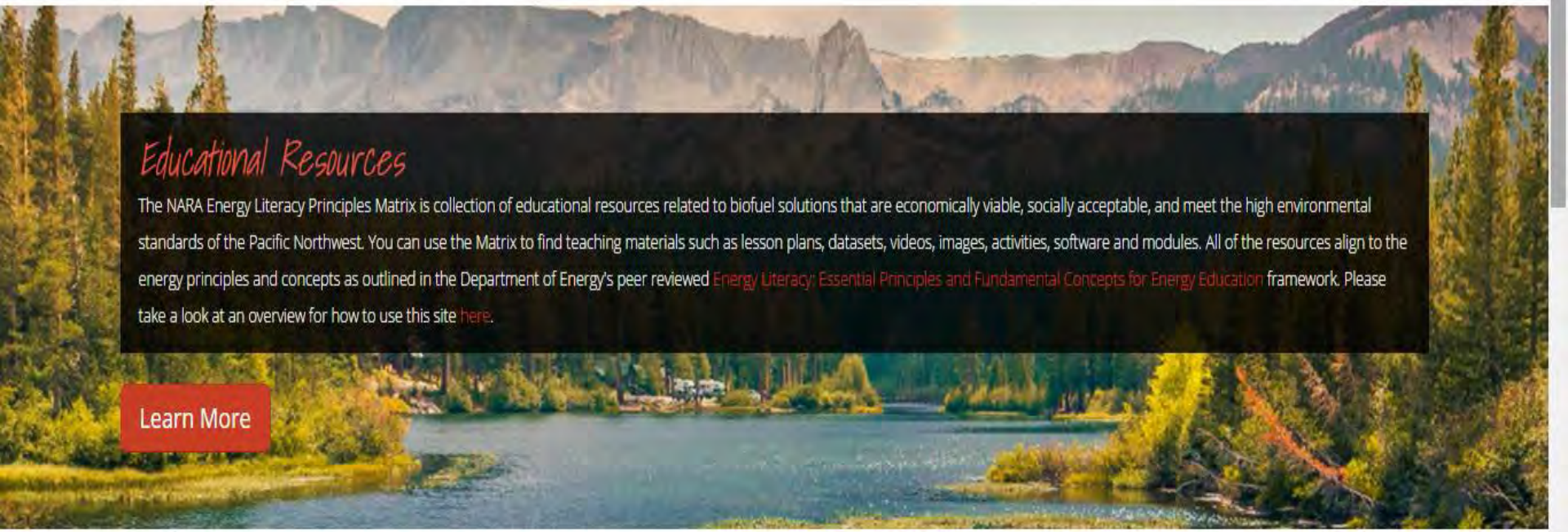

Educational Resources

The NARA Energy Literacy Principles Matrix is collection of educational resources related to biofuel solutions that are economically viable, socially acceptable, and meet the high environmental standards of the Pacific Northwest. You can use the Matrix to find teaching materials such as lesson plans, datasets, videos, images, activities, software and modules. All of the resources align to the energy principles and concepts as outlined in the Department of Energy's peer reviewed Energy Literacy: Essential Principles and Fundamental Concepts for Energy Education framework. Please take a look at an overview for how to use this site here.

Learn More

SEARCH
Find what the matrix has to offer.

LEARN
Learn from the matrix's information.

PREPARE
Prepare from the resources in the matrix.

TEACH
Easily teach what the matrix has provided.

NARA

Search

Search the NARA Matrix's vast collection of educational resources related to biofuel research. You can use the Matrix to find teaching materials such as lesson plans, datasets, videos, images, activities, software and modules.

THREE EASY WAYS TO SEARCH

BASIC SEARCH

Quickly find results through a basic key word search.

› Search Now

ADVANCED SEARCH

Use the advanced search feature to narrow results to specific areas of the matrix, topic, or resource type.

› Search Now

MATRIX BROWSER

Browse the matrix by drilling down by topic, sub-topic and resource.

