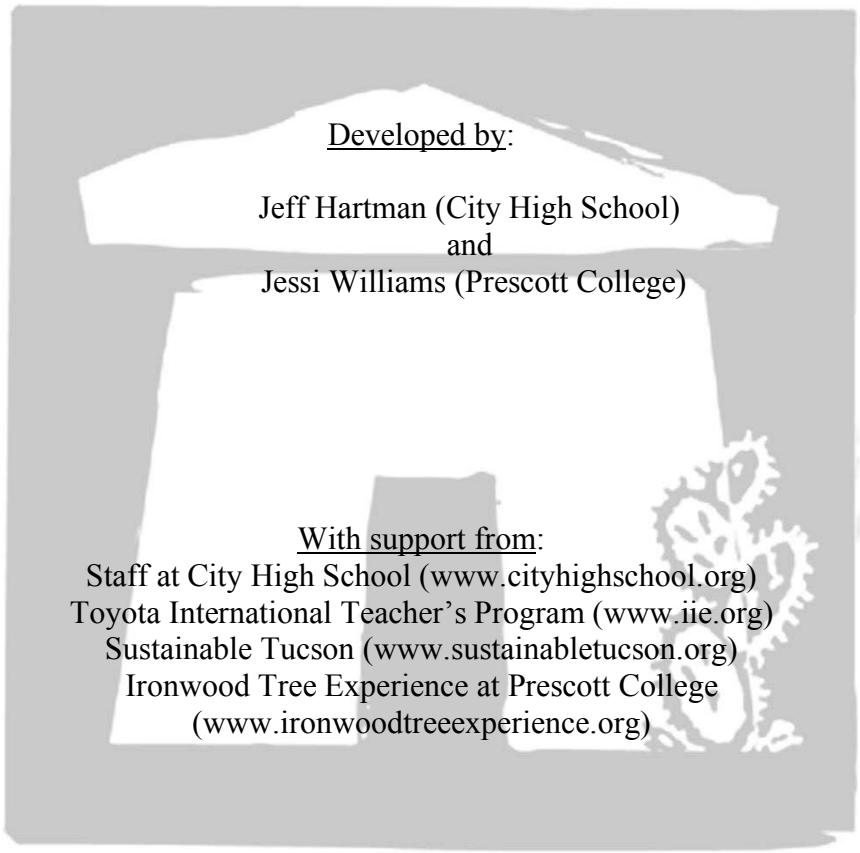
Designing A Sustainable House

A project-based curriculum for high school students



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(www.ironwoodtreeexperience.org)

Note: This curriculum was specifically designed for a 9th grade Integrated Science and Math class at City High School in Tucson, Arizona, but we encourage teachers to adapt and use any of the materials. Many of these lessons were derived from other sources. I've tried to recognize the sources whenever possible, but some of these lessons have been passed around so many times it is difficult to do. You could say freely sharing lessons is one of the practices that helps make teaching sustainable.

Comments and suggestions are welcome. Please direct them to:

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Project Overview:

This is a six-week unit that is taught at the end of the year in a 9th grade Integrated Science and Math class at City High School. Class meets four times per week in a double block period (2 hours). One period is theoretically devoted to math (Algebra 1) and the other to Integrated Science, but often the two subjects are combined. The double-block schedule provides curriculum flexibility and allows more time for extended projects, field trips and activities.

City High practices place-based, project-centered learning. This unit is one example of how we do this. Throughout the unit, students work on individual lessons focused on the local environment. Whenever possible, we use local resources and local examples to teach key concepts to help students develop a sense of place. Students demonstrate what they have learned by completing a final project, in this case by designing a model of a sustainable house.

The overarching goals of this unit include:

- To introduce students to the concept of sustainability and sustainable development;
- To develop a vocabulary to discuss sustainability issues;
- To teach students how energy is conserved, stored and transferred;
- To teach students about their local environment (the Sonoran Desert);
- To teach students about another biome (the Costa Rican rainforest);
- To compare and contrast sustainability issues in two different environments;
- To teach mathematical concepts (scaling, graphing, proportionality).

This is a major curriculum unit. Though students will be given time in class for directed research, students are also expected to work outside of class to complete the assignments. As a final project, each student will make a 4-6 minute verbal presentation supported by a powerpoint, a storyboard, or a model of a sustainable house.

Note: In the spring of 2007, Jeff Hartman was selected to participate in the **Toyota International Teachers Program** (see www.iie.org and www.biodiversityisgood.com). The group traveled to Costa Rica and studied sustainability and biodiversity issues in the Costa Rican rainforest, with the goal of integrating this experience into existing curriculum. Much of this project is an outgrowth of that experience. An existing unit on sustainability issues in the local environment was expanded so that half the class designs a sustainable home for the Sonoran Desert and the other half designs a sustainable house for the Costa Rican rainforest. The differences between these two places create a wonderful opportunity to compare and contrast sustainability practices, to evaluate alternative technologies to discover which technology is most appropriate for a given environment, and to broaden cultural perspectives.

Quick Glance: Daily Curriculum Overview

Week 1 – Introduction to Sustainability

Day 1 – Movie: The Lorax. Discuss movie; complete assignment. Homework: Passionate reading on the need and the urgency for sustainability.

Day 2 -- Discussion of the reading. Lecture – What is sustainability? Complete definition worksheet. Emphasize importance of conservation.

Day 3 -- Brainstorming re: what they would need to build a sustainable house. Complete Worksheet. Introduce sustainable house project. Hand out general project guidelines.

Day 4 – Powerpoint presentation on Costa Rican rainforest. Students select locale, receive climate data and project presentation guidelines. Organize research groups.

