Lesson 5: Forest Science and Technology

NUTSHELL

In this lesson, students analyze the production of three construction materials — wood, concrete, and steel. Students create a life cycle analysis that illustrates the energy inputs and pollution outputs that occur during the production of each material. Students compare the renewability, longevity, and function of each material and quantify their overall environmental impact. Students describe how different forest management and production techniques can improve the environmental impacts of wood use. Groups study the role of science and technology in sustaining forests and analyze current technologies, trends, and issues. In summary, groups identify areas in which advances are needed and create a proposal to present a solution.

ENDURING UNDERSTANDINGS

- Forests are renewable resources. They can be used and regenerated at regular intervals.
- Forest management is the use of techniques (e.g., planting, harvesting) to promote, conserve, or alter forests to meet desired outcomes.
- Science and technology contribute to the understanding of forests, the impacts of human actions on these systems, and how forests can be sustained. As knowledge is gained, forest management is adapted.
- Increased population and demand on forest resources lead to the need for increases and improvements in management (e.g., harvest techniques, genetics), technological systems (e.g., GIS, tools), and wood utilization. Without advances in these areas, sustainability of forests is more difficult.
- A citizen, acting individually or as part of a group, can make lifestyle decisions and take a variety of actions to ensure the sustainable use of our forests.
- Management for sustainable forests will continue to require creativity, innovation, and collaborative thinking by individuals, organizations, governments, and industry.
- Challenges related to forestry will change over time. As new challenges arise, forestry professionals will need to respond. Examples of current challenges include fragmentation of forest lands, non-native species, threatened species, and endangered species.
- Choices humans make today directly affect our ability to sustain forest ecosystems essential to meeting future needs.

ESSENTIAL QUESTIONS

- What factors need to be considered to determine whether concrete, steel, or wood is the most sustainable building material?
- What roles do technology play in forest management?

(Continued on page 185.)

"The best time to plant a tree is twenty years ago.
The second best time is now."

Chinese Proverb

OBJECTIVES

Upon completion of this lesson, students will be able to:

- List common pollutants emitted during the manufacture and transport of concrete, steel, and wood.
- Compare and contrast the energy inputs and pollution outputs required for the manufacture and transport of concrete, steel, and wood.
- Describe the processes involved in the manufacture of dimension lumber.
- Define the relationship that time scale and landscape scale have with sustainable forest management.
- Identify social, economic, and ecological values associated with forests and explain how these values translate into management objectives.
- Formulate solutions to forestry challenges using technology, forest management, and consumer action.
- Explain how different forest challenges may change over time.

SUBJECT AREAS

Agriculture Education, Language Arts, Marketing Education, Science

PROCESS SKILLS

Life cycle analysis, Map interpretation, Proposal development

LESSON/ACTIVITY TIME

Total Lesson Time: 315 minutes

- Introduction............................20 minutes
- Activity 1 ....50 minutes
- Activity 2 ....50 minutes
- Activity 3 ....40 minutes
- Activity 4 ....20 minutes
- Activity 5 ....50 minutes
- Activity 6 ....30 minutes
- Activity 7 ....20 minutes
- Activity 8 ....20 minutes
- Conclusion.............................15 minutes

STANDARDS CONNECTIONS

Standards for this lesson can be viewed online at the LEAF website ***(www.leafprogram.org)***.

BACKGROUND INFORMATION

Life Cycle Analysis

Research institutions and industries are responding to increased environmental awareness and concern shown by consumers, environmental groups, industries, and the government about energy consumption and pollution associated with the products we buy and use every day. **Life Cycle Analysis (LCA)** is a tool that has been developed in an attempt to address energy and pollution problems related to different patterns of human behavior.

LCA is a method used to monitor and quantify the energy inputs and pollution outputs associated with the manufacture, use, and disposal/reuse of a given product. LCA is often called "cradle to grave" analysis since the measurement of **environmental impact** begins as raw materials are extracted and finishes as the product, and all of its byproducts, are used completely or become waste. LCAs enable a manufacturer to quantify how much energy and raw materials are used, and how much waste (solid, liquid, and gas) is generated during each manufacturing process. Their results can be used by businesses to determine activities by citizens and to make wise lifestyle choices and consumer decisions.

MATERIALS LIST

For Each Student

- Paper/notebook
- Copy of Student Page ✐ ***3, Detailed Wood Production Process***
- Copy of Student Page ✐ ***8, Forest Certification***

For Every 2 Students

- Copy of Student Page ✐ ***1, Pollutant Match-up***
- Copy of Student Pages ✐ ***2A-B, Energy and Pollution***
- Colored copy of Student Page ✐ ***4, Land Cover, Ashland County, Wisconsin***
- Copy of Student Pages ✐ ***5A-B, Landscape Scale Worksheet***
- Copy of Student Page ✐ ***6, Forest Challenges***
- Copy of Student Page ✐ ***7, Forestry Innovation and Technology***
- Copy of Student Page ✐ ***9, Proposal Format***
- String
- Rulers

For the Teacher

- Marker board
- World atlas with map scale
- Teacher Page ***1, Energy Sources***, to project
- Teacher Key ***2, Pollutant Match-up Key***
- Teacher Page ***3, Life Cycle Analysis Diagram***, to project
- Copy of Teacher Page ***4, Life Cycle Analysis***
- Teacher Page ***5, Energy and Pollution Comparison***, to project
- Teacher Page ***6, Environmental Impact Comparison***, to project
- Copy of Teacher Pages ***7A-B, Discussion: Landscape Scale***
- Teacher Page ***8, Wisconsin Land Cover Map***
- Student Page ✐ ***4, Land Cover, Ashland County, Wisconsin***, to project
- Teacher Page ***9, Softwood Lumber: Plantation Management***, to project
- Teacher Page ***10, Hardwood Lumber and Veneer: Uneven-aged Forest Management***, to project
- Teacher Page ***11, Aspen Paper Pulp: Clearcut Management***, to project
- Teacher Page ***12, Tree Time***, to project
- Copy of Teacher Key ***13, Forest Challenges Key***
- Teacher Page ***14, Progressive Harvesting***, to project
- Teacher Page ***15, Forest Modeling***, to project
- Teacher Page ***16, Engineered Wood Products***, to project
- Teacher Page ***17, GPS and GIS***, to project
- Teacher Page ***18, Log Scanning***, to project
- Teacher Page ***19, Protection and Tree Improvement***, to project

"A woodland in full color
is awesome as a forest fire,
in magnitude at least,
but a single tree
is like a dancing tongue of
flame to warm the heart."

Hal Borland

Using LCAs, researchers can develop a complete environmental profile for a specific product. It is still difficult to compare the overall environmental impact of different products. Though it is possible to compare products by categories (e.g., air pollution emitted, water pollution emitted, and energy used), it is often misleading to claim that one product is more environmentally sound than another. This is due to the different environmental effects that the manufacturing of products may have. For example, how can we compare a product that requires a large energy demand to one that requires heavy water use (further taking into consideration that in some regions, water is a scarce resource)? How do we compare a manufacturing process that creates landfill waste (solid waste and possible groundwater pollution) to a manufacturing process that burns much of its waste for energy (predominantly air pollution)? For this reason, one must first look at the LCA for each product individually. When comparing products, one must look at all the environmental impacts and base decisions on those that are given high priority locally, regionally, and globally.

Wood and the Environment

A number of institutions have been working on LCAs for different wood products in North America, including the Athena Institute and the Consortium for Research on Renewable Industrial Materials. Most studies conclude that wood building products have lower environmental impact than other products. In fact, wood products can have a positive effect on global warming because they store carbon instead of releasing it into the air.

Two main factors help **steel** and **concrete** remain competitive with wood as the most environmentally friendly construction material in the U.S. — forest management methods and the distance from the harvest site to the market. Of the two factors, the most energy-intensive and pollution-causing is the transport of material. With every new LCA of wood products, the environmental impact of transportation is outlined as the major environmental concern.

This is not always the case with concrete or steel, since the primary rock deposits used for concrete (sand, lime, and gravel) are widely distributed and a large portion of metal used in steel manufacturing is recycled regionally. Our eagerness to buy the cheapest wood products regardless of their origin (e.g., Indonesia, Canada, the Pacific Northwest, and Brazil) is the main factor increasing the environmental impact of wood use.

Unlike the mining of rocks and minerals, wood is produced by trees, which use the sun as an energy source. In addition, when properly managed, forests are a renewable resource. These two factors set wood apart from concrete and steel.

If consumers demand, policies require, and/or pricing structures favor products from local forests with long-term management plans, local forest managers and wood products industries would have incentives to manage forests sustainably. This outcome could greatly reduce the environmental cost of wood use by decreasing the transportation associated with the current marketplace. Unfortunately, current consumption patterns are driven much more by price than by wood origin or forest management concerns.

"Keep a green tree in your heart and perhaps a singing bird will come."

Chinese Proverb

VOCABULARY TERMS

Biofuel: A fuel produced from organic matter available on a renewable basis: includes trees, agricultural crops and residues, wood wastes and residues, aquatic plants, animal wastes, and municipal wastes.

Clearcutting: Harvesting all the trees in a given area at the same time. This is sometimes used as a management technique to encourage species that do not tolerate shade during regeneration.

Clinker: A hard mass of fused material produced in furnaces by the burning of coal.

Coke: Coal from which most of the gases have been removed; burns with intense heat and little smoke and is often used as an industrial fuel.

Concrete: A hard, compact building material formed from a mixture of cement, sand, gravel, and water.

Concrete Milling: A concrete manufacturing process in which mined material is mixed to the proper percentages of sand, limestone, iron, and bauxite, then heated and ground.

Concrete Mining: Involves the open pit extraction of sand, gravel, and limestone.

Engineered Wood Product: A product made from wood and wood waste; examples include laminated veneer lumber, medium density fiberboard, oriented strand board (OSB), particleboard, and plywood.

Environmental Impact: The effect that an activity has on the environment; limited environmental impact estimates include energy consumption and pollution emissions, while more comprehensive estimates can include elements such as land cover change and biodiversity.

Even-aged Management: A set of forest management techniques used to maintain a stand with trees of uniform age and size; often associated with red pine plantations and aspen stands.

Forest Certification: The verification, by a third party, that a forest is being managed by a predetermined set of standards designed to ensure that social, ecological, and economic values of a forest are maintained for current and future generations.

Forest Modeling: A digital representation of a forest that is used to simulate a process and predict an outcome.

Function (material): The practical use of a material; depends on the material's characteristics and the application for which the material is needed.

Genetic Engineering (bioengineering, biotechnology): The directed modification of an organism's gene sequence to produce a new inheritable trait; accomplished by splicing a specific gene, usually from another organism, into an individual's DNA sequence.

Geographic Information System (GIS): A computerized system that gives resource managers the ability to organize and access information (e.g., soil type, watershed, population density) about a specific area.

Global Positioning System (GPS): A handheld device that collects data from satellites to provide users with the coordinates of their location on the surface of earth.

VOCABULARY TERMS

Greenhouse Gas: Atmospheric gases that capture heat that is reflected back from earth; include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and chlorofluorocarbons (CFCs).

Hybridization: The natural or controlled reproduction of two individuals with a different genetic makeup.

Life Cycle Analysis (LCA): A detailed accounting of the energy use and pollution outputs caused by the extraction, manufacture, transportation, use, and disposal of materials used to create a given consumer product.

Log Scanning: A technique that uses lasers, cameras, and X-rays to examine a log that enters a mill.

Longevity: The length of time a material lasts before it needs to be replaced.

Melting and Metallurgy: A steel manufacturing process in which iron is separated from iron ore and mixed with small percentages of other metals to form steel.

Planing (wood lumber): A sawmill process in which the surface of a board is shaved straight and smooth after sawing and kiln drying.

Pollution: Harmful substances emitted to the environment that can negatively affect living organisms.

Prescribed Fire: The controlled application of fire to a predetermined area in attempt to modify the ecosystem to meet management objectives.

Progressive Harvesting: A tree removal technique in which the landing, the area where logs are processed and stacked for transportation, is moved with the harvest. The technique reduces damage to forest soils, minimizing effects on surface water and vegetation.

Protection (forest or tree): The variety of techniques used to reduce damage to trees or forested areas; techniques include prescribed fire, pesticide application, fertilization, pruning, and thinning.

Renewability: The ability of a resource to regenerate, grow back, or produce more.

Selection Cut: A management technique in which specific trees in an area are chosen and cut.

Slag: An inert solid material containing sulfur and oxides that is formed as a byproduct of steel manufacturing; can be sent to landfills or used for road construction, concrete products, or mineral wool.

Steel: A hard, tough metal made from iron alloyed with small percentages of carbon, nickel, chromium, and manganese.

Steel Casting: A steel manufacturing process in which liquid steel alloy is formed and hardened into a near finished product.

Steel Mining: Involves the open pit extraction of iron ore.

Steel Treating/Finishing: The final steel manufacturing process in which steel is cold rolled or galvanized (plated with zinc) to strengthen and protect the exterior of the product.

Sustainable Management: Maintenance of forests to meet current and future ecological, economic, and social needs.

Tree Harvest: The process of gathering a tree crop; includes felling, skidding, removal of limbs, cutting to length, and material removal.

VOCABULARY TERMS

Tree Improvement: The modification of a tree to encourage certain desirable characteristics such as form, growth rate, and resistance to disease; improvement techniques include hybridization and bioengineering.

Uneven-aged Management: A set of forest management techniques used to maintain a stand with trees of different ages and sizes; often associated with the management of mature hardwood species.

Sustainable Forest Management

The way a forest is managed can have a large influence on the environmental impact of wood production. Management also impacts the current and future availability of economic, social, and ecological forest values.

The economic values of forests (products, jobs, commerce, etc.) depend on forest management to satisfy current and future consumer demands. Social values of forests (including cultural heritage, beauty, recreation, and public spaces) depend on forest management to protect and encourage local and regional community resources. Ecological values (including wildlife, water quality, and air quality) depend on forest management to encourage diverse wildlife habitat, maintain forested areas, and protect soil and water resources.

The goal of **sustainable management** is to provide all three of these forest values to current generations without diminishing our ability to provide the same for future generations. This requires that we work to efficiently manage forests across the landscape and through time.

Climate, soil, vegetation, and disturbance characteristics vary across the landscape. Forest managers must work on a landscape scale to identify and manage areas for uses suitable to their characteristics. For example, wetlands are important for water quality and biodiversity and may need to be managed to provide these services. Fertile, upland hardwood forests are important for the production of hardwood lumber and veneer, and may need to be used to supply consumer demands.

Trees require long periods of time to produce characteristics desirable for certain uses (e.g., 50 years for maple syrup and 100 years for softwood lumber). Forest managers work with a time scale that requires continual investment of money and energy to receive benefits in the distant future. Forest managers must ensure that desirable species regenerate and grow, and they must continually protect the trees from damaging agents such as insects, disease, and deer browsing.

Technology in the Forest

The science of forestry has developed from more than a century of study. Forestry science is now used to describe forests and forest processes and efficiently manipulate those processes to meet human wants and needs. Today, forest managers employ a variety of strategies and techniques to achieve their goals, and increasingly, the goal of sustainable forest management. Technology has a major influence on the development of research and management techniques.