› Search Now

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Basic Search

Quickly find results through a basic key word search. Enter the key word in the search box below. If you want narrow results to specific areas of the matrix, topic, or resource types please use the advanced search feature.

Search

Search

NARA

Search

Search the NARA Matrix's vast collection of educational resources related to biofuel research. You can use the Matrix to find teaching materials such as lesson plans, datasets, videos, images, activities, software and modules.

THREE EASY WAYS TO SEARCH

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MATRIX BROWSER

Browse the matrix by drilling down by topic, sub-topic and resource.

› Search Now

NARA

Advanced Search

Use the advanced search feature to narrow results to specific areas of the matrix, topic, or resource type.

Search

Filter By Topic:

Filter By Sub-Topic:

Filter By Type:

Filter By Grade Level:

1-2 3-4 5-6 7-8 9-10 11-12 Public

Search

NARA

Search

Search the NARA Matrix's vast collection of educational resources related to biofuel research. You can use the Matrix to find teaching materials such as lesson plans, datasets, videos, images, activities, software and modules.

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ADVANCED SEARCH

Use the advanced search feature to narrow results to specific areas of the matrix, topic, or resource type.

› Search Now

MATRIX BROWSER

Browse the matrix by drilling down by topic, sub-topic and resource.

› Search Now

Matrix Browser

Topic: 1. Energy is a physical quantity that follows precise natural laws.	**Topic:** 2. Physical processes on Earth are the result of energy flow through the Earth system.	**Topic:** 3. Biological processes depend on energy flow through the Earth system.	**Topic:** 4. Various sources of energy are used to power human activities.	**Topic:** 5. Energy decisions are influenced by economic, political, environmental, and social factors.	**Topic:** 6. The amount of energy used by human society depends on many factors.	**Topic:** 7. The quality of life of individuals and societies is affected by energy choices.	**Topic:** 8. Wood based bio-fuels are one form of energy that is renewable
Sub-Topic: 1.1 Energy is a quantity that is transferred from system to system.	**Sub-Topic:** 2.1 Earth constantly changes as energy flows through the system.	**Sub-Topic:** 3.1 The Sun is the major source of energy for organisms and the ecosystems of which they are a part.	**Sub-Topic:** 4.1 Humans transfer and transform energy from the environment into forms useful for human endeavors	**Sub-Topic:** 5.1 Decisions concerning the use of energy resources are made at many levels.	**Sub-Topic:** 6.1 Conservation of energy has two very different meanings.	**Sub-Topic:** 7.1 Economic security is impacted by energy choices.	**Sub-Topic:** 8.1 Sources of cellulosic residuals used are found in forest operations and in industry process
Sub-Topic: 1.2 The energy of a system or object that results in its temperature is called thermal energy.	**Sub-Topic:** 2.2 Sunlight, gravitational potential, decay of radioactive isotopes, and rotation of the Earth	**Sub-Topic:** 3.2 Food is a biofuel used by organisms to acquire energy for internal living processes.	**Sub-Topic:** 4.2 Humans use of energy is subject to limits and constraints.	**Sub-Topic:** 5.2 Energy infrastructure has inertia.	**Sub-Topic:** 6.2 One way to manage energy resources is through conservation.	**Sub-Topic:** 7.2 National security is impacted by energy choices.	**Sub-Topic:** 8.2 Transportation and logistic considerations shape cost and feasibility within supply chains.