Week 2 – Energy Issues

Day 1 – Local speaker to address alternative energy options.

Day 2 – Lecture: Energy 101. Math worksheet re: how to calculate KWH. Homework: Reading from Global Science textbook re: alternative energy technologies.

Day 3 – Complete energy worksheet. Wants/needs/energy usage/possible sources.

Day 4 -- Visit to Armory Park de Sol (local energy efficient community).

Week 3 – Sustainable Building Materials and Design

Day 1 – Debrief visit. Lecture; Introduction to building materials and design. KWL to brainstorm a list of criteria for sustainable building materials. Compare their list to handout. Introduce worksheet re: sustainable materials.

Day 2 – Research sustainable materials. Divide into groups and research possible materials and criteria questions. Complete worksheet.

Day 3 – Finish research.

Day 4 -- Tragedy of the Commons fishing exercise. Emphasize social aspect of sustainable design.

Week Four – Garden/Food/Scale Drawings

Day 1 – Introduction to gardening issues. Tour of City High's community garden. Possible tour of local farmer's market.

Day 2 – Introduce requirements for garden plan. Guest lecture re: planting schedules (Costa Rica and Sonoran Desert).

Day 3 – Begin scale drawings – acre plot, house and garden.

Day 4 -- Complete scale drawings

Week Five – Water/wastewater

Day 1 -- U of A water resources center. Guest speaker Bard Lancaster. Introduce rainwater harvesting and math worksheet.

Day 2 – Lecture: wastewater, water conservation. Research composting toilets, greywater recycling, rainwater harvesting, septic tanks. Complete water plan worksheet.

Day 3 – Work on final project

Day 4 – Work on final project

Week Six -- Final presentations

Days 1,2,3,4 – Student presentations.

Arizona State Standards:

During the course of this six-week unit, the following Arizona State High School Science Standards will be addressed:

Strand 1: Inquiry Process

Concept 2: Scientific Testing (Investigating and Modeling)

PO 5. Record observations, notes, sketches, questions, and ideas using tools such as journals, charts, graphs, and computers.

Concept 4: Communication: Communicate results of investigations.

PO 1. For a specific investigation, choose an appropriate method for communicating the results.

PO 2. Produce graphs that communicate data. (See MHS-S2C1-02)

PO 3. Communicate results clearly and logically.

PO 4. Support conclusions with logical scientific arguments.

Strand 2: History and Nature of Science

Concept 1: History of Science as a Human Endeavor

PO 3. Analyze how specific changes in science have affected society.

PO 4. Analyze how specific cultural and/or societal issues promote or hinder scientific advancements.

Strand 3: Science in Personal and Social Perspectives

Concept 1: Changes in Environments. Describe the interactions between human populations, natural hazards, and the environment.

PO 1. Evaluate how the processes of natural ecosystems affect, and are affected by, humans.

PO 3. Assess how human activities (e.g., clear cutting, water management, tree thinning) can affect the potential for hazards.

PO 4. Evaluate the following factors that affect the quality of the environment:

- urban development
- smoke
- volcanic dust

PO 5. Evaluate the effectiveness of conservation practices and preservation techniques on environmental quality and biodiversity.

Concept 2: Science and Technology in Society. Develop viable solutions to a need or problem.

PO 1. Analyze the costs, benefits, and risks of various ways of dealing with the following needs or problems:

- various forms of alternative energy
- storage of nuclear waste
- abandoned mines
- greenhouse gases
- hazardous wastes

PO 2. Recognize the importance of basing arguments on a thorough understanding of the core concepts and principles of science and technology.

PO 3. Support a position on a science or technology issue.

PO 4. Analyze the use of renewable and nonrenewable resources in Arizona:

- water
- land
- soil
- minerals
- air

Strand 5: Physical Science

Concept 3: Conservation of Energy and Increase in Disorder. Understand ways that energy is conserved, stored, and transferred.

PO 1. Describe the following ways in which energy is stored in a system:

- mechanical
- electrical
- chemical
- nuclear

PO 2. Describe various ways in which energy is transferred from one system to another (e.g., mechanical contact, thermal conduction, electromagnetic radiation.)

PO 3. Recognize that energy is conserved in a closed system.

PO 4. Calculate quantitative relationships associated with the conservation of energy.

Strand 6: Earth and Space Science

Concept 1: Geochemical Cycles. Analyze the interactions between the Earth's structures, atmosphere, and geochemical cycles.

PO 5. Describe factors that impact current and future water quantity and quality including surface, ground, and local water issues.

Lesson #1: Introduction to Sustainability

Lesson objectives:

- To introduce students to the concept of sustainability
- To teach students the basic vocabulary used to discuss issues of sustainability
- To teach basic internet research techniques (searching, checking sources, citing sources)
- To provide students with an overview of a biome they haven't studied (the Costa Rican rainforest)

Key Concepts:

- Definition of sustainability
- Importance of conservation
- What features are needed to build a sustainable house
- Sustainable building depends on the environment

Vocabulary

- ✓ Sustainability
- ✓ Environmental Conservation
- ✓ Organic
- ✓ Fair Trade
- ✓ Emissions
- ✓ Permaculture
- ✓ Ecological
- ✓ Ecologically sound
- ✓ Eco-system

Materials and Resources Needed (including worksheets):

Movie: The Lorax
Worksheet: The Lorax
Reading: Selected Reading on Sustainability.
Worksheet: What Is Sustainability?
Worksheet: What is needed for a sustainable house?
Handout: General Project Guidelines

Lesson Outline:

Engage – One period. Movie: 25 min. Discussion/optional worksheet: 25 min.
The unit begins with the classic movie: The Lorax. Following the movie, teacher facilitates a class discussion on sustainability. Important points to consider: When was the movie made? How long has sustainability been an issue? An optional worksheet is included with this lesson. A longer (two-period) lesson plan on which this is based referenced in the appendix.