"This oak tree and me, we're made of the same stuff."

Carl Sagan

Forest management is the use of techniques to promote environmental conditions that support some species of plants and animals. Depending on the objectives, forest management can also be used to create conditions that do not support some plant and animal species. To be successful, forest managers must understand the characteristics and needs of the plants and animals for which they are encouraging, as well as for those they are attempting to discourage. Common management techniques include using **prescribed fire**, thinning, harvesting (selection, shelterwood, seed-tree, and **clearcutting**), fertilization, site preparation, tree planting, and pesticide and herbicide use.

Our understanding and management of forests has greatly improved due to the development and use of **Global Positioning Systems (GPS)**, **Geographic Information Systems (GIS)**, remote sensing, and **forest modeling** technologies. GPS allows researchers to precisely map topography, reference research areas, monitor landscape changes, and track wildlife. GIS gives researchers and managers the capability to acquire, view, interpret, and correlate a variety of geographic information, including soil type, vegetation, human demographics, climate, topography, bedrock geology, and hydrology. Remote sensing allows for the continuous monitoring of environmental conditions (e.g., moisture, temperature, pH, ozone, light intensity) using instrumentation that remains on-site and records data at specified intervals or records information from satellites. Forest modeling helps to guide management activities by using data on tree characteristics, environmental conditions, and management techniques to predict how forests will react to different management strategies.

Technology in the Mill

Over the last 50 years, the forest products industry has increased efficiency, making use of twice as much material from each log that enters a mill. In the United States, about 49% of wood is turned into solid or **engineered wood products**, 28% is used for paper pulp, and 23% is used for fuelwood and byproducts. New technology and innovation by the forest products industry are responsible for these advances.

Two of the most influential technologies in saw and veneer mills are scanning technology and engineered wood products. Scanning technology involves the use of lasers, optical scanners, and X-ray scanners to accurately measure logs and detect both superficial and interior flaws. Scanners allow for increased energy efficiency and optimal utilization of logs.

Further increasing wood utilization, engineered wood incorporates much of the waste left from the sawing process into products that can be substituted for solid wood products or products made from other materials. Lumber, veneer, sawdust, irregular wood, and wood chips are formed and glued into panels, boards, and trusses. These include plywood, oriented strand board (OSB), glued laminated timber, laminated veneer lumber, and structural I-joists.

These technologies, as well as automated handling systems and pollution filtering technologies, have helped the forest products industry to reduce its energy inputs and pollution outputs per volume of product.

> "But down deep, at the molecular heart of life we're essentially identical to trees."
>
> *Carl Sagan*

The Role of Technology in Sustainable Management

Technology can help us to manage forests sustainably.

- Technology helps us manage forests across the landscape. GPS, GIS, and remote sensing allow us to more efficiently map, analyze, monitor, understand, and manage natural resources.
- Technology helps us manage our forests through time. Forest modeling, tree improvement, and tree protection allow us to better plan, protect, and ensure the availability of forest values in the future.
- Technology helps us reduce the environmental impact of transportation, heat, and electricity needs. Renewable energy technologies (e.g., photovoltaic panels, **biofuels**, wind turbines) can reduce our dependence on fossil fuel sources of energy.

Technology alone cannot ensure the sustainable management of forests. Humans must make decisions and take actions that reduce the environmental impact of resource use. Sustainable management requires action by public institutions, private businesses, and individuals. Collective decisions must be made about how public and private institutions manage resources, use energy, and emit pollution. Individuals must make decision s about consumer habits and consider how they influence the current and future availability of forest resources.

PROCEDURE

Introduction – Pollution and Energy

1. Explain to students that during the next few class periods, they will be using a tool that describes the environmental impact of products that they buy and use. Ask the class to think of products that they use and list them on the board. The list may include things such as furniture, pencils, toothbrushes, food, toilet paper, clothes, etc.

   Once the list is on the board, have students identify from what each of the products is made. For example, furniture is made of wood, plastic, metal, cotton, etc. Tell students that each of the materials used in the products came from somewhere, required energy to make, and its production inevitably causes some sort of pollution.

   You may wish to choose an example and discuss it. *(Toothbrushes are made of plastic, which is made from oil that is extracted from the ground. The energy required to manufacture the plastic comes from oil or coal, which is also extracted from the ground, and emits a variety of pollutants, including air pollution, water pollution, and solid waste pollution.)*

2. Explain to students that the manufacturing of products requires energy. Energy is needed to extract, transport, cut, form, heat, treat, and package materials. Ask students to think of common sources of energy used in Wisconsin. List them on the board and have them guess percentages. The percentages should represent the energy used to provide power to Wisconsin industries and households; do not include gas used for transportation. See Teacher Page ***1, Energy Sources***, for examples. Once the list is formed, project Teacher Page ***1, Energy Sources***. Explain the benefits and costs of each.

NOTE: Looking at the total energy consumption in the U.S., 39% comes from petroleum. Petroleum is used as gasoline and diesel for transportation.

3. Have students form pairs and hand each pair a copy of Student Page ✎ ***1, Pollutant Match-up***. Ask them to complete the worksheet using their current knowledge and deductive reasoning skills.

   Once students are finished, use Teacher Key ***2, Pollutant Match-up Key*** to go through each of the answers, having the student pairs match different definitions. It is important that all of the students have the correct answers on their worksheet.

   After all the definitions have a match, ask students if, by looking at the definitions, they get a general idea of where most of the pollutants on the list come from. *(Many of them come from petroleum combustion, mining, and steel manufacturing.)* Tell students that in the following activities they are going to be using an analytical method that will allow them to better identify where pollution comes from and compare the environmental impact (energy input and pollution output) of different products we use.

Activity 1 – Creating Life Cycle Analysis for Wood, Concrete, and Steel

1. Explain that to reduce the environmental impact of product manufacturing and use, we first need to define the energy required and pollution emitted during the process. The tool, a life cycle analysis, tracks a product from its creation to its disposal (or reuse) and describes all of the energy inputs and pollution outputs at each stage.

   Project Teacher Page ***3, Life Cycle Analysis Diagram***. Use the top diagram to explain that a simple LCA starts with a natural resource and ends with a consumer product. Each stage, or process, used to manufacture and transport the product is analyzed. It is important to include the environmental impact of transportation because the transportation of materials often requires more energy and gives off more pollution than the actual manufacturing of the product.

   Use the bottom diagram to explain to students that, for each process, the LCA outlines all the raw material and energy inputs (above the dotted line) and all the material and pollution outputs (below the dotted line).

2. Tell students that they will be using life cycle analysis to study the environmental impact of three different products — wood, concrete, and steel.

   Form groups of two to three students and have the groups discuss how each of these materials is produced. Write the names of the three materials (wood, concrete, steel) on the left side of the board, leaving plenty of space between them. Begin with wood and ask each group to write down how a wood board is produced. Tell them to think about the manufacturing process in stages, and have them identify each stage.

   Once the groups have the stages identified, call on different groups to share their ideas. Consolidate their ideas into production stages, and list the stages from left to right across the board. Once wood is finished, ask them to think of how a slab of concrete is produced, and then how a steel beam is produced.

   The stages should be similar to the following:
   - **Wood:** Tree harvest, transport, sawing, drying, planing, transport
   - **Concrete:** Mining, transport, milling (mixing, burning, and grinding), transport
   - **Steel:** Mining, transport, melting and metallurgy, forming, treating, transport)

3. Ask the class to think about how each of these materials is used. Have students name and discuss applications for each. Make sure that construction uses are mentioned for each of the materials (e.g., wood: house frames, concrete: foundations, steel: structural beams).

   Once the general production processes are on the board and students have discussed the applications for each material, ask them how they think they can compare the environmental impact of producing the three materials. *(Create a LCA for each.)*

4. Ask students to write down which material they think is the most environmentally friendly to produce and which is the least. Tell students that to find out, they are going to create life cycle analyses for the materials.

   Hand each group a copy of Student Pages ✎***2A-B, Energy and Pollution***. Review the information on the sheet with the class. Have students identify and discuss the different production stages and the energy requirements and pollution associated with them. Assign each group one of the materials (concrete, steel, or wood) to outline on a piece of paper. Be sure that at least one outline is created for each material.

   Again, project Teacher Page ***3, Life Cycle Analysis Diagram***. Explain to the groups that they are going to outline the inputs and outputs associated with the manufacture of their material. Their outlines should be created in a similar form to that shown on the board — distinct production stages labeled with inputs (rectangles) and outputs (squares). Use Teacher Page ***4, Life Cycle Analysis***, to help student groups complete their outlines.

5. Once all the groups have completed their outlines, have a representative from each concrete, steel, and wood group present their outline. Have students compare and contrast the manufacturing process, energy inputs, and pollution outputs for each material.

   Ask the class which material produces the greatest number of pollutants. *(Steel.)* Ask the class which material produces the fewest. *(Wood.)* Ask groups to identify some of the pollutants from steel manufacturing, concrete manufacturing, and wood manufacturing. Ask the class if they can determine which material uses the most energy. *(No, the quantity of energy inputs is not listed.)* Ask them if they can tell which material produces the largest quantity of pollution. *(No, the quantities of pollutants are not listed.)*

   Explain to the class that to determine the answers to these questions, they need to compare the energy inputs and pollution outputs needed to produce an equal cubic volume of each material. Have the student groups look at Student Pages ✎***2A-B, Energy and Pollution***, and the LCA outlines that they have just created and guess which material requires the most energy and which material produces the most pollution. Have them write down their answers.

NOTES

6. Project Teacher Page **5, *Energy and Pollution Comparison***. Ask a few students to interpret different elements of the chart and graph.

   Interpretations should be similar to the following:
   - Wood requires the **least** energy to produce. To produce an equal volume, concrete requires 70% more energy than wood, and steel requires 140% more energy than wood.
   - Wood production emits the lowest amount of **greenhouse gases**. To produce an equal volume, concrete production emits 81% more than wood, and steel emits 45% more than wood.
   - Wood production emits the least **air pollution**. To produce an equal volume, concrete production emits 67% more than wood, and steel emits 42% more than wood.
   - Wood production emits the least **water pollution**. To produce an equal volume, concrete production emits 90% more than wood, and steel emits 1,900% more than wood.
   - Wood and steel production create the least **solid waste pollution**. To produce an equal volume, concrete production emits 96% more than wood or steel.

Activity 2 - Environmental Impacts of Wood, Concrete, and Steel Production

1. Tell students that they have just compared the environmental impact of producing and delivering the materials, but they still have not determined the environmental impact of using the materials over time. To further explain, tell students that if they look at the comparisons, they will see that wood requires less energy to produce and its production gives off less pollution. BUT what if you were to find out that steel lasts twice as long? Or that concrete requires less energy to maintain? Or that you need more wood to support the same amount of weight as steel? That means you would have to use more wood to make up for these deficiencies.
2. Tell the class that to determine the environmental impact of using the materials over time, there are three factors that they must consider — **function**, **renewability**, and **longevity**. Write the terms on the board and ask the class to define them. The definitions should be similar to the following:
   - **Function:** The practical use of a material; depends on the material's characteristics and the application for which the material is needed.
   - **Renewability:** The ability of a resource to replenish itself in the future; current use does not diminish future supply.
   - **Longevity:** The length of time a material lasts before it needs to be replaced.
3. Have students work in pairs to compare and contrast the characteristics of concrete, steel, and wood. They should describe their relative weight, strength, resistance to environmental stresses, and ease of use (cutting, forming, molding, etc.). Once the students finish, have a few of the pairs read their paragraphs to the class. Allow students to discuss the answers and share their ideas. *(Ideas should include: Wood is lighter and more easily cut than steel. Steel is stronger and more resistant to environmental stresses than wood. Concrete is more easily molded than wood or steel.)*

> "Around a flowering tree, one finds many insects."
>
> *Guinea Proverb*

4. Conduct a large-group brainstorm with your class to identify all of the components used in the construction of a house. List ideas on the board. Ideas should include such things as roofing (shingles, plywood, insulation, etc.), framing (joists, rafters, beams, etc.), walls (siding, plywood, sheet rock, insulation, paint, etc.), foundation (walls, supports, basement floor, etc.), and furniture (doors, cabinets, etc.).

   Once the brainstorm is complete, have students work individually and draw three columns on a piece of paper with the headings “concrete,” “steel,” and “wood.” Have them place the materials listed on the board in the column of the material that they feel is most suitable for that component/function. Have them share and explain their answers. *(e.g., Concrete is best suited for the foundation of a house because it can be easily formed on-site and is resistant to moisture. Wood is best suited for framing because it is light, strong, and easily cut to size and secured on-site. Steel is best suited for major structural support because it is very strong.)* Emphasize to the class that the function of the material is determined by its characteristics: concrete can be easily formed and poured when wet, wood is exceptionally strong for its weight, and steel can support large amounts of weight for its volume.

5. Have students identify which of the materials are renewable and explain their answers. *(Wood is the only renewable resource of the three — if forests are managed sustainably, wood can be produced indefinitely. The materials for both concrete and steel are mined from the ground and, though abundant and often recyclable, exist in finite quantities.)* Ask the class what this signifies for the environmental impact of the three materials over time. *(Wood can continue to be produced in one location, but steel and concrete will continually need to be found and extracted from rock and metal deposits, or gathered and recycled at locations around the world.)*

6. Tell students that to find out the longevity of all of the materials, each material would need to be studied under similar conditions. Form small groups of two to three students and briefly discuss how the three materials could be accurately studied to determine their longevity. *(The materials must be tested for the same use and under similar conditions.)* Have each group come up with an experiment that they could use to test for the longevity of the three materials. Variables should include physical, chemical, and biological stresses. *(Some ideas may include constructing buildings, bridges, or other structures from each material and monitoring their longevity and maintenance; exposing each material to similar environmental stresses in a laboratory setting.)* As the groups finish, have them share their ideas with the class.

7. Tell the class that studies to determine the proper function, renewability, and longevity of materials for the purpose of reducing energy use and pollution are now being conducted all over the world. In one study (2004), the Consortium for Research on Renewable Industrial Materials (a nonprofit organization formed by 15 research institutions) compared the environmental impact of wood, steel, and concrete in residential buildings.

   In the experiment, the researchers constructed two single-family homes in Minneapolis, Minnesota (cold climate). In one home, they used wood wherever possible — in floors, roofs, walls, etc. In the other home, they used steel wherever possible. The researchers also constructed two single-family homes in Atlanta, Georgia (warm climate). In one home, they used wood whenever possible, and in the other, they used concrete.

The researchers spent the same amount of money on each home, constructed each home in the same design and size, and made sure that each home had the same amount of energy efficiency (i.e., it had the same R value, or insulation value). They then forecasted the maintenance and eventual replacement that would be needed for the wood, concrete, and steel in each respective house, and the additional energy requirement and pollution caused by such replacements.

8. After explaining the experiment, ask students to take into consideration the three factors you just discussed (function, renewability, and longevity) and hypothesize which home they think had the least overall environmental impact — the mostly concrete home, mostly steel home, or mostly wood home. Have students explain their answers.