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Topic: 1. Energy is a physical quantity that follows precise natural laws.	Topic: 2. Physical processes on Earth are the result of energy flow through the Earth system.	Topic: 3. Biological processes depend on energy flow through the Earth system.	Topic: 4. Various sources of energy are used to power human activities.	Topic: 5. Energy decisions are influenced by economic, political, environmental, and social factors.	Topic: 6. The amount of energy used by human society depends on many factors.	Topic: 7. The quality of life of individuals and societies is affected by energy choices.	Topic: 8. Wood based bio-fuels are one form of energy that is renewable
Sub-Topic: 1.1 Energy is a quantity that is transferred from system to system.	Sub-Topic: 2.1 Earth constantly changes as energy flows through the system.	Sub-Topic: 3.1 The Sun is the major source of energy for organisms and the ecosystems of which they are a part	Sub-Topic: 4.1 Humans transfer and transform energy from the environment into forms useful for human endeavors	Sub-Topic: 5.1 Decisions concerning the use of energy resources are made at many levels.	Sub-Topic: 6.1 Conservation of energy has two very different meanings.	Sub-Topic: 7.1 Economic security is impacted by energy choices.	Sub-Topic: 8.1 Sources of cellulosic residuals used are found in forest operations and in industry process
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Sub-Topic: 1.3 Energy is neither created nor destroyed.	Sub-Topic: 2.3 Earth's weather and climate are mostly driven by energy from the Sun.	Sub-Topic: 3.3 Energy available to do useful work decreases as it is transferred from organism to organism.	Sub-Topic: 4.3 Fossil and biofuels are organic matter that contain energy captured from sunlight.	Sub-Topic: 5.3 Energy decisions can be made using a systems-based approach.	Sub-Topic: 6.3 Human demand for energy is increasing.	Sub-Topic: 7.3 Environmental quality is impacted by energy choices.	Sub-Topic: 8.3 Pretreatment processes makes sugars more available.
Sub-Topic: 1.4 Energy available to do useful work decreases as it is	Sub-Topic: 2.4 Water plays a major role in the storage and transfer	Sub-Topic: 3.4 Energy flows through food webs in one direction, from	Sub-Topic: 4.4 Humans transport energy from place to place.	Sub-Topic: 5.4 Energy decisions are influenced by economic factors.	Sub-Topic: 6.4 Earth has limited energy resources.	Sub-Topic: 7.4 Increasing demand for and limited supplies of	Sub-Topic: 8.4 The conversion processes includes adding specific

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Search **Results**

2013 RENEWABLE ENERGY DATA BOOK

Department of Energy publication detailing the amount of energy used and produced in 2013 across all sectors.

Associated Grade Levels: 7-8 9-10 11-12 Public

A BLANKET AROUND THE EARTH

NASA site explaining the different greenhouse gasses and their effects on our planet. The explain that the IPCC stated humans within the last 250 years have above a 90% chance of causing some of the climate change.

Associated Grade Levels: 9-10 11-12 Public

Resource

A Blanket Around the Earth

Description:

NASA site explaining the different greenhouse gasses and their effects on our planet. The explain that the IPCC stated humans within the last 250 years have above a 90% chance of causing some of the climate change.

Web Location:

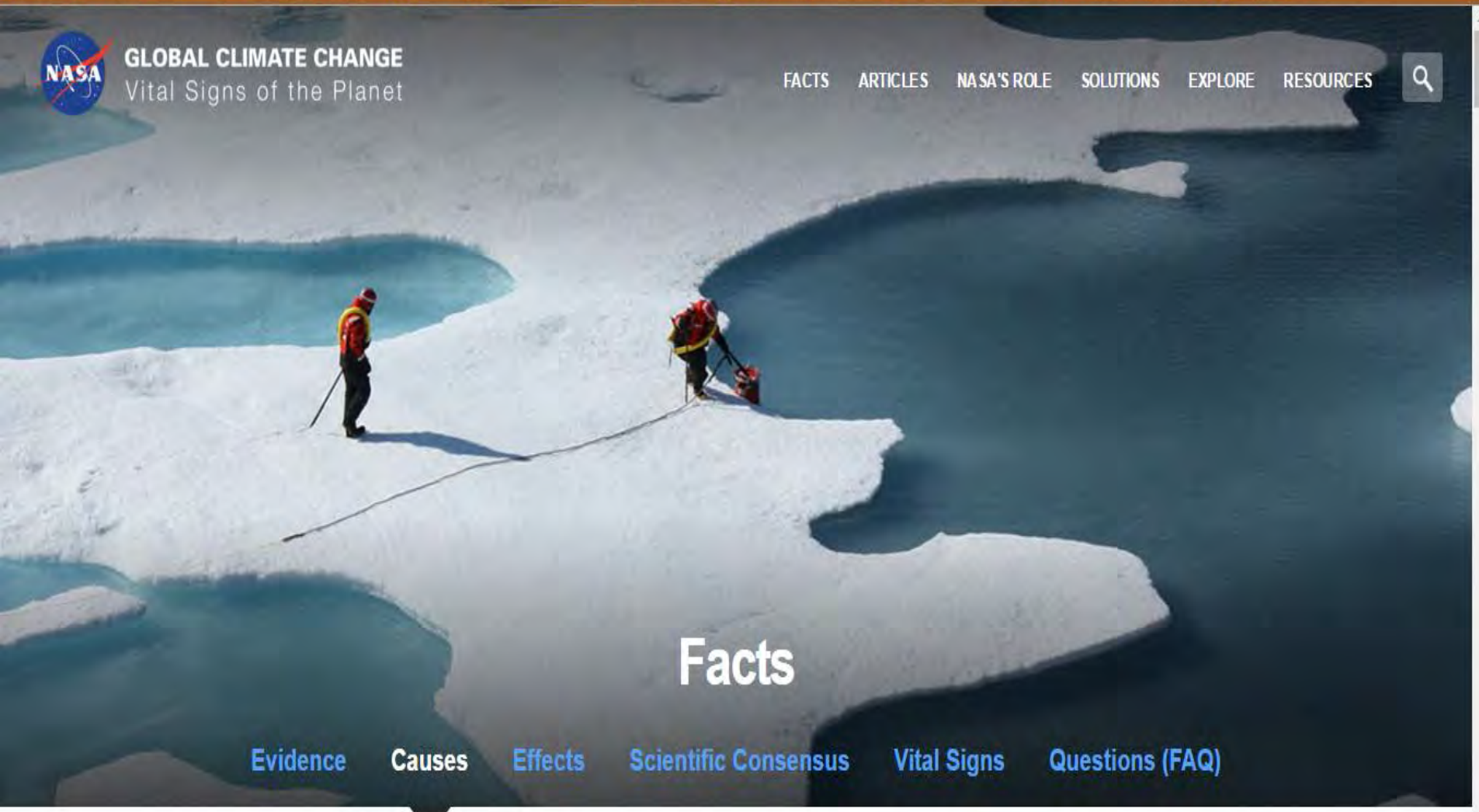
http://climate.nasa.gov/causes/

Related Topics:

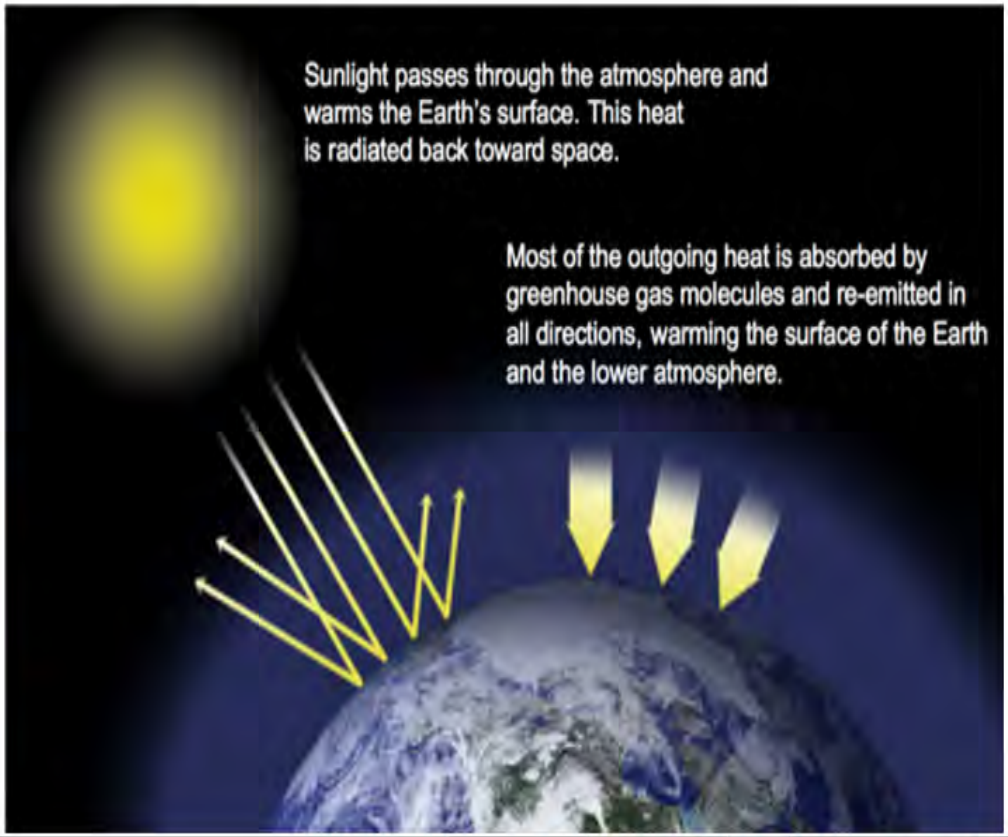
1. Energy is a physical quantity that follows precise natural laws.
2. Physical processes on Earth are the result of energy flow through the Earth system.
3. Biological processes depend on energy flow through the Earth system.