Explore – Homework.
Following the movie, students are assigned a contemporary reading on the topic of sustainability. Possibilities include:

- "Save The Planet: Vote Smart" by Thomas Friedman
- "Hope In Harder Times" by David Orr

Explain – One period. Discussion (15 min.), lecture (10 min.), handout/worksheet (25 min.)
Teacher facilitates a discussion of the reading, making sure students comprehend the key points. Following the discussion, students are given a brief lecture re: What Is Sustainability? Lecture focuses on history of sustainability and definitions. Lecture also emphasizes conservation as a key theme that cuts through all aspects of sustainability. Students read the handout: What Is Sustainability? and complete the worksheet.

Elaborate – One period (50 min.). Group work/guided discussion.
Working in pairs or small groups, students brainstorm what it means specifically to design a sustainable house. What issues must be addressed? How might they be addressed? Students (or groups) are given a worksheet to guide the discussion. Following the discussion, students will be given the general guidelines for the sustainable house project. The second page contains a list of issues to consider and can be used to stimulate discussion or ideas if students get stuck in the brainstorming exercise.

Evaluate – Most of the evaluation for this unit will be based on the final project, but students can be evaluated during most lessons based on class participation and completion of assignments.

Wrap Up/Transition – One period (50 min.) Lecture/discussion/group work.
At the end of this lesson, the teacher will deliver a powerpoint lecture about Costa Rica and the Costa Rican rainforest. This will introduce the entire class to a different environment and set the stage for those students who are assigned to design a home for the Costa Rican rainforest. (**Note:** If the teacher or student has knowledge or interest in another place, the curriculum can be adjusted to focus on another location. The key is to provide a couple different environments for students to compare and contrast.)

Following the presentation, the project presentation guidelines are handed out so that students can begin organizing their project. Students are randomly assigned one of the two environments. Students are encouraged to share information but they all must design their own home. Teachers can adjust by letting students work in groups or assigning students to a given environment based on the level of challenge. In this case, researching an environment the class hasn't studied much and many guest speakers won't know much about [i.e., the Costa Rican rainforest] is more difficult than researching the Sonoran Desert.

Dr. Seuss' *The Lorax*

The LORAX is a fictional story about a man whose activities abused the environment and about what he learned from the experience. The story was written in 1971 and yet it contains many common components found in the environmental problems and issues facing humans around the world today. *The LORAX* also contains many of the components associated with sustainable development.

Sustainable development is a tricky idea. It suggests that humans "sustain" the environment by preserving, protecting, and conserving. Yet, economic development is still necessary in all countries, regardless of their current economic status. Many experts believe that this apparent conflict between outcomes is the key to the quality of future human life on the planet and that economic development using environmentally-friendly technology can help promote economic development that sustains the environment. The central focus of sustainable development is to balance quality of life with quality of the environment.

Questions

Name: _____

1. The Once-ler used the land's natural resource to start a business which made and sold a product. What was the product? How was it used by buyers?
   The Once-ler's Product: _____
   The Product's Uses: _____

2. The product was made out of what natural resource?
   _____
   _____

3. The use of technology often requires the use of natural resources. This utilization of natural resources can have an effect on the environment. How did the production of thneeds affect important natural resource(s) in the story?
   _____
   _____
   _____

4. Often, technological production creates "byproducts". For example, a byproduct of sawing wood is sawdust. Sometimes the byproducts of technology are unwanted or dangerous (ex: poisonous chemicals). Name two byproducts that resulted from making thneeds.

   Byproduct 1: _____
   Byproduct 2: _____

5. Were these two byproducts helpful or harmful to the environment?

   Byproduct 1: _____
   Byproduct 2: _____

6. The Once-ler's business failed. Why did it fail? What could he have done to prevent this?

   _____
   _____
   _____
   _____
   _____
   _____

Now, think about the building materials used in your own home. List two of these building materials. Then list the byproducts of production and the by products of use.

Building material #1: _____

Production byproduct: _____

Use byproduct: _____

Building material #2: _____

Production byproduct: _____

Use byproduct: _____

At the end of the movie, the Lorax hints that we are doomed unless…. Unless what?

Name two things you can do to improve or offset the impact of your house on the local environment.

Selected (Angry) Readings on Sustainability

Note: The goal here is to force students to confront the hard choices associated with the need to become a more sustainable society. To do that, we believe one must move beyond the nice and easy parts of the issue to make it personal and to challenge people to change behavior. That's why we refer to this as an "angry" reading.

There are many choices for an angry reading. Included on the next couple pages are two possibilities: an editorial by Thomas Friedman titled " Save The Planet: Vote Smart" and an article by David Orr titled "Hope In Harder Times."

We are developing a list of articles designed to inspire, provoke and challenge people to act. Feel free to email us your favorites.

Passionate, provocative Articles on Sustainability:

"Save The Planet: Vote Smart" by Thmas Friedman

"Hope In Harder Times" by David Orr

"One Hundred Days of Climate Action" by David Orr

"The Ecology of Work" by Curtis White (originally published in the May/June 2007 issue of Orion Magazine

October 21, 2007
OP-ED COLUMNIST
Save the Planet: Vote Smart

By THOMAS L. FRIEDMAN
People often ask: I want to get greener, what should I do? New light bulbs? A hybrid? A solar roof? Well, all of those things are helpful. But actually, the greenest thing you can do is this: Choose the right leaders. It is so much more important to change your leaders than change your light bulbs.