   Project Teacher Page ***6, Environmental Impact Comparison***. Tell the class that after taking into account energy inputs and pollution outputs in manufacturing the materials, the longevity of each material, and their renewability, the researchers came up with the results shown. Have students interpret parts of the table and graph.

   Their interpretations should be similar in format to the following:
   - Wood use requires the least **energy**. Concrete requires 16% more than wood, and steel requires 17% more than wood.
   - Wood use produces the lowest amount of **greenhouse gases**. Concrete use produces 31% more than wood, and steel produces 26% more than wood.
   - Wood use produces the least **air pollution**. Concrete use produces 23% more than wood, and steel produces 14% more than wood.
   - Wood and concrete use produce the least **water pollution**. Steel use produces 312% more than wood or concrete.
   - Steel use produces the least **solid waste pollution**. Wood use produces 1% more than steel, and concrete produces 51% more than steel.

9. Tell the class that wood performs better than steel or concrete for a variety of reasons. First, trees grow using the sun's energy (unlike steel or concrete), and forests can continue to regenerate when properly managed (unlike mineral deposits). Wood is also better suited for most structural features in a house because it is lightweight, strong, and easily cut and installed. However, in some home applications (like below-ground walls and major structural supports), concrete and steel last longer. The maintenance and replacement required for wood still uses less energy and creates less pollution than the use of steel or concrete.

Activity 3 – Exploring the Environmental Costs of Wood Production

1. Explain to the class that as population and consumer demand grow, it is important that people choose to use materials that require less energy and produce less pollution. As they have seen, current research shows that between concrete, steel, and wood, wood has the least environmental impact in many categories (energy inputs, greenhouse gas emissions, air pollution, and water pollution). Even so, there must still be improvements in wood production that reduce the energy inputs and pollution outputs.

   Hand a copy of Student Page ***3, Detailed Wood Production Process***, to each student. Review each stage of wood processing with the class, and have students highlight or mark areas where improvements could be made in energy efficiency and pollution reduction.

The following areas should be highlighted:

- Machinery used for tree harvest (distance traveled and machine efficiency)
- Distance from harvest site to sawmill (harvest location and vehicle efficiency)
- Forest management/certification (reduction of future energy inputs and pollution outputs through sustainable forest management)
- Wood moisture content (reducing moisture would save drying energy and reduce the weight of shipment)
- Measuring and sawing (using more/wasting less wood)
- Energy sources for manufacturing (using more renewable energy sources for machinery, lighting, heating/cooling, drying, transport, etc.)
- Drying methods (energy inputs)
- The use of wood waste for energy (air pollution)
- Distance from sawmill to consumer markets (locality and energy inputs for transportation)

Review each of the areas and tell the students that they are going to look in detail at one specific area — transportation.

2. Tell the class that they are going to work in their group to transport a shipment of lumber to Milwaukee, Wisconsin. Each group will be shipping the same amount of wood, but will have a different city from which they are sending their shipment. The groups will need to determine the method of shipment (i.e., by road, rail, sea, river, or a combination) and how much energy is required.

   Place the following transportation energy coefficients on the board:

   Road = 1.1 (1.1 Mj/tonne-km)
   Rail = 0.35 (0.35 Mj/tonne-km)
   River = 0.35 (0.35 Mj/tonne-km)
   Sea = 0.1 (0.1 Mj/tonne-km)

   Explain to the class that rail and river transport requires 3.5 times more energy than ocean transport, and road transport requires 11 times more energy than ocean transport. Tell the groups that they must deliver the shipment using the least amount of energy as possible while utilizing the transportation systems available.

3. Assign one of the following cities to each group and provide them with the total distance from their city to Milwaukee.
   - **Ashland, Wisconsin**
     300 miles, 480 kilometers
   - **Atlanta, Georgia**
     700 miles, 1,120 kilometers
   - **Calgary, Canada**
     1,500 miles, 2,400 kilometers
   - **Portland, Oregon**
     1,700 miles, 2,720 kilometers
   - **Munich, Germany**
     4,500 miles, 7,200 kilometers
   - Brazilia, Brazil
     4,900 miles, 7,840 kilometers
   - **Moscow, Russia**
     5,100 miles, 8,160 kilometers
   - **Jakarta, Indonesia**
     9,700 miles, 15,520 kilometers

   Tell the groups that the distance represents the linear distance on the globe. They will use an atlas with map scale, string, and ruler to determine the distances traveled by road, rail, and/or water and calculate the total distance in kilometers. Groups can use railways only where they exist and can only use waterways navigable by ocean liner or barge.

"Keep a green tree in your heart and perhaps a singing bird will come."

Chinese Proverb

Examples of Total Energy Use

		Ashland	Atlanta
ROAD	Km	0	160
	Energy (x 1.1)	0	176
RAIL	Km	0	960
	Energy (x 0.35)	0	336
SEA	Km	480	0
	Energy (x 0.1)	48	0
RIVER	Km	0	0
	Energy (x 0.35)	0	0
Total Energy (Mj)		48	512

		Calgary	Portland
ROAD	Km	800	160
	Energy (x 1.1)	880	176
RAIL	Km	1,600	2,560
	Energy (x 0.35)	560	896
SEA	Km	0	0
	Energy (x 0.1)	48	0
RIVER	Km	0	0
	Energy (x 0.35)	0	0
Total Energy (Mj)		1,440	1,072

		Munich	Brazilia
ROAD	Km	320	800
	Energy (x 1.1)	352	880
RAIL	Km	480	320
	Energy (x 0.35)	168	112
SEA	Km	6,400	5,720
	Energy (x 0.1)	640	572
RIVER	Km	0	1,000
	Energy (x 0.35)	0	350
Total Energy (Mj)		1,160	1,914

		Moscow	Jakarta
ROAD	Km	500	350
	Energy (x 1.1)	550	385
RAIL	Km	700	0
	Energy (x 0.35)	245	0
SEA	Km	6,960	14,170
	Energy (x 0.1)	696	1,417
RIVER	Km	0	1,000
	Energy (x 0.35)	0	350
Total Energy (Mj)		1,491	2,152

Example calculation to determine the energy required for a 1 tonne shipment from Ashland to Milwaukee:

1 tonne x 480 Km x 0.1 Mj/tonne - Km = 48 Mj

4. Once students have their shipping methods chosen and total energy calculated (see example on bottom of page 199), have them present their results to the class. Write each group's total energy use on the board. Have the class identify the city that requires the most energy for shipment *(Jakarta)* and the city that requires the least *(Ashland)*.

   Have each group calculate the additional energy used to ship to Milwaukee from their city compared to Ashland. Have them calculate both the amount and the percent increase and write it on the board. Have students discuss the differences and the impact that using locally produced wood products can have on the pollution produced and energy used in transportation.

Activity 4 – Developing Practical Solutions

1. Tell students that now that they have looked at one strategy to reduce pollution production and energy use in transportation, they will now look at the lumber production process. Ask the groups to brainstorm solutions to reduce energy inputs and pollution outputs associated with wood manufacture and use. Tell the groups that they should start with Student Page ✎***3, Detailed Wood Production Process***, and write a few general ideas next to the highlighted or marked areas on their page.

Ideas may include:

- Machinery used for tree harvest — clean burning engines, new harvest methods
- Distance from harvest site to sawmill — harvest local wood, build local sawmills
- Forest management/certification — support forest certification, buy certified wood products
- Wood moisture content — innovation or technology to protect wood with lower moisture content
- Measuring and sawing — encourage the use of high-tech measuring and sawing equipment
- Energy sources — create an alternative energy infrastructure (use wind, solar, and/or biofuels to replace coal-fired power plants)
- Drying methods — use a new technology and/or innovation to reduce the energy inputs for drying (solar drying, clean burning wood waste, etc.)
- The use of wood waste for energy — use a new technology or innovation to reduce the particulate matter released from the burning of wood
- Distance from sawmill to consumer markets — encourage consumers to buy local products

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2. Once the groups have some ideas identified, have them come up with some solutions. Ask them to identify a problem and briefly describe some strategies that they will use to solve it. Give them five to 10 minutes to come up with some ideas. Once the groups have finished, have them share their ideas with the rest of the class.

   Tell students that practical solutions must satisfy the following three criteria and write them on the board:
   - Address the primary cause of the problem
   - Work with available human and technological resources
   - Meet the needs of businesses, communities, and individuals

   Use one of the group's ideas and apply the three criteria to it. Have the class discuss if the proposal meets all three of the criteria.

3. Tell students that in the next few activities, they will be given information that will help them identify strategies that they can use to develop practical solutions. The information will help them in the final activity of this lesson when they develop a proposal that outlines a practical solution that reduces the environmental impacts of wood use.

   Tell the class that solutions come from advancements in the following three categories, and write them on the board:
   - **Forest Management:** Improvements in management and planning can help ensure the protection of current and future ecological, social, and economic values of forests.
   - **Innovation and Technology:** Innovation and technology can help reduce energy consumption, use wood more efficiently, and reduce pollution.
   - **Consumption Patterns:** Adaptations in consumption patterns can influence how forests are managed, how much resources are used, and reduce the energy needed to transport materials.

Activity 5 – Forest Management: Landscape Scale

1. Tell students that they are first going to look at the role that forest management plays in reducing the environmental impact of lumber production. Forest managers attempt to understand and respond to the realities that exist on the landscape. Their job is to maintain the supply of economic, environmental, and social benefits of forests for current and future generations.

   Write the terms "economic," "social," and "ecological" across the board. Have students brainstorm benefits that they receive from forests that fit in one of the categories. *(The list should include: Economic — jobs, forest products, tourism; Social — recreation, beauty, history, community; Ecological — wildlife, protection of air, water, soil resources.)*

   Tell students that to ensure all these benefits are protected for current and future generations, forest managers must work in two major scales — the landscape scale and the time scale.

2. Tell students that they will first look at how the landscape can influence decisions about forest management. Hand each group of two to three students a colored copy of Student Page ✎***4, Land Cover, Ashland County, Wisconsin***, and Student Pages ✎***5A-B, Landscape Scale Worksheet***. Review the worksheet and tell groups that they will record answers on their worksheet during the following teacher presentation.

> "Trees are poems that the earth writes upon the sky."
>
> ✤ *Kahlil Gibran* ✤

Have students identify the scale and map features. To help orient the students, ask if anyone has been to the shore of Lake Superior in northern Wisconsin or to any of the places pictured on the map. Have students describe some of the areas. Point out the different land cover types on the map, and have the student groups come up with definitions for each of the land types and write them on Student Pages ✎***5A, Landscape Scale Worksheet***. Once the groups have come up with definitions, have groups share them with the class.

The definitions should be similar to the following:

- **High-intensity Urban:** City centers; dominated by roadways, office buildings, manufacturing facilities, etc.
- **Low-intensity Urban:** Small towns and the outskirts of big cities; dominated by residential housing, schools, parks, etc.
- **Golf Course:** A managed, partially forested area used for the game of golf
- **Agriculture:** A managed, unforested area used to produce crops such as corn, soybeans, hay, oats, etc.
- **Grassland:** Unforested land dominated by wildflowers and grasses
- **Coniferous Forest:** Forestland dominated by cone-bearing trees
- **Deciduous Forest:** Forestland dominated by broadleaf trees that lose their leaves each winter
- **Mixed Forest:** Forestland dominated by both coniferous and deciduous trees
- **Open Water:** Lakes, rivers, and streams
- **Wetland:** A forested or nonforested area that is submerged underwater for all or part of a year
- **Shrubland:** An unforested area dominated by shrubs, wildflowers, and grasses

3. Once the groups have defined the land cover types, use the questions and answers in questions #1 and #2 of Teacher Pages ***7A-B, Discussion: Landscape Scale***, to help them discuss the ecological, social, and economic aspects of forest use. Have students take notes and answer the questions on Student Pages ✎***5A-B, Landscape Scale Worksheet***, while you go over the discussion points. All of the answers to the questions come from Teacher Pages ***7A-B, Discussion: Landscape Scale***.

   Remind students that on the Ashland County land cover map, there were a variety of forest types (coniferous, deciduous, mixed). They are now going to look at how different types of forests are managed. Use the questions and answers in questions #3 and #4 to discuss forest management objectives. Project Student Page ✎***4, Land Cover, Ashland County, Wisconsin***, Teacher Page ***9, Softwood Lumber: Plantation Management***, Teacher Page ***10, Hardwood Lumber and Veneer: Uneven-aged Forest Management***, and Teacher Page ***11, Aspen Paper Pulp: Clearcut Management***, during the discussion.

4. Ask students if they are beginning to see how social, environmental, and economic aspects of the land influence land use patterns. Project Teacher Page ***8, Wisconsin Land Cover Map***. Use the questions and answers in question #5 of Teacher Pages ***7A-B, Discussion: Landscape Scale***, to facilitate the discussion.

> "Let's take our hearts for a walk in the woods and listen to the magic whispers of old trees."
>
> *Unknown*

5. To summarize the importance of understanding the landscape scale, tell students that managing forests on a landscape scale can greatly increase the efficiency of growing wood for wood products, while providing for other human needs. Give the following examples:
   - Areas more suitable for forest management can be identified and used, while other areas (grasslands, farms, wetlands) can be managed for other benefits.
   - Forests more suitable for wood production (i.e., fertile, productive, healthy, adapted to disturbance, less susceptible to damage) can be used to produce wood resources.
   - Forests that are important for the protection of water resources and critical habitat can be managed to protect them.
   - Forests more suitable for recreation activities can be managed accordingly.
   - All human populations consume wood resources. Some of these populations live in forested areas and others do not. By identifying, managing, and using wood resources that are close to home, the energy required and pollution produced by transportation can be reduced.

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Activity 6 – Forest Management: Time Scale

1. Tell students that in addition to looking at the landscape, forest managers must also look at the time scale. This means that foresters must understand the type of forests that exist today, the current needs and challenges, and how they will change in the future.

   Project Teacher Page ***12, Tree Time***. Ask the class to speculate on what each tree is most valued for.

   Answers should be similar to the following:
   - **Aspen:** Valued as a wildlife species because of its use as food and shelter by deer, grouse, and many bird species. It is highly valued as pulp for paper production.
   - **Red Pine:** Valued for lumber and pulp. Historically, it was a major component in mature forests throughout central and northern Wisconsin.
   - **Sugar Maple:** Valued for lumber, veneer, and syrup. It is dominant in mature deciduous and mixed forests throughout northern Wisconsin.
   - **Eastern Hemlock:** Very long-lived and is the dominant tree in old-growth forests in northern Wisconsin. It is an important wildlife tree and used for pulp, but is not currently used for many wood products.

   Review information on the Teacher Page with the class, pointing out that the growth rate for the different tree species is shown in different ways. Help students put the tree ages in perspective. Ask them how old they are, how old their parents/guardians are, and how old their grandparents are. Have them write the ages on a piece of paper. Ask students if they have ever had maple syrup. Have them calculate how old they, their parents, and grandparents were when the sugar maple trees were planted that produce their maple syrup. Do this for a variety of products and services, including some that take a long time to produce (e.g., old-growth eastern hemlock forests).

2. Tell students that not only do trees take a relatively long time to grow, but they also must overcome a lot of dangers. Ask students to brainstorm a list of agents that might harm or kill a tree (e.g., disease, insects browsing, fire, ice, windstorms, drought, air pollution, landuse change). Tell students that all the agents in the list present challenges to forest managers and that some challenges are greater than others.