Associated Grade Levels:

9-10 11-12 Public


NASA
GLOBAL CLIMATE CHANGE
Vital Signs of the Planet
FACTS
ARTICLES
NASA'S ROLE
SOLUTIONS
EXPLORE
RESOURCES
Facts
Evidence
Causes
Effects
Scientific Consensus
Vital Signs
Questions (FAQ)

A blanket around the Earth



We live in a greenhouse

Life on Earth depends on energy coming from the sun. About half the light reaching Earth's atmosphere passes through the air and clouds to the surface, where it is absorbed and then radiated upward in the form of infrared heat. About 90 percent of this heat is then absorbed by the greenhouse gases and radiated back toward the surface, which is warmed to a life-supporting average of 59 degrees Fahrenheit (15 degrees Celsius).

Is the sun to blame?

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SEARCH
Find what the matrix has to offer.

LEARN
Learn from the matrix's information.

PREPARE
Prepare from the resources in the matrix.

TEACH
Easily teach what the matrix has provided.

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A Guide to The Energy of the Earth
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Use this resource to see how you compare to national and worldwide averages for carbon emissions. This... read more ›

Featured Topic

A Guide to The Energy of the Earth

Description:

This brief Ted.Ed lesson details many exciting principles related to energy. This brief video details many topics from electricity production to the carbon cycle

Additional Topics:

No additional topics at this time.

RESOURCES

A Guide to The Energy of The Earth

A TED-Ed video lesson about the different sources of energy and how using these different resources can impact our daily lives.

Associated Grade Levels: 5-6 7-8 9-10 11-12 Public

Assessments

Current **Assessments**

NARA Energy Literacy Assessment

This survey is designed to see what you know about energy and energy use.

Assessment Results

energyliteracyprinciples.org/assessments.aspx

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Assessments

Current **Assessments**

NARA Energy Literacy Assessment

Assessing energy literacy principles

Assessment Results

About NARA

Scientists from public universities, government laboratories and private industry from throughout the Northwest, and beyond, are joining together to focus on developing ways to turn one of the region's most plentiful commodities—wood and wood waste—into jet fuel.

Led by Washington State University, the Northwest Advanced Renewables Alliance (NARA) will take a holistic approach to building a supply chain for aviation biofuel with the goal of increasing efficiency in everything from forestry operations to conversion processes. Using a variety of feedstocks, including forest and mill residues, construction waste, as well as new energy crops, the project aims to create a sustainable industry to produce aviation biofuels and important co-products. The project includes a broad alliance. . . View More →

NARA is primarily supported by an Agriculture and Food Research Initiative Competitive Grant no. 2011-68005-30416 from the USDA National Institute of Food and Agriculture.