Why? Because leaders write the rules, set the standards and offer the tax incentives that drive market behavior across a whole city, state or country. Whatever any of us does individually matters a tiny bit. But when leaders change the rules, you get scale change across the whole marketplace. And the energy-climate challenge we face today is a huge scale problem. Without scale, all you have is a green hobby.

Have no illusions, everything George Bush wouldn't do on energy after 9/11 — his resisting improved mileage for cars and actually trying to weaken air-conditioner standards — swamped any good works you did. Fortunately, the vacuum in the White House is being filled by leaders from below.

Take the New York City taxi story. Two years ago, David Yassky, a City Council member, sat down with one of his backers, Jack Hidary, a technology entrepreneur, to brainstorm about how to make New York City greener — at scale. For starters, they checked with the Taxi and Limousine Commission to see what it would take to replace the old gas-guzzling Crown Victoria yellow cabs, which get around 10 miles a gallon, with better-mileage, low-emission hybrids. Great idea, only it turned out to be illegal, thanks to some old size regulations designed to favor Crown Vics.

Recalled Mr. Hidary: "When they first told me, I said, 'Are you serious? Illegal?'" So he formed a nonprofit called SmartTransportation.org to help Mr. Yassky lobby the City Council to change the laws to permit hybrid taxis. They also reframed it as a health issue, with the help of Louise Vetter, president of the American Lung Association of the City of New York.

"New York City has among the dirtiest air in the U.S.," Ms. Vetter said. "When it comes to ozone and particulate matter, New Yorkers are breathing very unhealthy air. Most of it is tailpipe emissions. And in New York City, where asthma rates are among the highest in the nation, the high ozone levels create very serious threats, especially for kids who spend a lot of time outdoors. Converting cabs from yellow to green would be a great gift to the city's children."

Matt Daus, who heads the taxi commission, which is independent of the mayor, was initially reluctant, but once he learned of the health and other benefits, he joined forces with Messrs. Yassky and Hidary, and the measure passed the City Council by 50 to 0 on June 30, 2005. Since then, more than 500 taxi drivers have converted to hybrids — mostly Ford Escapes, but also Toyota Highlanders and Priuses, and others.

On May 22, Mayor Michael Bloomberg, one of the greenest mayors in America, decided to push even further, insisting on a new rule, which the taxi commission has to approve, that will not just permit but require all cabs — 13,000 in all — to be hybrids or other low-emission vehicles that get at least 30 miles a gallon, within five years.

"When it comes to health and safety and environmental issues, government should be setting standards,"

the mayor said. “What you need are leaders who are willing to push for standards that are in society’s long-term interest.” When the citizens see the progress, Mr. Bloomberg added, “then they start to lead.” And this encourages leaders to seek even higher standards.

I asked Evgeny Freidman, a top New York City fleet operator, how he liked the hybrids: “Absolutely fabulous! We started out with 18, and now we have over 200, mostly Ford Escapes. Now we only put hybrids out there. The drivers are demanding them and the public is demanding them. It has been great economically. With gas prices as they are, the drivers are saving $30 dollars a shift.” He said drivers who were getting 7 to 10 miles a gallon from their Crown Vics were getting 25 to 30 from their hybrids. The cost of shifting to these hybrids, he added, has not been onerous.

Now Mr. Hidary is trying to get law firms and investment banks, which use gas-guzzling Town Cars — 12,000 in the city — to demand hybrid sedans only.

This is how scale change happens. When the Big Apple becomes the Green Apple, and 40 million tourists come through every year and take at least one hybrid cab ride, they’ll go back home and ask their leaders, “Why don’t we have hybrid cabs?”

So if you want to be a green college kid or a green adult, don’t fool yourself: You can change lights. You can change cars. But if you don’t change leaders, your actions are nothing more than an expression of, as Dick Cheney would say, “personal virtue.”

Optimism and Hope in a Hotter Time

David W. Orr

Fraudulent hope is one of the greatest malefactors, even enervators, of the human race, concretely genuine hope its most dedicated benefactor.

-Ernst Bloch

We like optimistic people. They are fun, often funny, and very often capable of doing amazing things otherwise thought to be impossible. Were I stranded on a life raft in the middle of the ocean and had a choice of a companion between an optimist and pessimist, I'd want an optimist, providing he did not have a liking for human flesh. Optimism, however, is often rather like a Yankee fan believing that the team can win the game when it's the bottom of the ninth, they're up by a run, with two outs, a two strike count against a .200 hitter, and Mariano Rivera in his prime is on the mound. He or she is optimistic for good reason. The Red Sox fans, on the other hand, believe in salvation by small percentages and hope for a hit to get the runner home from second base and tie the game. Optimism is the recognition that the odds are in your favor; hope is the faith that things will work out whatever the odds. Hope is a verb with its sleeves rolled up. Hopeful people are actively engaged in defying the odds or changing the odds. Optimism leans back puts its feet up and wears a confident look knowing that the deck is stacked.

I know of no good reason for anyone to be optimistic about the human future, but I know lots of reasons to be hopeful. How can one be optimistic, for example, about global warming? First, it isn't a "warming," but rather a total destabilization of the planet brought on by the behavior of one species: us. Whoever called this "warming" must have worked for the advertising industry or the northern Siberian Bureau of Economic Development. The Intergovernmental panel on Climate Change—the thousand plus scientists who study climate and whose livelihoods depend on authenticity, replicability, data, facts, and logic—put it differently. A hotter world means rising odds of:

- More heat waves and droughts
- More and larger storms
- Bigger hurricanes
- Forest dieback
- Changing ecosystems
- More tropical diseases in formerly temperate areas
- Rising ocean levels—faster than once thought
- Losing many things nature once did for us
- And losing things like Vermont maple syrup
- More and nastier bugs
- Food shortages due to drought, heat, and more and nastier bugs
- More death from climate driven weather events
- Refugees fleeing floods, rising seas, drought, and expanding deserts
- International conflicts over energy, food, and water
- And, if we do not act quickly and wisely, runaway climate change to some new stable state most likely without humans.