3. Hand a copy of Student Page ✐***6, Forest Challenges***, to each group. Read the description of each challenge. Tell students that all the challenges listed are currently posing threats to Wisconsin forests.

   Have students go through the list and draw an up arrow for challenges they think will grow in the future, a sideways arrow for those they think will stay the same, and a down arrow for those they think will decrease. Have them explain their reasoning in the right-hand column. Once students are finished, use Teacher Key ***13, Forest Challenges Key***, to review all of the challenges and help students identify solutions.

4. Tell students that by understanding how forests and social needs will change through time, forest managers can help ensure the current and future benefits of forests in the following ways:
   - Anticipate demand for forest resources in the future and manage forests accordingly
   - Use management techniques like prescribed fire, tree planting, thinning, fertilizing, and tree improvement (breeding) to reduce the amount of time it takes forests to grow
   - Use management techniques to help forests overcome challenges (e.g., pest control, wildlife management, wildfire prevention, introduced species eradication)

Activity 7 – Innovation and Technology

1. Tell students that technology and innovation are very important for the reduction of energy inputs and pollution outputs for lumber production. Through the next activity, they will look at a variety of technologies and innovations that have helped reduce the environmental impact of tree harvest and the production of wood products.

2. Have students differentiate between the terms “innovation” and “technology.” Place the two terms on the board and lead a brainstorm to define each. Have students look for key words that they might associate with one of the two terms.

   The words should be similar to the following:
   - **Innovation:** New, creativity, originality, imagination, inspiration, improvement, modernization.
   - **Technology:** Future, invention, equipment, computers, robotics, genetics, engineering, machinery, tools, etc.

   Next, have students compare and contrast them. *(Innovation is an improved way of doing things; technology is the equipment or process used for solving a specific technical problem.)*

3. Explain to the class that advancements that lead to the reductions of energy inputs and pollution outputs result from both innovation and technology. Technology and innovation have a circular relationship. This means that new technologies result from innovation, and innovations result from new technologies.

   Hand a copy of Student Page ✐***7, Forestry Innovation and Technology***, to each group.

Use the information on Student Page ✐7, ***Forestry Innovation and Technology***, and project Teacher Page 14, ***Progressive Harvesting***, Teacher Page 15, ***Forest Modeling***, Teacher Page 16, ***Engineered Wood Products***, Teacher Page 17, ***GPS and GIS***, Teacher Page 18, ***Log Scanning***, and Teacher Page 19, ***Protection and Tree Improvement***, to discuss each of the technologies and how they influence the energy inputs and pollution outputs of different processes.

4. Once you have presented all the technologies, ask the class if anyone is familiar with one of the technologies. Have volunteers further explain their experience. Tell the students that the worksheet will be useful to them as they develop their proposals in the next activity.

Activity 8 – Consumption Patterns

1. Tell the groups that another strategy they can use to minimize the energy inputs and pollution outputs associated with lumber production is to make wise consumer choices for themselves and help others make wise choices as well. Lead a class brainstorm to identify actions that consumers can take to reduce the impact of the manufacture and use of wood products. *(Actions may include buy local wood, buy wood from well-managed forests, buy recycled products, use less wood, buy products from manufacturers that use renewable energy sources.)* Ask students how they would know if wood was local, from a well-managed forest, recycled, or from a manufacturer that uses renewable energy sources. *(The product would need a label or students would need to research the company that produced it.)*

2. Tell students that products made from wood from certified forests are beginning to be sold in retail stores. These products have a label indicating they are certified. Certified forest products come from forests managed to meet environmental, social, and economic standards. The forests are inspected by organizations that have no affiliation with the landowner, forest manager, or forest products industry. If the management of the forest meets the standards, then the products that come from the forest are marked as certified.

   Hand a copy of Student Page ✐8, ***Forest Certification***, to each student. Discuss the four different certification programs and how forests certified by these organizations might be managed differently than other forests. *(Other forests might not have management plans. They might be managed for only economic values. The forest manager may not intend to keep the area forested, but instead sell it for development or agriculture.)*

3. Explain to students that consumers, by looking at product labels, have the opportunity to purchase wood products that come from well-managed forests and that use recycled materials. Tell students that information on where wood comes from and how it is manufactured are more difficult to obtain. Discuss with the class how information on wood origin and energy sources might help consumers make wise decisions. *(Consumers would have the option to buy products made locally and buy products that come from facilities that use renewable energy sources — both would reduce the energy needed and pollution emitted during manufacture and transport.)*

> “Trees and stones will teach you what you cannot learn from masters.”
>
> ✤ *Bernard of Clairvaux* ✤

Conclusion – Proposing Solutions

1. Tell students that they have just learned about different strategies that are used to reduce the environmental impact of wood use. Refer back to the three categories listed on the board.
   - **Forest management** (landscape scale and time scale)
   - **Innovation and technology**
   - **Consumption patterns** (buying certified forest products and buying locally)

   Tell students that they will now work in groups to write a proposal that outlines a practical solution to reduce the environmental impact of forest products.

2. Have students work in groups to choose a specific problem that was identified in Student Page ✎***3, Detailed Wood Production Process***, or in discussion throughout the lesson. They should use one or more strategies to decrease the environmental impact that the process causes.

3. Hand a copy of Student Page ✎***9, Proposal Format***, to each group. Review the proposal format, set a hand-in or presentation date, and allow time for questions.

SUMMATIVE ASSESSMENT

Have students choose three products found in their home and describe their use, country of origin, longevity, and renewability. For each product, have students find ways to reduce the environmental cost of the product by a) reducing consumption; b) using a similar product that is produced locally, lasts longer, or is recyclable; or c) substituting the product for a product that has the same use but is made from a different material. Have students explain how each of their choices will reduce the environmental cost of use.

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ENERGY SOURCES

ENERGY SOURCE	BENEFITS	COSTS
COAL 49.5% of Wisconsin's electricity use	• Coal is the cheapest source of energy • Technology exists to reduce the pollution caused by coal combustion	• Releases more pollutants than any other material • Coal mining causes changes on the landscape • Most coal is from out-of-state
NUCLEAR 15% of Wisconsin's electricity use	• Nuclear energy causes little pollution at the site of generation	• Disposal of nuclear material is difficult and has health risks • Plants pose a large security risk • Nuclear fuel production uses a large amount of energy
NATURAL GAS 24% of Wisconsin's electricity use and growing rapidly; widely used for residential heating and cooking	• Emits less pollution than coal or petroleum • Can be transported in a dense liquid form, reducing the energy costs	• Must be imported to Wisconsin • Requires energy to extract from the ground and transport • Price is unstable
HYDROELECTRIC 3% of Wisconsin's electricity use and decreasing	• Causes little pollution • Hydroelectric dams can serve a variety of purposes, including the maintenance of water levels and the creation of reservoirs	• Can alter terrestrial and aquatic environments • Disrupts the migration patterns of fish • Expensive to maintain
WIND, SOLAR, AND BIOFUELS 11% of Wisconsin's electricity use and growing	• Renewable • Cause little to no pollution • Have the potential to produce energy locally, reducing transportation costs	• Still more expensive to use than some other energy sources • Infrastructure does not currently exist for the large-scale use of these energy sources
WOOD WASTE Used by the wood products industry to provide energy for manufacturing facilities	• Makes use of sawdust, chips, and unmarketable wood from sawmills • Produced on-site • Technology exists to reduce pollution from combustion	• Burning of wood waste releases particulate matter (fly ash and unburned carbon) into the atmosphere
PETROLEUM Oil, diesel, and gas provide the vast majority of energy used for transportation	• Supply is currently available • Technology exists to reduce the pollution emitted during oil and gas combustion	• Emits a variety of pollutants, including greenhouse gases • Limited future supply • Many large reserves are found in environmentally sensitive or politically unstable regions

Teacher Page 1

POLLUTANT MATCH-UP KEY

POLLUTANT

AIR
- Carbon Dioxide (CO_2)
- Carbon Monoxide (CO)
- Nitrogen Oxides (NOx)
- Sulfur Dioxide (SO_2)
- Methane
- Volatile
- Organic
- Compounds (VOC)
- Mercury
- Particulate Matter (PM)

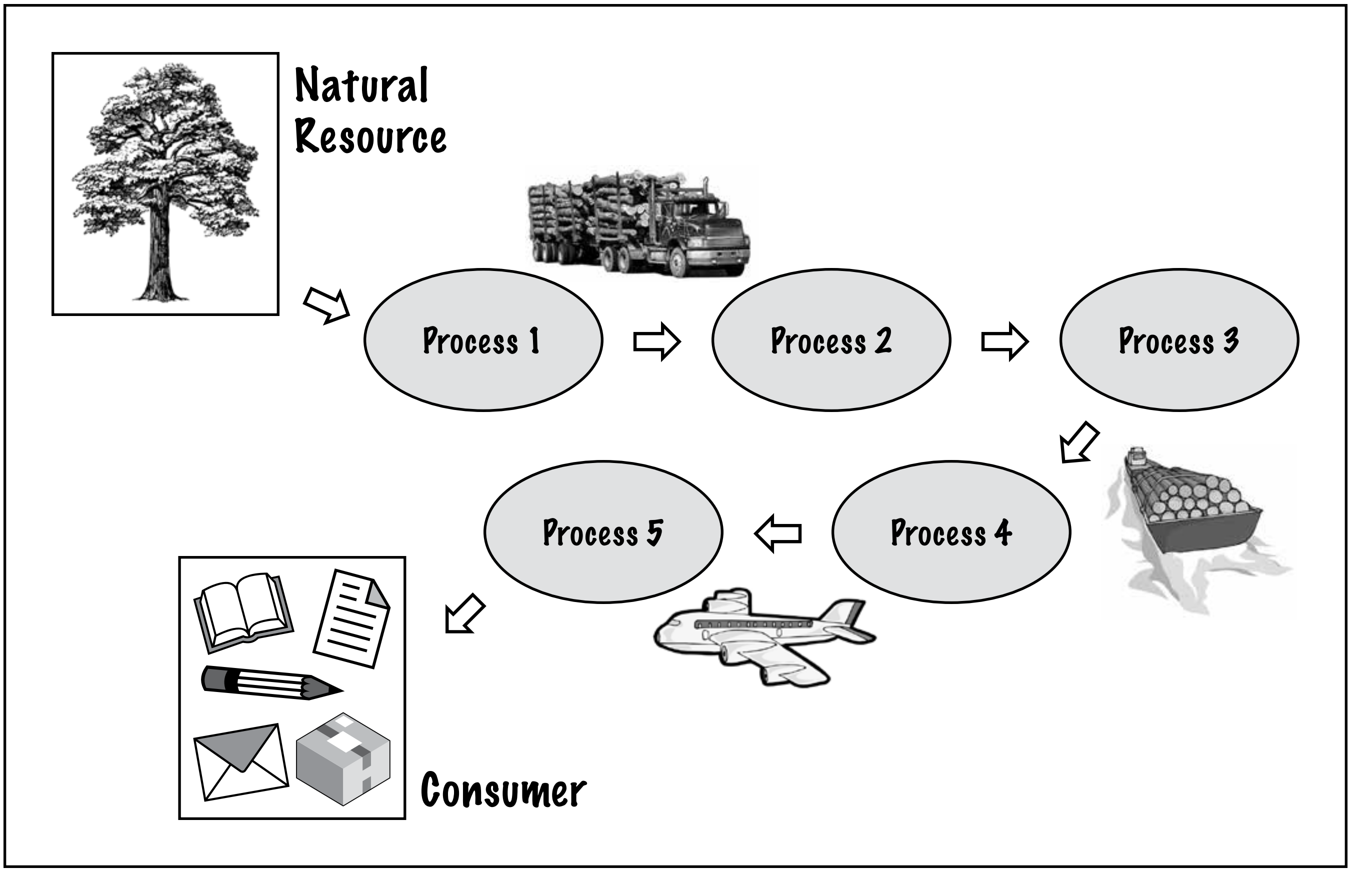
WATER
- Suspended Solids
- Heavy Metals
- Oil and Grease
- Phosphorous and Nitrogen Compounds
- Sulphates and Sulphides
- Chlorides
- Fluorides
- Benzene
- Cyanides