CONTACT US

Justin@nararenewables.org

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Led by Washington State University

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12. When sunlight is absorbed by a plant, it

Correct Answer: 2

#	Answer	Bar	Response	%
1	gets stored as electrical energy in the leaves		21	9%
2	powers photosynthetic reactions that produce sugars		202	82%
3	is conducted down to the root system where new energy is produced		23	9%
	Total		246	

13. Why is there less available energy at the top of the food chain as compared to the bottom of the food chain?

Correct Answer: 1

#	Answer	Bar	Response	%
1	most of the energy consumed by organisms is used to meet their own body's needs		176	72%
2	organisms higher on the food chain consume less		35	14%
3	producers are less energy efficient than consumers		35	14%
	Total		246	

14. Which of the following answers best describes the greatest impact that humans have on the energy flow in earth's ecosystem:

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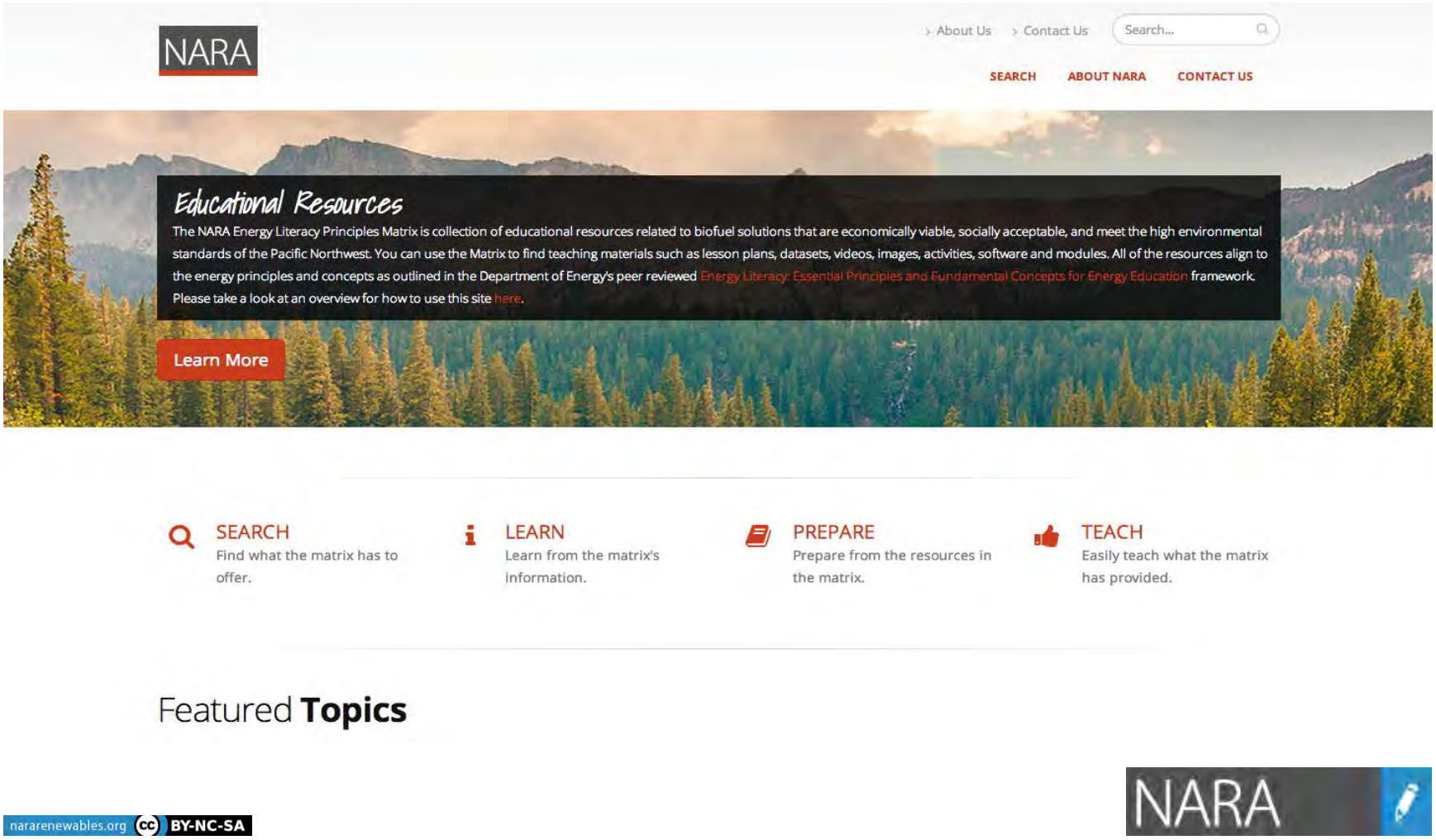
Northwest Advanced Renewables Alliance