Some of these changes are inevitable given the volume of heat trapping gases we've already put into the atmosphere. There is a lag of several decades between the emission of carbon dioxide and other heat trapping gases and the weather headlines and still another lag until we experience

their full economic and political effects. The sum total of the opinions of climate experts goes like this:

1. We've already warmed the planet by .8 C
2. We are committed to another ~.6 C warming
3. It's too late to avoid trauma but
4. It's probably not too late to avoid global catastrophe which includes the possibility of runaway climate change
5. There are no easy answers or magic bullet solutions
6. It is truly a global emergency.

Item four above is anyone's guess since the level of heat trapping gases is higher than it has been in the past 650,000 years and quite likely for a great deal longer. We are playing a global version of Russian roulette and no one knows for certain what the safe thresholds of various heat trapping gases might be. Scientific certainly about the pace of climate change over the past three decades has a brief shelf-life but the pattern is clear. As scientists learn more, it's mostly worse than they previously thought. Ocean acidification went from being a problem a century or two hence to being a crisis in a matter of decades. Melting of the Greenland and Antarctic ice sheets went from being possible hundreds of years hence to a matter of decades and a century or two. The threshold of perceived safety went down from perhaps 560 ppm CO_2 to perhaps 450 ppm CO_2. And so forth.

Optimism in these circumstances is like whistling as one walks past the graveyard at midnight. There is no good case to be made for it but the sound of whistling sure beats the sound of the rustling in the bushes beside the fence. But whistling doesn't change the probabilities one iota nor does it much influence any goblins lurking about. Nonetheless, we like optimism and optimistic people. They soothe, reassure, and sometimes they motivate us to accomplish a great deal more than we otherwise might. But sometimes optimism misleads, and on occasion badly so. This is where hope enters.

Hope, however, requires us to check our optimism at the door and enter the future without illusions. It requires a level of honesty, self-awareness, and sobriety that is difficult to summon and sustain. I know a great many smart people and many very good people, but I know far fewer people who can handle hard truth gracefully without despairing. In such circumstances it is tempting to seize on anything that distracts us from unpleasant things. The situation is rather like that portrayed in the movie "A Few Good Men" in which Jack Nicholson playing a beleaguered Marine Corp officer tells the prosecuting attorney (Tom Cruise): "You can't handle the Truth!" T. S. Eliot, less dramatically noted the same tendency: "Human kind cannot bear very much reality." (Four Quartets. Burnt Norton)

Authentic hope, in other words, is made of sterner stuff than optimism. It must be rooted in the truth as best we can see it, knowing that our vision is always partial. Hope requires the courage to reach farther, dig deeper, confront our limits and those of nature, work harder, and dream dreams. Optimism doesn't require much effort since you're likely to win anyway but hope has to hustle, scheme, make deals, and strategize. But how do we find authentic hope in the face of climate change, the biological holocaust now underway, the spread of global poverty, seemingly unsolvable human conflicts, terrorism, and the void of world leadership adequate to the issues?

I've been thinking about the difference between optimism and hope since being admonished recently to give a "positive" talk at a gathering of ranchers, natural resource professionals and students. Presumably the audience was incapable of coping with the bad news it was assumed that I would otherwise deliver. I gave the talk that I intended to give and the

audience survived, but the experience caused me to think more about what we say and what we can say to good effect about the kind of news that readers of this journal reckon with daily.

The view that the public can only handle happy news, nonetheless, rests on a chain of reasoning that goes like this:

- We face problems which are solvable not dilemmas which can be avoided with foresight but are not solvable and certainly not losses which are permanent;
- people, and particularly students, can't handle much truth, so
- resolution of different values and significant improvement of human behavior otherwise necessary are impossible;
- greed and self-interest are in the driver's seat and always will be, so
- the consumer economy is here to stay but
- consumers sometimes want greener gadgets and
- capitalism can supply these at a goodly profit and itself be greened a bit, but not improved otherwise; so
- matters of distribution, poverty, and political power are non-starters;
- therefore, the focus should be on problems solvable at a profit by technology and policy changes;
- significant improvement of politics, policy, and governance are unlikely and probably irrelevant because
- better design and market adjustments can substitute for governmental regulation and thereby eliminate most of the sources of political controversy—rather like Karl Marx' prediction of the withering away of the state.

Disguised as optimism, this approach is, in fact, pessimistic about our capacity to understand the truth and act nobly. So we do not talk about limits to growth, unsolvable problems, moral failings, the unequal distribution of wealth within and between generations, emerging dangers, impossibilities, technology gone awry, or necessary sacrifices. "Realism" requires us to portray climate change as an opportunity to make a great deal of money, which it may be for some, but without saying that it might not be for most or mentioning its connections to other issues, problems, and dilemmas or the possibility that the four horsemen are gaining on us. We are not supposed to talk about coming changes in our "lifestyles," a telling and empty word implying fashion not necessity or conviction.