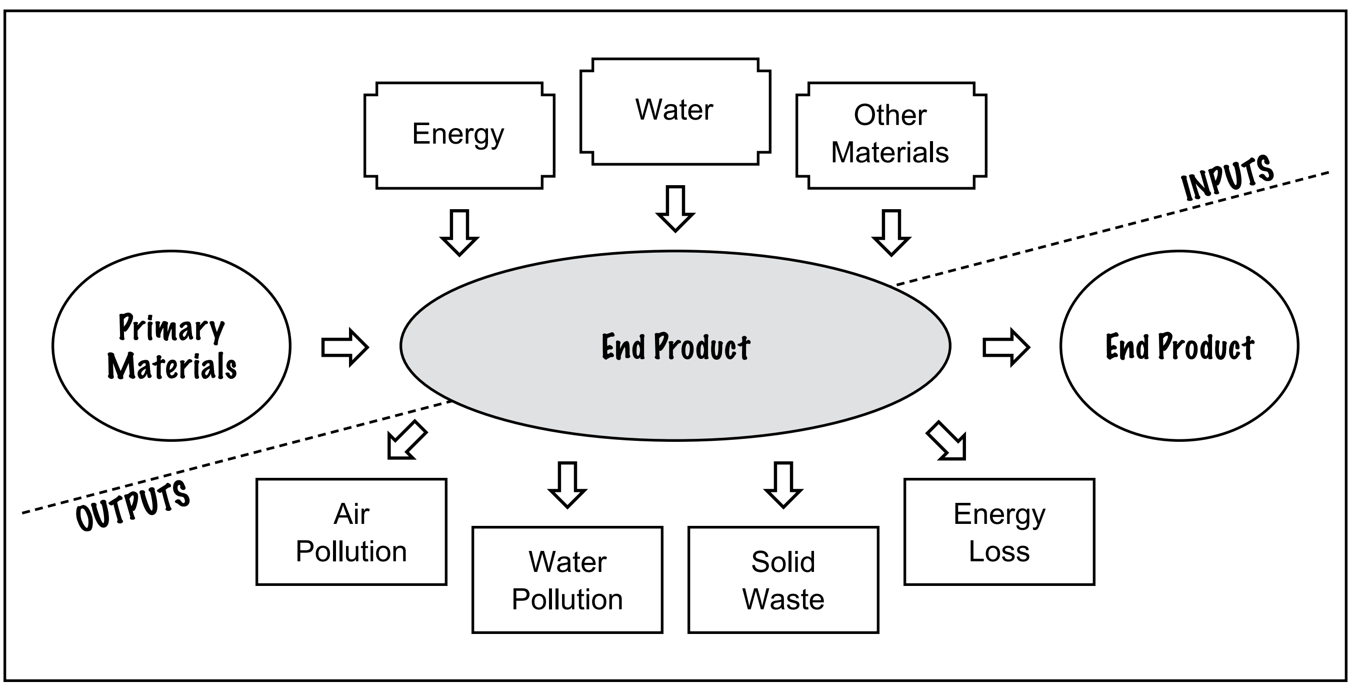
SOLID WASTE
- Slag

DEFINITION

1. Carbon Monoxide – A colorless, odorless, poisonous gas formed when carbon in fossil fuels is not burned completely; a byproduct of vehicle exhaust and fuel combustion in industrial boilers and incinerators.
2. Chlorides – A general term for chemicals containing chlorine; nickel chloride and methyl chloride are common effluents from concrete and steel manufacturing facilities.
3. Nitrogen Oxides – A general term for a group of highly reactive gases, all of which contain nitrogen and oxygen in varying amounts; form when fuel is burned at high temperatures; one of the main ingredients in ground-level ozone.
4. Particulate Matter – A general term used for a mixture of solid particles and liquid droplets found in the air; produced by crushing and grinding operations and burning of wood; can remain in the lower atmosphere for extended periods of time.
5. Slag – A co-product of the production of iron and steel; the fused refuse separated from metals during smelting.
6. Volatile Organic Compounds – Carbon containing gases that mix with nitrogen oxides to form smog; released into the atmosphere from the combustion of fossil fuels; include chemicals like ammonia, methane, and formaldehyde.
7. Fluorides – A general term for chemicals containing fluorine; hydrogen fluoride is used in metal treating and is a common water pollutant from steel manufacturing.
8. Oil and Grease – Petroleum-based compounds used to lubricate machinery; often found in water effluents from steel manufacturing plants and concrete mills.
9. Phosphorous and Nitrogen Compounds – Chemical compounds, including nitrate, nitrite, and phosphate, which cause increased growth of vegetation in waterways.
10. Methane – A greenhouse gas that is more than 20 times more effective in trapping heat in the atmosphere than carbon dioxide; emitted from a variety of sources, including landfills, natural gas and petroleum systems, livestock, and coal mining.
11. Cyanides – A group of compounds based on a common structure formed when elemental nitrogen and carbon are combined; a powerful and rapid-acting poison that is a common effluent of mining and steel manufacturing.
12. Sulfur Dioxide – Belongs to the family of sulfur oxide gases, which dissolve easily in water and cause acid rain; formed when coal or oil are burned, when gasoline is extracted from oil, or metals are extracted from ore.
13. Mercury – A naturally occurring element that can cause brain damage in humans, especially babies and young children; primarily emitted into the atmosphere by coal-fired power plants; accumulates to toxic levels in fish.
14. Carbon Dioxide – A greenhouse gas emitted from a variety of sources, including animal respiration and the burning of fossil fuels and wood.
15. Suspended Solids – A general term for pollutants that do not dissolve in water; can include such things as soil, dust, soot, municipal waste, etc.
16. Heavy Metals – Naturally occurring elements that pose health risks when found in high concentrations; include zinc, lead, chromium, iron, nickel, and mercury; common water and/or air pollution from mining and steel manufacturing.
17. Sulphates and Sulphides – Sulfur compounds which cause acidification of water systems; releases of sulfur into waterways can be caused by mining operations.
18. Benzene – A chemical often used in the cleaning and treatment of steel; enters the environment in water and can pose health hazards to humans.

LIFE CYCLE ANALYSIS DIAGRAM





LIFE CYCLE ANALYSIS

Concrete, Steel, and Wood

CONCRETE

Petroleum, Coal	Petroleum	Coal, Water	Coal, Natural Gas	Coal, Gypsum	Petroleum
Mining (lime, sand, gypsum, iron, clay, bauxite) →	Transport →	Milling →	Burning →	Grinding →	Transport
CO_2, CO, CH_4, NOx, SO_2, VOC, mercury, PM, suspended solids, heavy metals	CO_2, CO, CH_4, NOx, SO_2, VOC	CO_2, CO, CH_4, NOx, SO_2, VOC, mercury, PM	CO_2, CO, CH_4, NOx, SO_2, VOC, mercury, suspended solids, aluminum, oil, grease, nitrate, nitrite, DOC, chlorides, sulphates, sulphides, phosphorous, zinc	CO_2, CO, CH_4, NOx, SO_2, VOC, mercury, PM	CO_2, CO, CH_4, NOx, SO_2, VOC

STEEL

Petroleum, Coal	Petroleum	Petroleum, Coal, Natural Gas, Water, Lime, Scrap Steel	Petroleum, Water, Treatment Chemicals, Coal, Natural Gas	Petroleum
Mining (iron ore, iron alloys, lime) →	Transport →	Melting and Metallurgy →	Casting and Treating →	Transport
CO_2, CO, CH_4, NOx, SO_2, VOC, PM, suspended solids, heavy metals	CO_2, CO, CH_4, NOx, SO_2, VOC	CO_2, CO, CH_4, NOx, SO_2, VOC, suspended solids, heavy metals, oil, grease, zinc, chromium, nickel, chlorides, fluorides, iron, nitrogen, phosphates, sulphides, slag	CO_2, CO, CH_4, NOx, SO_2, VOC, mercury, benzene, cyanide	CO_2, CO, CH_4, NOx, SO_2, VOC

WOOD

Petroleum	Petroleum	Coal, Water, Wood Waste	Wood Waste and/or Natural Gas	Coal, Wood Waste	Petroleum
Tree Harvest →	Transport →	Sawmilling (debark, saw, trim) →	Kiln Drying →	Planing →	Transport
CO_2, CO, CH_4, NOx, SO_2, VOC	CO_2, CO, CH_4, NOx, SO_2, VOC	CO_2, CO, CH_4, NOx, SO_2, VOC, mercury, carbon, PM	CO_2, CO, CH_4, NOx, SO_2, VOC, carbon, PM	CO_2, CO, CH_4, NOx, SO_2, VOC, mercury, carbon, PM	CO_2, CO, CH_4, NOx, SO_2, VOC

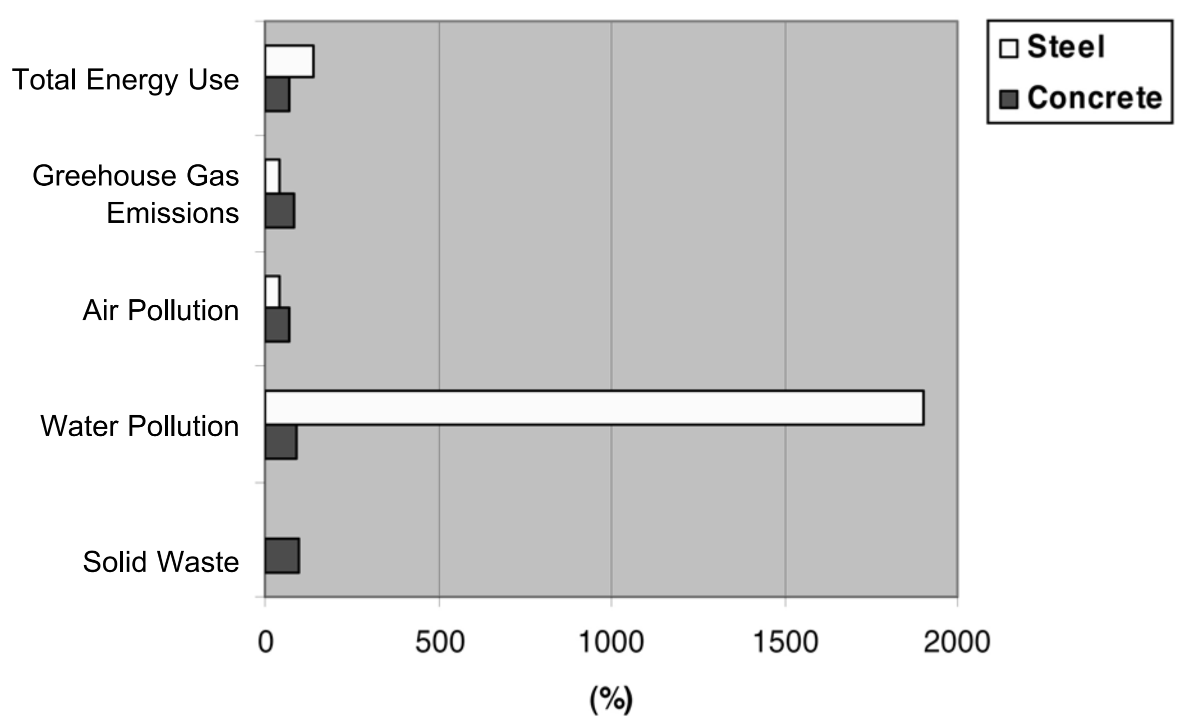
Teacher Page 4

ENERGY AND POLLUTION COMPARISON

To Manufacture an Equal Volume of Concrete, Steel, or Wood

Categories	Wood	Concrete	Steel
Total Energy Use	Lowest	70% More Than Wood	140% More Than Wood
Greenhouse Gas Emissions	Lowest	81% More Than Wood	45% More Than Wood
Air Pollution	Lowest	67% More Than Wood	42% More Than Wood
Water Pollution	Lowest	90% More Than Wood	1,900% More Than Wood
Solid Waste	Lowest; Equal to Steel	96% More Than Wood or Steel	Lowest; Equal to Wood

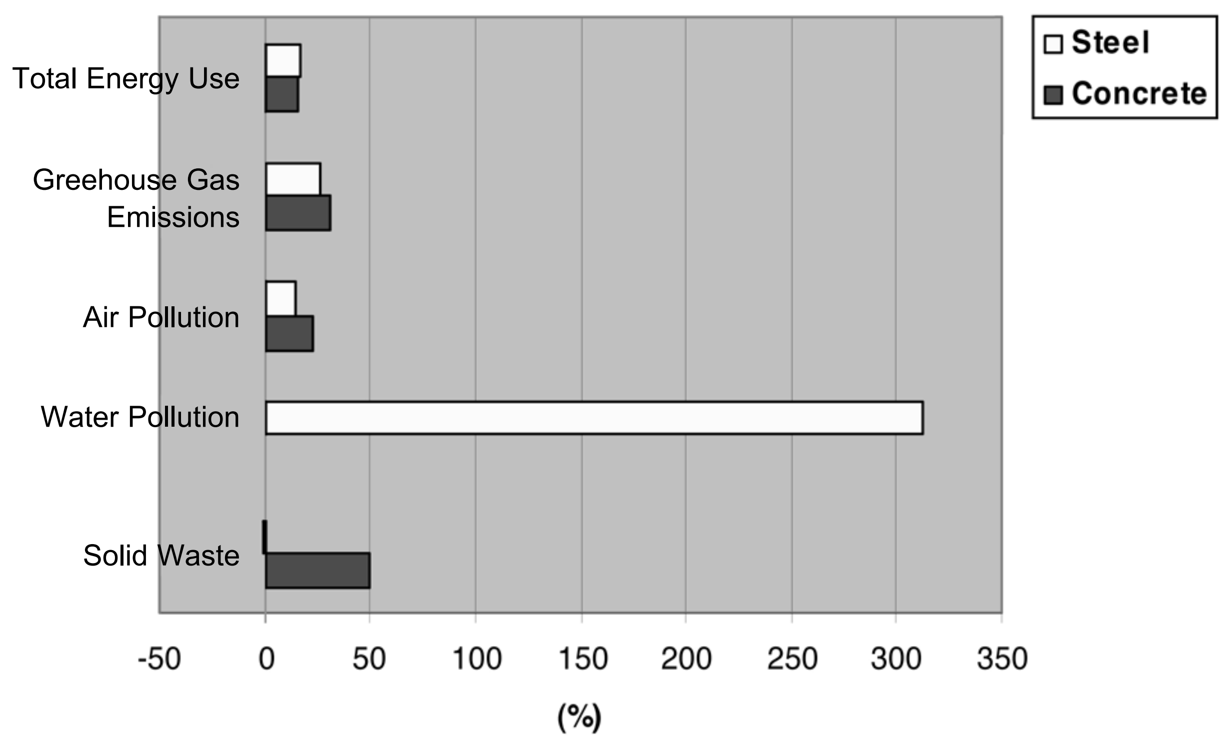
Energy and Pollution: % Difference Compared to Wood



ENVIRONMENTAL IMPACT COMPARISON

Categories	Wood	Concrete	Steel
Total Energy Use	Lowest	16% More Than Wood	17% More Than Wood
Greenhouse Gas Emissions	Lowest	31% More Than Wood	26% More Than Wood
Air Pollution	Lowest	23% More Than Wood	14% More Than Wood
Water Pollution	Lowest; Equal to Concrete	Lowest; Equal to Wood	312% More Than Wood or Concrete
Solid Waste	1% More Than Steel	51% More Than Steel	Lowest

Environmental Impact: % Difference Compared to Wood



DISCUSSION: LANDSCAPE SCALE

1. Have small groups work with the Ashland County Land Cover Map (see page 233) to discuss and answer the following questions.
   - **Which land cover types are designed for human habitation and use?** High-intensity urban areas, low-intensity urban areas, golf courses, and agricultural land are the most obvious areas developed for human habitation and use, but each of the land cover types has human influences. Ashland County has a population of about 17,000 people, but tens of thousands of people visit each year to fish, hunt, camp, and enjoy other tourist activities.
   - **Is there a lot of agricultural land in Ashland County?** No, only small areas of agricultural land exist in Ashland County because of the cold weather (short growing season).
   - **Where do you think the residents get their food?** Residents must import much of their food from other counties, states, and countries where agriculture is more productive.
   - **Does there appear to be a large amount of forestland in Ashland County?** Yes, Ashland County has about 670,000 acres of land, 81% of which is forested.
   - **Which land cover types are forested?** Coniferous forest, deciduous forest, mixed forest, and some wetlands.
   - **Compared to other counties that you are familiar with in Wisconsin, do you think that Ashland County would be a good place to manage forests for wood production?** Ashland County is one of the most heavily forested and least populous regions in the state and is well-suited for forest management to supply wood resources.
   - **Do you think that all of the forests of Ashland County should be used solely for wood production or are there other needs that should be taken into consideration?** Ashland County is a very popular tourist attraction for outdoor enthusiasts (hikers, nature photographers, anglers, hunters, boaters, etc.). It has many streams and wetlands that drain into Lake Superior, making it a very important source of fresh water for both fish and human populations. Its forests also offer critical habitat for many species of animals and plants.

2. Use Student Page ***4, Land Cover, Ashland County, Wisconsin***, to discuss the following forest management objectives — wildlife, water resources, and recreation.
   - **Which land cover types in Ashland County do you think are important for wildlife that require large, undeveloped areas for habitat (e.g., black bear, pine marten, fisher, eastern timber wolf, neotropical migratory birds)?** Coniferous, deciduous, or mixed forest that is distant from populated areas and roads could serve as habitat for these species.
   - **Which land cover types do you think are most critical for protecting water resources?** Forest and grassland areas that surround lakes, rivers, and wetlands.
   - **Which land cover types do you think are most important for human recreation (scenery, camping, hiking, hunting, etc.)?** A variety of areas within mixed forest, coniferous forest, and deciduous forest can serve for recreation purposes, but most of these areas should be undeveloped and in undisturbed settings (little evidence of logging or other human activities).
   - **What types of wood products might we produce from Ashland County?** Paper (aspen pulp), wood for home construction (lumber from coniferous trees — softwood lumber), wood for furniture (wood from deciduous trees — hardwood lumber and veneer).
   - **Which land cover types do you think are most suitable for producing wood products?** Coniferous forest, deciduous forest, mixed coniferous/deciduous forest.