Biomass to Aviation Fuel Supply Chain

Learn MORE

EnergyLiteracyPrinciples.org



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Implications

Developing sustainable alternatives to conventional energy sources is key 21st century challenge, one that will require a future workforce prepared to succeed in the bioenergy sector.

Moving education forward at the speed of research will require a transformational shift in academic approaches, away from entrenched disciplinary specialization and towards pedagogies rooted in authentic, experiential learning and real-world issues (Hougham, et al 2012).

The overarching goal of the education component of this project is to **recruit, motivate, and train students to become next-generation bioenergy professionals by transforming bioenergy-based education**. We achieve this goal by introducing bioenergy literacy in many venues where students and stakeholders can engage with research in progress.

The potential outlined here for **integrated and holistic educational approaches for multidisciplinary grant-funded** work stretches beyond energy literacy, offering a framework that could be used in a variety of large-scale research programs.

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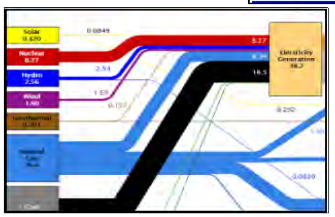
The Journal of Sustainability Education

www.SustEd.org

January 2015: Energy Education

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Sample Articles

Opinions

Undergraduate Energy Education: The Interdisciplinary Imperative

By Kenneth Klemow, Wilkes University

Special Collection on BioEnergy Literacy from the Northwest Advanced Renewables Alliance

Global Sustainability: An Authentic Context for Energy Education

By Danica Hendrickson, Kimberly Corrigan, Alicia Keefe, Danielle Shaw, Sheeba Jacob, Laura Skelton, Jennifer Schon, Karla Bradley Eitel and Justin Hougham, Northwest Advanced Renewables Alliance

Reports and Case Studies

Energy information sharing in social networks: The roles of objective knowledge and perceived understanding

By Brian G. Southwell, Joseph J. Murphy, Jan E. DeWaters (Clarkson University), Patricia A. LeBaron and Jessica Fitts Willoughby, RTI International

Scholarly Articles

Put A Brick In The Toilet: Overcoming Student Perceptions of the Effectiveness of Naïve Environmental Solutions

By Theodore J. Hogan, Northern Illinois University, and Paul Kelter, North Dakota State University

MultiMedia

There's no such thing as a free megawatt: Hydrofracking as a Gateway Drug to Energy Literacy

By Don Duggan-Haas, Paleontological Research Institution Museum of the Earth

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Acknowledgement

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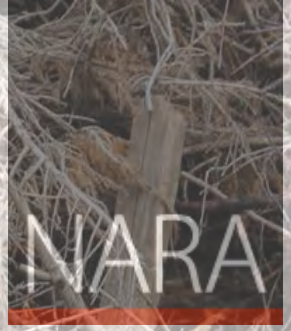

Education at the Speed of Research: Integrating Research and Education for BioEnergy Literacy

Dr. R. Justin Hougham, University of Wisconsin-Extension
Upham Woods Outdoor Learning Center
Alex Nussbaum – Lead Research Naturalist
Taylor Riedl – Research Naturalist
Marc Nutter – Research Naturalist
Sarah Burgess – Research Naturalist
Northwest Advanced Renewables Alliance- Education and Outreach