Ultimately, this approach is condescending to those who are presumably incapable of facing the truth and acting creatively, courageously, and even nobly in dire circumstances. Solving climate change for example is reduced to a series of wedges representing various possibilities that would potentially eliminate so many gigatons of carbon without any serious changes in how we live. There is, accordingly, no wedge called "suck it up" because that is considered to be too much to ask of people who have been consuming way too much, too carelessly, for too long. The "American way of life" is thought to be sacrosanct. In the face of a global emergency, brought on in no small way by the profligate American way of life, few are willing to say otherwise. So we are told to buy hybrid cars, but not asked to walk, travel by bikes, or go less often, even at the end of the era of cheap oil. We are asked to buy compact fluorescent light bulbs, but not to turn off our electronic stuff or not buy it in the first place. We are admonished to buy green, but seldom asked to buy less or repair what we already have or just make do. We are encouraged to build LEED-rated buildings that are used for maybe ten hours a day for five days a week, but we are not told that we cannot build our way out of the mess we've made or to repair existing buildings. We are not told that the consumer way of life will have to be rethought and re-designed to exist within the limits of natural systems and better fitted to our

human limitations. And so we continue to walk north on a south bound train as Peter Montague once put it.

And maybe, told that its hindquarters are caught in a ringer, the public would panic or, on the other hand, become so despairing as to stop them from doing what they otherwise would do that could save us from the worst outcomes possible. This is an old view of human nature epitomized in the work of Edward Bernays, a nephew of Sigmund Freud and the founder of modern advertising. Public order, he thought, had to be engineered by manipulating people to be dependent and dependable consumers. People who think too much or know too much were in his view a hazard to social stability.

Maybe this is true and maybe gradualism is the right strategy. Perhaps the crisis of climate and those of equity, security, and economic sustainability will yield to the cumulative effects of many small changes without any sacrifice at all. Maybe changes now underway are enough to save us. Maybe, small changes will increase the willingness to make larger changes in the future. And state-level initiatives in California, Florida, and Northeastern states are changing the politics of climate. Wind and solar are growing at 40%+ per year . . . taking us toward a different energy regime. A cap and trade bill will soon pass in Congress and maybe that will be enough. Maybe we can win the game of climate roulette at a profit and never have to confront the nastier realities of global capitalism and inequity or confront the ecological and human violence that we've unleashed in the world.

But I wouldn't bet the Earth on it.

For one, the remorseless working out of the big numbers (eg. 430 CO_{2e} +2.5year) give us no margin for safety and none for delay in reducing CO_{2e} levels before we risk triggering runaway change. "Climate," as Wallace Broecker once put it, "is an angry beast and we are poking it with sticks" and we've been doing that for a while. So call it prudence, precaution, insurance, common sense, or what you will but this ought to be regarded as an emergency like no other. Having spent any margin of error we might have had thirty years ago, we now have to respond fast and effectively or else. That's what the drab language of the Fourth report from the Intergovernmental Panel on Climate Change is saying. What is being proposed, I think, is still too little, too late—necessary but not nearly sufficient. And it is being sold as "realism" by people who have convinced themselves that they have to understate the problem in order to be credible.

Second, climate roulette is part of a larger equation of exploitation of people and nature, violence, inequity, imperialism, and inter-generational exploitation the parts of which are interlocked. In other words, heat trapping gases in the atmosphere are a symptom of something a lot bigger. To deal with the causes of climate change we need a more thorough and deeper awareness of how we got to the brink of destroying the human prospect and much of the planet. It did not happen accidentally but is, rather, the logical working out of a set of assumptions, philosophy, worldview, and unfair power relations that have been evident for a long time. The wars, gulags, ethnic cleansings, militarism, and the destruction of forests, wildlife, and oceans throughout the 20th century were earlier symptoms of the problem. We've been playing fast and loose with life for a while now and it's time to discuss the changes we must make in order to conduct the public business fairly and decently over the long-haul.

The upshot is that the forces that have brought us to the brink of climate disaster, biological holocaust, and are responsible for the spread of global poverty—the crisis of sustainability—remain mostly invisible and in charge of climate policy. The fact is that climate stability, sustainability, and security are impossible in a world with too much violence, too many weapons, too much unaccountable power, too much stuff for some, too little for others, and a political system that is bought and paid for behind closed doors. Looming climate catastrophe, in other words, is a symptom of a larger disease.

What do I propose? Simply this: that those of us concerned about climate change, environmental quality, and equity treat the public as intelligent adults who are capable of understanding the truth and acting creatively and courageously in the face of necessity—much as a doctor talking to a patient with a potentially terminal disease. There are many good precedents for telling the truth. Abraham Lincoln, for one, did not pander, condescend, evade, or reduce moral and political issues to economics, jobs, and happy talk. Rather he described slavery as a moral disaster for slaves and slave owners alike. Similarly, Winston Churchill in the dark days of the London blitzkrieg in 1940 did not talk about defeating Nazism at a profit and the joys of urban renewal. Instead he offered the British people only "blood, toil, tears, and sweat." And they responded with heart, courage, stamina, and sacrifice. At the individual level, faced with a life-threatening illness, people more often than not respond heroically. Every day, soldiers, parents, citizens, and strangers do heroic and improbable things in the full knowledge of the price they will pay.

Telling truth means that the people must be summoned to a level of extraordinary greatness appropriate to an extraordinarily dangerous time. People, otherwise highly knowledgeable of the latest foibles of celebrities, must be asked to be citizens again, to know more, think more, take responsibility, participate publicly, and, yeh, suck it up. They will have to see the connections between what they drive and the wars we fight, the stuff they buy and crazy weather; the politicians they elect and the spread of poverty and violence. They must be taught to see connections between climate, environmental quality, security, energy use, equity, and prosperity. They must be asked to think and to see. As quaint and naïve as that may sound, people have done it before and it's worked.