3. Use Teacher Pages ***9***, ***10***, and ***11*** to discuss how forests are managed for wood products.

   Teacher Page 9, Softwood Lumber: Plantation Management — *Plantations are often established and managed to produce lumber from coniferous trees like red pine, white pine, and white spruce. The lumber is called softwood lumber. Softwood lumber is widely used in the construction of houses. Trees used for softwood lumber are most often grown in plantations. Fertile coniferous forests on relatively flat ground that are easily accessible are most suitable for pine plantations.*
   - **What are the most noticeable characteristics of a pine plantation?** All the trees are the same species, the same age/size, are planted in rows/evenly spaced. Pine plantations contain few other species.

Teacher Page 7A

DISCUSSION: LANDSCAPE SCALE

- **What do you think the benefits are of growing trees in a plantation?** Plantations are a form of even-aged management. Plantations maximize wood growth per unit area. It is easier to predict growth and plan harvests in plantations. They are easier to manage and access with machinery than typical coniferous or mixed forests. Since more wood is produced per unit area, plantation management has the potential to reduce harvests in other forested areas.

Teacher Page 10, Hardwood Lumber and Veneer: Uneven-aged Forest Management — *Fertile deciduous and mixed forests are often managed for the production of hardwood lumber and veneer to make furniture, cabinets, and a variety of other wood products. Hardwoods are deciduous trees like maple, ash, oak, beech, birch, and basswood. These types of forests often appear to be more "natural" than tree plantations.*

- **What differences can you see between the plantation and this mature northern hardwood forest?** The mature northern hardwood forest has a variety of tree species and a variety of tree ages/sizes. Trees are growing randomly across the landscape. Trees are less evenly dispersed on the landscape and there are more forbs (nonwoody plants) and shrubs.
- **How might forest management differ in this type of forest than in a plantation?** Foresters have to manage for a variety of tree species and a variety of tree ages. This is done through selective cutting. To ensure the continuous production of wood through time, environmental conditions must be made favorable for the natural regeneration of trees. Large- and medium-sized trees, saplings, and seedlings must be present so that when larger trees are harvested, trees grow in their place.

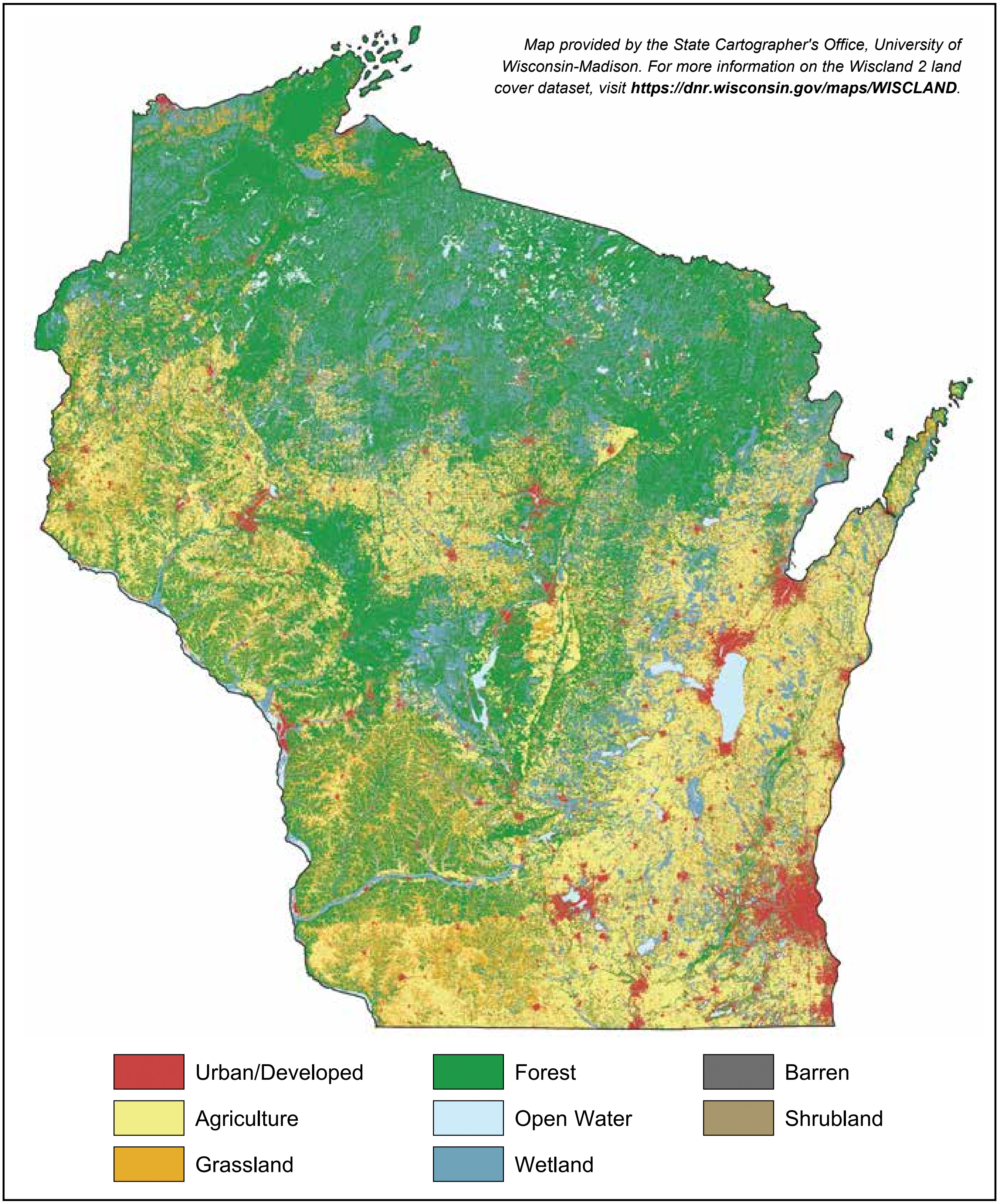
Teacher Page 11, Aspen Paper Pulp: Clearcut Management Young — *Deciduous forests are often managed for aspen trees for use as pulp to make paper. Aspen trees are a natural component of many young forests in Wisconsin.*

- **What differences do you see between the mature northern hardwood forest and the aspen stand?** There is only one species of tree — aspen. The aspen trees are much closer together, they appear to be the same size/age, and there is no space in the understory.
- **What management techniques do you think are used to promote the growth of aspen stands like this one?** When deciduous forests in Wisconsin are clearcut or removed by fire (even-aged management), aspen is usually the first tree to grow. Clearcutting or fire management is often used to promote aspen growth, and after a few treatments, aspen grows very thick, much like the stand in the picture. Aspen is cut approximately every 50 years to maximize harvest and ensure the regeneration of aspen, which grows best in full sun.

4. To summarize the discussion, tell students that all the management objectives they discussed need to be satisfied if human populations continue to value wildlife, clean water, recreation, and wood products. If any one dominates the landscape, some forest values will be absent. Managing forests on a landscape scale is necessary to ensure that all of these values are provided.
5. Have students examine ***Teacher Page 8, Wisconsin Land Cover Map,*** to answer the following questions.
   - **Where is Ashland County?** Northern border on Lake Superior.
   - **What type of land cover dominates the county?** Forest.
   - **What type(s) of land cover dominate(s) Wisconsin?** 46% forest, 50% agriculture, 4% urban.
   - **Which regions are suited for the production of forest products?** North and southwest.
   - **Where is the highest population density on the map?** Milwaukee County and Dane County.
   - **What type of land use surrounds the most populated areas in the state?** Urban areas and agriculture. Southern Wisconsin is well-suited to agriculture and heavily farmed.
   - **Do you think that the populated areas produce enough wood in their surrounding areas to meet their demand?** No, they need to import wood products from other areas in Wisconsin (e.g., Ashland County), other states (e.g., Oregon), and other countries (e.g., Brazil). Communities in southern Wisconsin depend on other regions for their wood.
   - **What would happen if landowners in Wisconsin stopped managing forests for wood products?** It is unlikely that decreases in the local production of wood would cause people to use less wood, since wood is readily available from many other places in the world. The result would only be a large increase in imported wood from other areas of the U.S. and the world.

Teacher Page 7B

WISCONSIN LAND COVER MAP



SOFTWOOD LUMBER: PLANTATION MANAGEMENT

HARDWOOD LUMBER AND VENEER: UNEVEN-AGED FOREST MANAGEMENT

ASPEN PAPER PULP: CLEARCUT MANAGEMENT

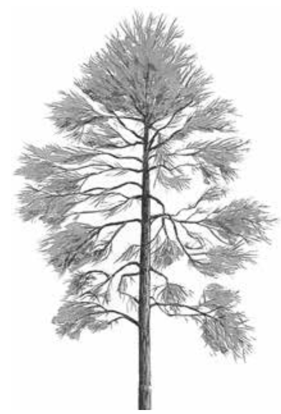
Teacher Page 11

TREE TIME

ASPEN

Grouse Habitat = 25 Years
Paper = 50 Years
Lumber = 70 Years
Death = 125 Years

RED PINE



Christmas Trees = 12 Years
Mast (Food) for Wildlife = 50 Years
Lumber = 100 Years
Death = 250 Years

SUGAR MAPLE

Maple Syrup = 50 Years
Paper = 80 Years
Lumber and Veneer = 130 Years
Death = 350 Years

EASTERN HEMLOCK

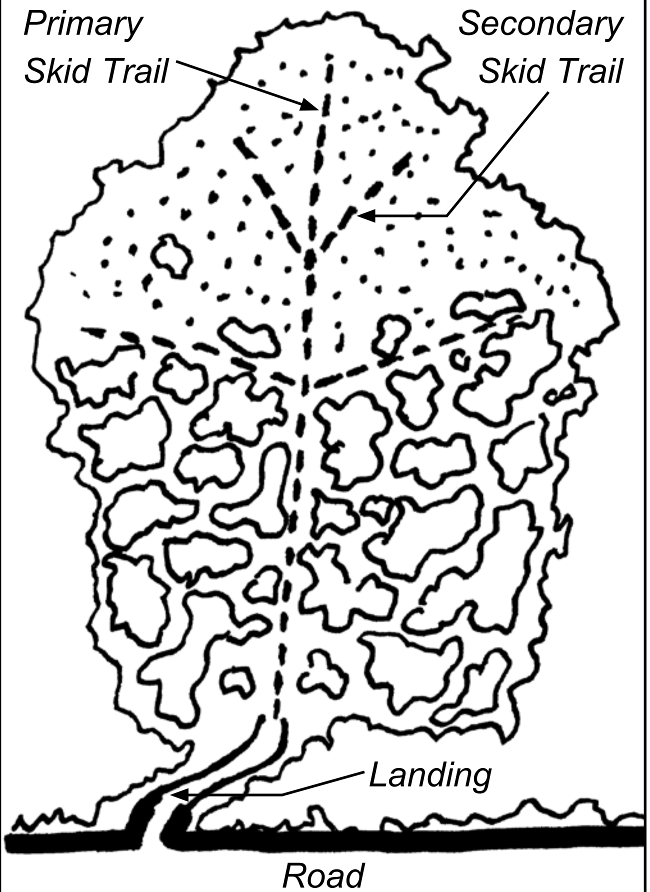
Mast (Food) for Wildlife = 150 Years
Lumber = 250 Years
Old-growth Forest = 350 Years
Death = 800 Years

FOREST CHALLENGES KEY

Forest Challenge	Trend ↑ ↔ ↓	Explanation
PESTS AND DISEASE: Native pests and diseases (e.g., the tent caterpillar, white pine blister rust) and introduced pests and diseases (e.g., the gypsy moth, Dutch elm disease) can weaken or kill trees.	↑	*Pest and disease problems will most likely increase in the future due to the expansion of introduced species populations currently in Wisconsin and new species that may arrive. Some of the most threatening are the emerald ash borer, sudden oak death, and the hemlock wooly adelgid.*
DEER POPULATIONS: As deer numbers increase, some plant species they prefer for food become less abundant or are lost. Other plants increase in abundance. Large numbers of deer affect tree regeneration and can change the tree composition in the forest.	↑ OR ↔	*Some deer population forecasts predict a stable population, while others predict increases. Increases can occur if winters become less severe, if hunting pressure diminishes, or if forest management and land use changes encourage the expansion of early successional forests.*
FIRE: Fire is suppressed throughout Wisconsin's forests to protect private property and human life. Prescribed fire is used in some forests to maintain historic fire conditions. Many wildfires occur (about 1,500 each year) and most are caused by debris burning, equipment use, and arson.	↔	*The frequency of fire across the landscape will most likely remain constant. Public awareness, forest management, and fire suppression techniques will continue to reduce the frequency of wildfires, and prescribed fire will be more widely used as a forest management technique.*
SEVERE WEATHER: Ice storms, extreme cold, severe winds, drought, and flooding can all cause damage to trees. Most of these events cannot be prevented, and the location and timing of specific events cannot be predicted.	↑ OR ↔	*The impact of severe weather on forests will most likely stay the same through time, with small events happening yearly and large events happening every 10 to 100 years. As climate changes globally, severe weather patterns will be more difficult to predict and may become more frequent.*
AIR POLLUTION: Since the early 1900s, levels of some environmental pollution have been increasing in quantities that may be harmful to plant and animal populations. Acid rain and smog can weaken and damage trees.	↑ OR ↔	*Levels of air pollution in Wisconsin will most likely increase or persist at current levels for some time. Though technologies exist to reduce pollutants caused by transportation, energy production, and product manufacturing, increases in consumption levels will most likely offset these advances.*
LAND USE CHANGE: Changes in land use (e.g., the conversion of forest to urban areas) can result in the reduction of plant, animal, and tree species, as well as fragmentation (the division of forest areas into smaller patches surrounded by developed and/or disturbed areas).	↑	*Urban areas in Wisconsin are expanding and more people are buying property in forested areas. Every year about 3,400 new parcels of land are carved out of Wisconsin's forested land base.*

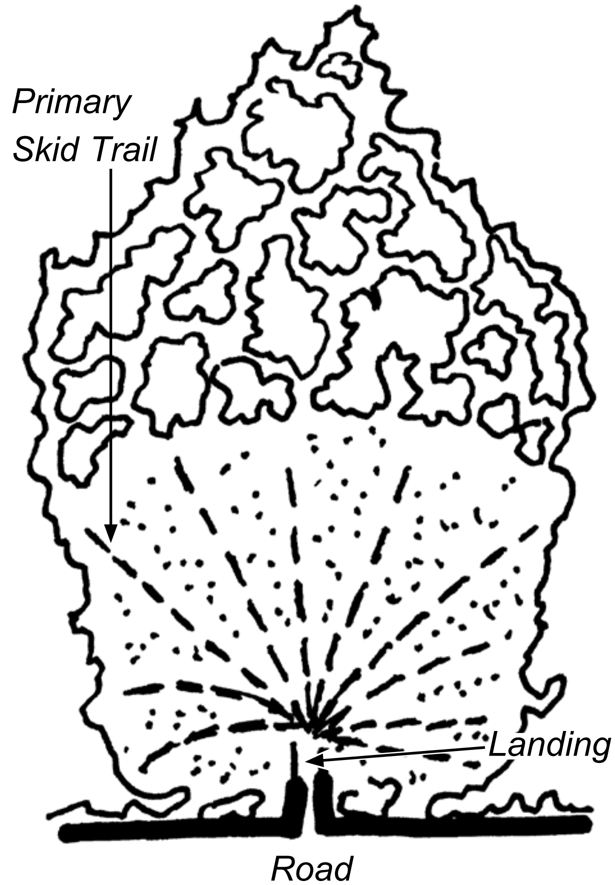
PROGRESSIVE HARVESTING

PROGRESSIVE HARVEST



- Uses primary and secondary skid trails
- Reduces damage to tree seedlings and saplings
- Reduces soil compaction at the landing site