Telling the truth means that we will have to speak clearly about the causes of our failures that have led us to the brink of disaster. If we fail to deal with causes, there are no band-aids that will save us for long. The problems can in one way or another be traced to the irresponsible exercise of power that has excluded the rights of the poor, the disenfranchised, and every generation after our own. That this has happened is in no small way as a direct result everywhere of money in politics which has aided and abetted the theft of the public commons including the airwaves where deliberate misinformation is a growing industry. Freedom of speech, as Lincoln said in 1860, does not include "the right to mislead others, who have less access to history and less leisure to study it." But the rights of capital over the media now trump those of honesty and fair public dialogue and will continue to do so until the public reasserts its legitimate control over the public commons including the airwaves.

Telling the truth means summoning people to a higher vision than that of the affluent consumer society. Consider the well studied but little noted gap between the stagnant or falling trend line of happiness in the last half century and that of rising GNP. That gap ought to have reinforced the ancient message that, beyond some point, more is not better. If we fail to see a vision of a livable decent future beyond the consumer society, we will never summon the courage, imagination, or wit to do the obvious things to create something better than what is in prospect. So, what does a carbon neutral society and increasingly sustainable society look like? My list consists of communities with:

Front porches
Public parks
Local businesses
Windmills and solar collectors
Local farms and better food
Better woodlots and forests
Local employment
More bike trails

Summer baseball leagues
Community theaters
Better poetry
Neighborhood book clubs
Bowling leagues
Better schools
Vibrant and robust downtowns with
Sidewalk cafes
Great pubs serving microbrews
More kids playing outdoors
Fewer freeways, shopping malls, sprawl, television
No more wars for oil or anything else.

Nirvanna? Hardly! Humans have a remarkable capacity to screw up good things. But it is still possible to create a future that is a great deal better than what is in prospect. Ironically, what we must do to avert the worst effects of climate change are mostly the same things we would do to build sustainable communities, improve environmental quality, build prosperous economies, and improve the prospects for our children.

Finally, I am an educator and earn my keep by perpetuating the quaint belief that if people only knew more they would act better. Some of what they need to know is new but most of it is old, very old. On my list of things people ought to know in order to discern the truth are a few technical things like:

1. The laws of thermodynamics that tell us that economic growth only increases the pace of disorder, the transition from low entropy to high entropy.
2. The basic sciences of biology and ecology eg. how the world works as a physical system.
3. Fundamentals of carrying capacity which apply to yeast cells in a wine vat, lemmings, and humans.

But they ought to know, too, about human fallibility, gullibility, and the inescapable problem of ignorance. So I propose that schools, colleges, and universities require their students to read Marlowe's Dr. Faustus, Mary Shelley's Frankenstein, Melville's Moby Dick, and the book of Ecclesiastes. I would hope that they would be taught how to distinguish those things that we can do from those that we should not do. And they should be taught the many disciplines of applied hope that include the skills necessary to grow food, build shelter, manage woodlots, make energy from sunlight and wind, develop local enterprises, cook a good meal, use tools skillfully, repair and reuse, and talk sensibly at a public meeting.

Hope, authentic hope, can be found only in our capacity to discern the truth about our situation and ourselves and summon the fortitude to act accordingly. We have it on high authority that the Truth will set us free from illusion, greed, and ill-will and perhaps with a bit of luck from self-imposed destruction.

What Is "Sustainability?"

Sustainability is a difficult term to define because it is a general concept and not a specific thing. There are many different definitions of sustainability, but common themes run through them all. Here are a couple definitions:

From Wikipedia: Sustainability is a characteristic of a process or state that can be maintained at a certain level indefinitely. For planet earth, it is thus the intent to provide the best outcomes for the human and natural environments both now and into the indefinite future. One of the most often-cited definitions of sustainability is the one created by the Brundtland Commission, led by the former Norwegian Prime Minister Gro Harlem Brundtland. The Commission defined sustainable development as development that "meets the needs of the present without compromising the ability of future generations to meet their own needs." Sustainability relates to the continuity of economic, social, institutional, and environmental aspects of human society, as well as the non-human environment. Sustainability is one of the four Core Concepts behind the 2007 Universal Forum of Cultures.

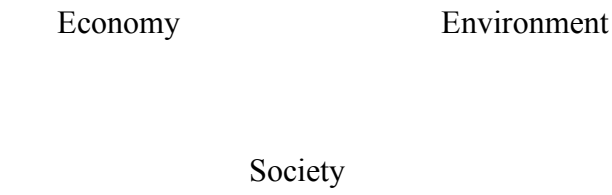
From the State of Oregon: Sustainability means using, developing, and protecting resources at a rate and in a manner that enables people to meet their current needs and also provides that future generations can meet their own needs. Sustainability requires simultaneously meeting environmental, economic and community needs.

From the IUCN, 1983: "Sustainable development is the maintenance of essential ecological processes and life support systems, the preservation of genetic diversity, and the sustainable use of species and ecosystems."

From the UNEP, 1987: Sustainability is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

From Robert Gilmann (author): Sustainability is equity over time … think of it as extending the Golden rule through time ... Do unto future generations as you would have them do unto you.

Many groups use a Venn diagram (or refer to a three-legged stool) to illustrate a definition of sustainability described by Oregon governor John Kitzhaber in 2000: "Imagine, if you will, three overlapping circles – one representing economic needs, one representing environmental needs, and one representing community social needs. The area where the circles overlap is the area of sustainability, the area of livability, the area where all the threads of quality of life come together."



Student Worksheet

What Is Sustainability?

Name: _____ Date: _____

As your final project for this unit, you will design and build a model of a "sustainable house." What is a sustainable house? Create your own definition and write it here.