TRADITIONAL HARVEST

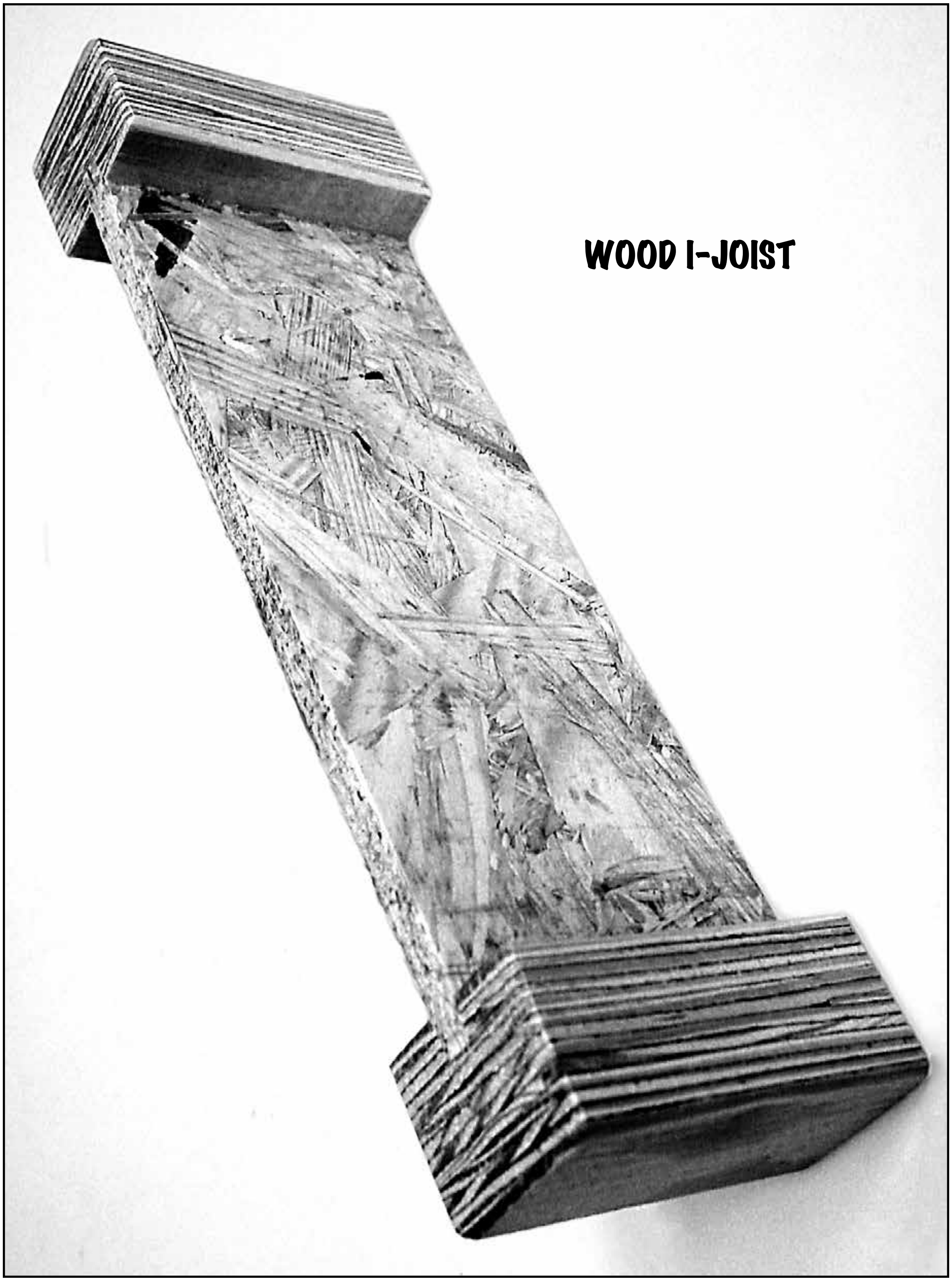


- Uses only primary skid trails
- Higher risk of damaging tree seedlings and saplings
- Causes soil compaction at the landing site which slows the regeneration of trees

Skid Trail: Path on which logs are removed from a forest.

FOREST MODELING

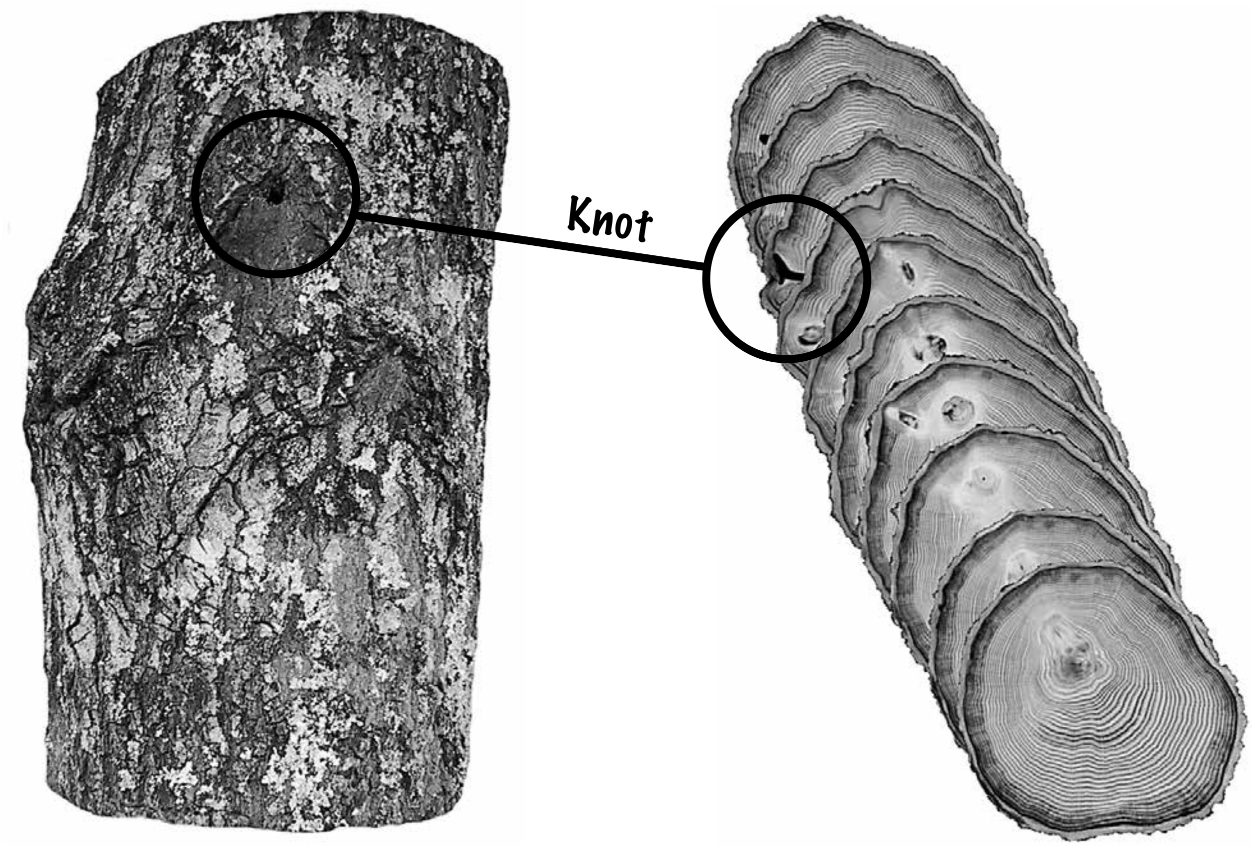
ENGINEERED WOOD PRODUCTS



GPS AND GIS

LOG SCANNING

CT Scan



CT scanning, or computer tomography, is used in some lumber mills to detect defects in logs. The images produced from a CT scan are realistic and show more detail than a traditional X-ray

Photo courtesy of U.S. Forest Service, Southern Research Station, Blacksburg, VA.

PROTECTION AND TREE IMPROVEMENT

POLLUTION MATCH-UP

POLLUTANT	DEFINITION
AIR • Carbon Dioxide (CO_2) • Carbon Monoxide (CO) • Nitrogen Oxides (NOx) • Sulfur Dioxide (SO_2) • Methane • Volatile • Organic • Compounds (VOC) • Mercury • Particulate Matter (PM) **WATER** • Suspended Solids • Heavy Metals • Oil and Grease • Phosphorous and Nitrogen Compounds • Sulphates and Sulphides • Chlorides • Fluorides • Benzene • Cyanides **SOLID WASTE** • Slag	1. A colorless, odorless, poisonous gas formed when carbon in fossil fuels is not burned completely; a byproduct of vehicle exhaust and fuel combustion in industrial boilers and incinerators. ______ 2. A general term for chemicals containing chlorine; nickel chloride and methyl chloride are common effluents from concrete and steel manufacturing facilities. ______ 3. A general term for a group of highly reactive gases, all of which contain nitrogen and oxygen in varying amounts; form when fuel is burned at high temperatures; one of the main ingredients in ground-level ozone. ______ 4. A general term used for a mixture of solid particles and liquid droplets found in the air; produced by crushing and grinding operations and burning of wood; can remain in the lower atmosphere for extended periods of time. ______ 5. A co-product of the production of iron and steel; the fused refuse separated from metals during smelting. ______ 6. Carbon containing gases that mix with nitrogen oxides to form smog; released into the atmosphere from the combustion of fossil fuels; include chemicals like ammonia, methane, and formaldehyde. ______ 7. A general term for chemicals containing fluorine; hydrogen fluoride is used in metal treating and is a common water pollutant from steel manufacturing. ______ 8. Petroleum-based compounds used to lubricate machinery; often found in water effluents from steel manufacturing plants and concrete mills. ______ 9. Chemical compounds, including nitrate, nitrite, and phosphate, which cause increased growth of vegetation in waterways. ______ 10. A greenhouse gas that is more than 20 times more effective in trapping heat in the atmosphere than carbon dioxide; emitted from a variety of sources, including landfills, natural gas and petroleum systems, livestock, and coal mining. ______ 11. A group of compounds based on a common structure formed when elemental nitrogen and carbon are combined; a powerful and rapid-acting poison that is a common effluent of mining and steel manufacturing. ______ 12. Belongs to the family of sulfur oxide gases, which dissolve easily in water and cause acid rain; formed when coal or oil are burned, when gasoline is extracted from oil, or metals are extracted from ore. ______ 13. A naturally occurring element that can cause brain damage in humans, especially babies and young children; primarily emitted into the atmosphere by coal-fired power plants; accumulates to toxic levels in fish. ______ 14. A greenhouse gas emitted from a variety of sources, including animal respiration and the burning of fossil fuels and wood. ______ 15. A general term for pollutants that do not dissolve in water; can include such things as soil, dust, soot, municipal waste, etc. ______ 16. Naturally occurring elements that pose health risks when found in high concentrations; include zinc, lead, chromium, iron, nickel, and mercury; common water and/or air pollution from mining and steel manufacturing. ______ 17. Sulfur compounds which cause acidification of water systems; releases of sulfur into waterways can be caused by mining operations. ______ 18. A chemical often used in the cleaning and treatment of steel; enters the environment in water and can pose health hazards to humans. ______

Student Page ✎1

ENERGY AND POLLUTION

Concrete, Steel, and Wood

CONCRETE • CONCRETE • CONCRETE • CONCRETE

PROCESS	ACTIVITY	ENERGY INPUTS	POLLUTION	OTHER INPUTS
Mining	Mining of gypsum, limestone, sand, iron, and bauxite; mine reclamation	Petroleum, Coal	• **Air:** CO_2, CO, CH_4, NOx, SO_2, VOC, mercury, PM • **Water:** suspended solids, heavy metals	
Transport	Transport with trucks, barges, trains, and/or ocean liners	Petroleum	• **Air:** CO_2, CO, CH_4, NOx, SO_2, VOC	
Milling	Factory of mixing materials	Coal	• **Air:** CO_2, CO, CH_4, NOx, SO_2, VOC, mercury, PM	Water
Burning	Baking materials to form "clinkers;" water is screened away or evaporated during baking	Coal, Natural Gas	• **Air:** CO_2, CO, CH_4, NOx, SO_2, VOC, mercury, PM • **Water:** suspended solids, aluminum, oil, grease, nitrate, nitrite, DOC, zinc, chlorides, sulphates, sulphides, phosphates	
Grinding	Grinding materials	Coal	• **Air:** CO_2, CO, CH_4, NOx, SO_2, VOC, mercury, PM	Gypsum
Transport	Transport with trucks, barges, trains, and/or ocean liners	Petroleum	• **Air:** CO_2, CO, CH_4, NOx, SO_2, VOC	

Student Page ✎ 2A

ENERGY AND POLLUTION
Concrete, Steel, and Wood

STEEL • STEEL • STEEL • STEEL • STEEL • STEEL

PROCESS	ACTIVITY	ENERGY INPUTS	POLLUTION	OTHER INPUTS
Mining	Mining of iron ore, coal, and limestone; mine reclamation	Petroleum, Coal	• **Air:** CO_2, CO, CH_4, NOx, SO_2, VOC, mercury, PM • **Water:** suspended solids, heavy metals	
Transport	Transport with trucks, barges, trains, and/or ocean liners	Petroleum	• **Air:** CO_2, CO, CH_4, NOx, SO_2, VOC	
Melting and Metallurgy	Sinter plant, coke ovens, blast furnaces, stoves	Coal (for electricity), Petroleum, Natural Gas	• **Air:** CO_2, CO, CH_4, NOx, SO_2, VOC, mercury, PM • **Water:** lead, suspended solids, oil, grease, zinc, chromium, nickel chlorides, fluorides, nitrogen, iron, sulphides, phosphates • **Solid:** Slag	Water, coal (for coke ovens), lime, scrap steel
Casting and Treating	Ladling, forming, and finishing of steel products	Coal, Petroleum, Natural Gas	• **Air:** CO_2, CO, CH_4, NOx, SO_2, VOC, mercury • **Water:** benzene, cyanide	Water treatment chemicals
Transport	Transport with trucks, barges, trains, and/or ocean liners	Petroleum	• **Air:** CO_2, CO, CH_4, NOx, SO_2, VOC	

WOOD • WOOD • WOOD • WOOD • WOOD • WOOD

PROCESS	ACTIVITY	ENERGY INPUTS	POLLUTION	OTHER INPUTS
Tree Harvesting	Mechanical harvest with diesel engines	Petroleum	• **Air:** CO_2, CO, CH_4, NOx, SO_2, VOC	
Transport	Transport with trucks, barges, trains, and/or ocean liners	Petroleum	• **Air:** CO_2, CO, CH_4, NOx, SO_2, VOC	
Sawmilling	Debarking, sawing and trimming of logs	Coal, Wood Waste	• **Air:** CO_2, CO, CH_4, NOx, SO_2, VOC, mercury, carbon, PM	Water for keeping logs moist
Kiln Drying	Drying with heat	Wood Waste and/or Natural Gas	• **Air:** CO_2, CO, CH_4, NOx, SO_2, VOC, carbon, PM	
Planing	Planing dry boards for smoothness, uniformity and straightness	Coal, Wood Waste	• **Air:** CO_2, CO, CH_4, NOx, SO_2, VOC, mercury, carbon, PM	
Transport	Transport with trucks, barges, trains, and/or ocean liners	Petroleum	• **Air:** CO_2, CO, CH_4, NOx, SO_2, VOC	

Student Page ✎ 2B

DETAILED WOOD PRODUCTION PROCESS

TREE HARVEST AND SHIPPING

Trees are harvested with gas- or diesel-powered machinery. If machinery with clean-burning fuel were used, the harvest of trees would produce less pollution.

Sometimes valuable trees are harvested and shipped to other states and countries to be cut into lumber or made into wood products. Producing lumber locally, rather than at a distant site, uses less energy and produces less pollution during transportation.

Trees can come from certified forests (forests managed for current and future economic, social, and ecological benefits) or from forests that are not certified. Forest certification guarantees that the wood comes from a well-managed forest, but increases cost.

SAWING

Logs are piled and watered to keep the wood from staining. If the wood could be protected at lower moisture levels, energy could be saved in the drying process after boards are cut.

Many sawmills use laser measurement and computer imagery to maximize the useable wood sawn from each log. As more sawmills use the technology, less wood is wasted.

The electricity used to power sawmill operations comes mainly from coal-fired power plants, which cause most of the pollution associated with the process. If clean sources of electricity were used, sawing would produce less pollution.

KILN DRYING

Boards are dried to reduce warping. They are placed in a large kiln that dries them with hot air. Heat is generated with wood waste, natural gas, and/or electricity.

Kiln drying is the biggest energy need for the production of wood boards. If alternative drying methods or clean sources of energy could be used to dry the boards, much energy would be saved and pollution would be greatly reduced.

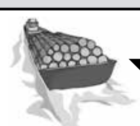
The use of wood waste to produce energy reduces solid waste and energy imports, but it releases particulate matter and carbon compounds into the atmosphere. Improved technology to cleanly burn wood waste would reduce energy inputs and pollution outputs.

PLANING AND SHIPPING

Each board is planed to straighten and leave a smooth finish. Energy inputs and pollution outputs during this process could be reduced by using a clean source of electricity.

Boards are sorted and packed for shipping. They are shipped directly to consumer markets around the world or to secondary wood products facilities where they are made into windows, doors, furniture, etc.

The environmental impact of the transport of wood boards to other parts of the country and world are much greater than that of planing and packaging them. The use of local markets and new transportation technologies would greatly reduce environmental costs.

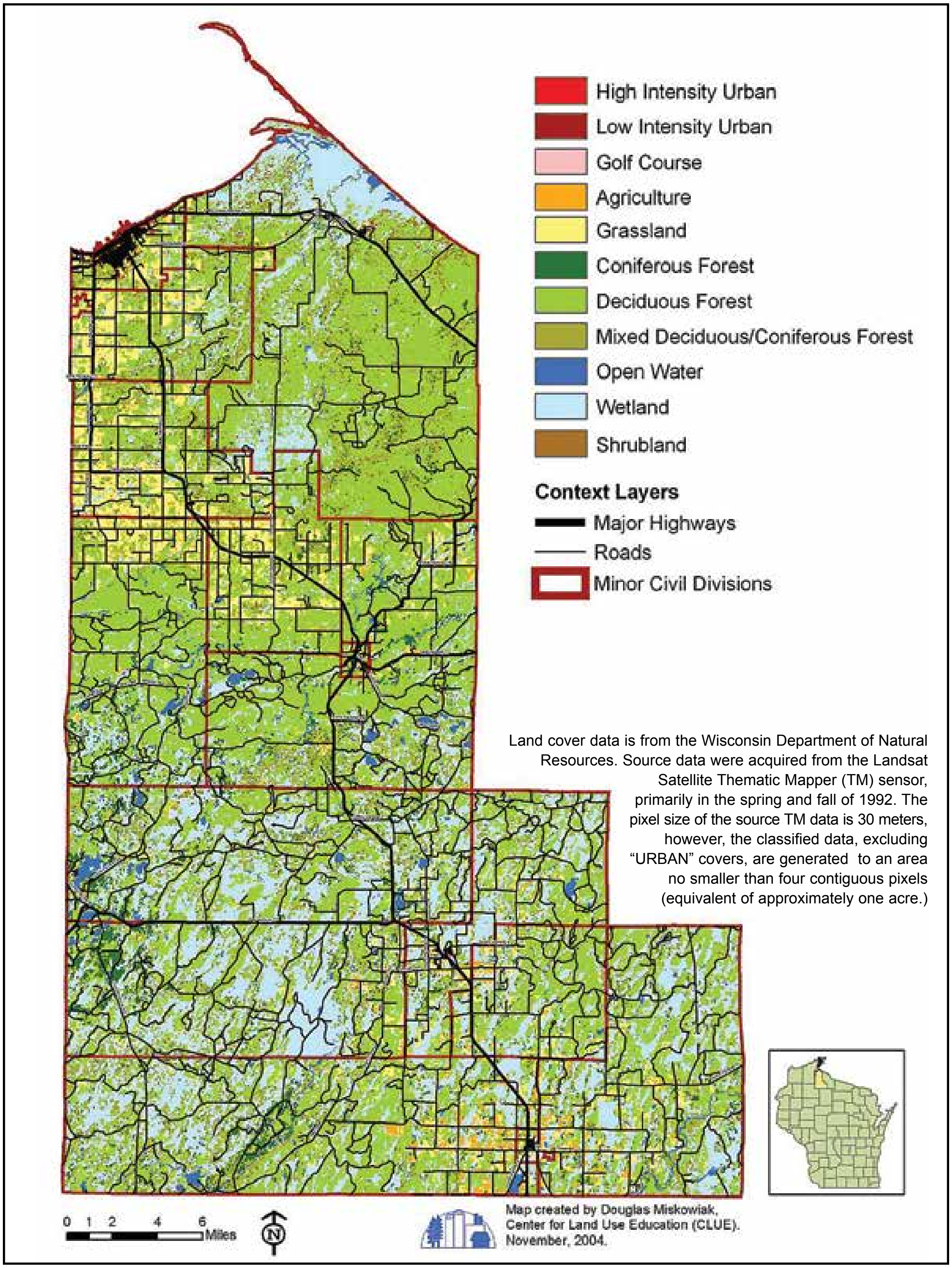


SECONDARY WOOD PRODUCTS FACILITIES

CONSUMER MARKETS

Student Page ✎ 3

LAND COVER, ASHLAND COUNTY, WISCONSIN



This map displays land cover in Ashland County, Wisconsin. Land cover data identifies land features that are visible on the ground, such as "forest" or "urban." Land cover data is not an interpretation of land use, such as "park" or "residential."

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LANDSCAPE SCALE WORKSHEET

1. **Define the following terms found on the land cover map for Ashland County:**
   High-intensity Urban Area: ______________________________

   Low-intensity Urban Area: ______________________________

   Golf Course: ______________________________

   Agriculture: ______________________________

   Grassland: ______________________________

   Coniferous Forest: ______________________________

   Deciduous Forest: ______________________________

   Mixed Forest: ______________________________

   Open Water: ______________________________

   Wetland: ______________________________

   Shrubland: ______________________________

2. **List the land cover types in Ashland County that are designed for human habitation and use.**

3. **List the land cover types in Ashland County that could be used for wood products. Next to each land cover type, identify a specific wood product that is made from trees found there.**

4. **Make a list of outdoor activities that bring tourists to Ashland County. Next to each activity, identify the land cover type(s) where the activity takes place.**

LANDSCAPE SCALE WORKSHEET

5. **List the land cover types in Ashland County that you think are important for wildlife that require large, undeveloped areas for habitat (e.g., black bear, pine marten, fisher, eastern timber wolf, and neotropical migratory birds) and explain why.**

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6. **List the land cover types in Ashland County that you think are most critical for protecting water resources and explain why.**

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7. **In two or three paragraphs, compare and contrast the characteristics of a pine plantation, a mixed forest, and an aspen forest. Use the following terms: *composition*, *structure*, *management*, and *wood products*.**

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8. **Identify the percent of the Wisconsin landscape dominated by the following land cover types:**

Forest: ______________ Agriculture: ______________ Urban: ______________

9. **Identify the regions of Wisconsin best suited for the production of forest products and explain why.**

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10. **Provide one specific example that illustrates the interrelationship of land cover, forest management, and human wants and needs in Wisconsin.**

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Student Page ✎ 5B

FOREST CHALLENGES

Forest Challenge	Trend ↑↔↓	Explanation
PESTS AND DISEASE: Native pests and diseases (e.g., the tent caterpillar, white pine blister rust) and introduced pests and diseases (e.g., the gypsy moth, Dutch elm disease) can weaken or kill trees.		
DEER POPULATIONS: As deer numbers increase, some plant species they prefer for food become less abundant or are lost. Other plants increase in abundance. Large numbers of deer affect tree regeneration and can change the tree composition in the forest.		
FIRE: Fire is suppressed throughout Wisconsin's forests to protect private property and human life. Prescribed fire is used in some forests to maintain historic fire conditions. Many wildfires occur (about 1,500 each year) and most are caused by debris burning, equipment use, and arson.		
SEVERE WEATHER: Ice storms, extreme cold, severe winds, drought, and flooding can all cause damage to trees. Most of these events cannot be prevented, and the location and timing of specific events cannot be predicted.		
AIR POLLUTION: Since the early 1900s, levels of some environmental pollution have been increasing in quantities that may be harmful to plant and animal populations. Acid rain and smog can weaken and damage trees.		
LAND USE CHANGE: Changes in land use (e.g., the conversion of forest to urban areas) can result in the reduction of plant, animal, and tree species, as well as fragmentation (the division of forest areas into smaller patches surrounded by developed and/or disturbed areas).		

FOREST INNOVATION AND TECHNOLOGY

RECENT INNOVATION AND TECHNOLOGY	PROPOSAL IDEAS
Progressive harvesting is a recent innovation that reduces the impact that tree harvesting has on soil. In a traditional harvest, the processing and stacking of logs is done from a single location — the landing. This leads to the compaction of forest soils. In a progressive harvest, the landing is moved with the harvest. This method reduces the impact on soil and vegetation.	
Forest modeling is a recent innovation that allows forest managers to project the growth of trees in a forested area and predict the effects that different management strategies will have. This innovation has led to computer technology that allows for the creation of complex models that help forest landowners to better plan for the future.	
Engineered wood products are products made from wood and wood waste such as irregular wood, wood chips, and sawdust. The waste, produced at sawmills and veneer mills, is processed and formed into boards, panels, and beams that can be used in place of other construction materials. This innovation makes better use of wood, reduces demand for larger trees, and reduces solid waste.	
Global Positioning Systems (GPS) is a technology that uses satellites to determine the exact location of points on the globe. **Geographic Information Systems (GIS)** is a new technology that gives land managers access to large amounts of information about soils, climate, topography, vegetation, wildlife, etc. Together, these two technologies allow us to better study, understand, and manage forests.	
Log scanning is done using lasers, cameras, and X-rays. It allows for precise measurement and use of each log that enters a mill. Lasers are used to measure the log, cameras to scan the surface for defects, and X-rays to look inside the log for internal knots. These technologies help sawmills to maximize efficiency and decrease waste.	
Protection refers to a variety of management methods used to protect forests from damaging agents such as disease, introduced species, and severe fire. These methods can include prescribed burns, thinning, pesticide application, and fertilization. **Tree improvement** refers a variety of strategies used to help trees resist disease, grow faster, and produce characteristics desirable for different applications. Two currently important strategies include hybridization and genetic engineering.	

FOREST CERTIFICATION

American Tree Farm System® (ATFS)
A program of the American Forest Foundation. It is committed to sustaining forests, watersheds, and healthy habitats by working with private landowners. Since 1941, they have educated private forest owners in the U.S. More than 30 million acres of privately owned forestland and 51,000 family forest owners from 46 states are now part of the program. To become a certified Tree Farm, landowners must develop a management plan based on strict environmental standards and pass an inspection every five years.

Forest Stewardship Council® (FSC)
Created to change the practice of sustainable forestry worldwide. It includes stakeholders with an array of perspectives on what represents a well-managed and sustainable forest. FSC sets principles, criteria, and standards that span economic, social, and environmental concerns. The FSC standards for forest management have been applied in over 57 countries around the world. The FSC logo identifies products which contain wood from well-managed forests certified according to the rules of the Forest Stewardship Council.

Sustainable Forestry Initiative® (SFI)
This certification program is a system of principles, objectives, and performance measures developed by professional foresters, conservationists, scientists, and industry representatives. It combines the perpetual growing and harvesting of trees with the long-term protection of wildlife, plants, soil, and water quality. There are currently over 136 million acres of forestland in North America enrolled in the SFI® program, making it among the world's largest sustainable forestry programs.

International Organization for Standardization (ISO)
The world's largest developer of standards. Creates standards for the production of many different goods and services. The ISO 14000 standards govern the environment and forestry and are used by more than 600,000 organizations in 152 countries. The standards are primarily concerned with environmental management. They attempt to minimize harmful effects on the environment caused by forestry and achieve continual improvement of the environmental performance of a business over time.

PROPOSAL FORMAT

1. **DESCRIPTION OF THE PROBLEM**
   Compose two to three paragraphs that describe the specific problem that you are addressing. Use the information you have received during class and any additional information that you can gather on the internet or from the library.

2. **JUSTIFICATION FOR ACTION**
   Compose one to two paragraphs that describe why it is important that action be taken to solve the problem. You should use economic, social, and ecological arguments to make your case.

3. **DESCRIPTION OF THE SOLUTION**
   Compose two to three paragraphs that describe actions that could be used to solve the problem, and detail a strategy that you will use to implement them. Identify goals that you would like to achieve in specific time periods. The solution that you propose can include innovations, technologies, forest management strategies, and consumer actions.

4. **TARGET AUDIENCE**
   Identify who will benefit from your proposal and how. Use the economic, social, and ecological values associated with your solution, and link them to countries, regions, communities, businesses, and government.

5. **POSSIBLE FUNDING SOURCES**
   Explain how your proposal will be funded. Funding can come from donations, the government, business investment, or revenue generation. You must identify why funding sources would want to give money for your proposal.