A sustainable house is …

_____
_____
_____
_____
_____
_____
_____

List three features you would expect find in a sustainable house:

1. _____
   _____
2. _____
   _____
3. _____
   _____

List three features you would not expect to find in a sustainable house:

1. _____
   _____
2. _____
   _____
3. _____
   _____

Discussion/Assignment Guidelines

What Do We Need To Build A Sustainable House?

Working individually or in groups assigned by your teacher, discuss the following questions and write your answers in your science notebook under the heading:
Sustainable House Requirements.

1. What economic, environmental and social factors must be addressed in order for a house to be considered sustainable?

   Discuss this with your group and then make a full page, three column list in your science notebook of these factors. Columns should be labeled economy, environment and society and each column should contain at least three factors that you believe must be met for a house to be considered sustainable. *(For example, under economy your group might decide that in order for a house to be sustainable it must cost less than $150,000.)*

2. In terms of environmental sustainability, a household must find acceptable ways to get energy, build a shelter, and secure food and water. What factors must be addressed in order for a household to meet these requirements in a sustainable manner?

   Discuss this with your group and then make a full page, three column list in your science notebook of all these factors. Columns should be labeled energy, building materials, and food/water. Each column should contain at least three factors you believe must be met in order for a house to be considered sustainable. *(For example, your group might decide that in terms of food, the only way to be sustainable is to only eat food that comes from within 200 miles of your location.)*

3. Look back at the definition of "sustainability" that you developed earlier in this unit. Discuss your definition with your group. Do you think this is still a good definition? If so, why? If not, how would you change it?

   Write your answer to this question in your science notebook.

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Sustainable House

Project Overview

For the remainder of the term we are going to explore the issue of sustainability. To facilitate this focus, each student (or in some cases teams of 2 students) will build a model of a "sustainable house" that they will present to the class as their final project. Your house will be located in one of two places: in the Sonoran Desert just outside the city limits of Tucson, Arizona or in the Costa Rican rainforest just outside the city limits of Turrialba, Costa Rica.

Basic requirements:

- Your house will be built on a one-acre plot and should house five people.
- Each house must have a kitchen, a bathroom, three bedrooms and contain at least 1,500 and no more than 3,000 square feet of living space.
- The house must be "off the grid." This means the house cannot be dependent on any municipal electrical, gas, water, or sewage treatment systems.
- The property will contain a pesticide-free garden that will produce food on a year-round basis.

Cost:
Although economic affordability is clearly a sustainability issue, there is no price limit for construction of your house and you do not have to estimate the total cost. However, for your final presentation, you must calculate:

- How many kilowatt hours of electricity you will need to maintain your home (on an annual basis);
- How much it will cost to build the energy system to generate power (electricity) for your house

This is a big project. We will devote lots of class time to research; however you will have to do some investigation and construction outside of class. There is lots of information about sustainability available in our textbooks and on the web. I will help you by providing some of these resources, bringing in guest speakers and giving short lectures on key topics.

Most of your grade will be based on your final presentation, however there also will be several short assignments during the course of this project.

Issues To Consider As You Design Your Sustainable House

As you begin to develop a plan for your sustainable house, you may want to consider the following issues.

Location
- What is the climate where your house will be built? How will this affect design and construction?
- How does daily and seasonal movement of the sun affect where and how your house should be built? Consider the topography of your plot and which direction your house will face.

Energy
- What energy source will your house use and why?
- What energy conservation measures will your house use and why?
- Is this source renewable or non-renewable?

Water/wastewater
- How will your house get its water?
- How much water will you need for five people?
- What will you do with your wastewater?

Building materials
- What materials will you use to build your house?
- Are these materials available locally (in Tucson or Turrialba?)
- Are these materials "eco-friendly?"

Household systems
- What are your lighting requirements?
- What are your air conditioning and air circulation requirements?
- Consider entrances, ventilation, mechanical systems, etc.

Garden
- How big is your garden and how much water will it take?
- What plants will you have growing at what times of the year (a calendar)?
- How good is the local soil? Will it need improvement and, if so, how will you improve it?
- How will you protect your garden from pests?

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Sustainable House Project

Project Presentation Guidelines

Presentation Guidelines

Your final project will be a 4-6 minute verbal presentation to the entire class and guest evaluators. Your verbal presentation must be supplemented by a powerpoint, a posterboard, or a model of some kind. Your final grade will be based on the overall quality of your presentation (organization, clarity, creativity) and how well you addressed the following areas:

House Design

- Does your model meet design requirements?
- Does it fit with the local environment?
- Do the interior (household) systems fit together?
- Does the design show creativity?

Energy

- How will you get power (electricity) for your house?
- What measures did you take to conserve power?
- Do these measures fit with the local environment?

Water/wastewater

- How will you get water for your household?
- What methods of water conservation did you incorporate?
- Do you have an effective and appropriate plan to deal with wastewater?

Building Materials

- Did the design incorporate sustainable building materials?
- Do these materials fit the local environment?

Garden

- Does your garden produce pesticide free, year round food?
- Does it fit in with the local environment?

Climate Data

During this project, you will have to research your given locale to determine what kinds of building practices make sense and are sustainable in that area. Here is some general climate information to get you started and to use in calculations throughout this project.

***

Turrialba, Costa Rica

Turrialba, Costa Rica is located in the province of Limon on the Caribbean side of Costa Rica. Average rainfall is between 118 – 157 inches per year. For this project, use 137 inches as your average rainfall total.

There is a dry(er) season from late-November until mid-April and a wet season from May through mid-November, but it can rain anytime. Downpours occasionally last for days.

Humidity is always high. Temperatures range from the mid 60s to the low-90s (Fahrenheit), and are generally in the 70s and 80s.

***

Tucson, Arizona

Tucson, Arizona is located on the eastern edge of the Sonoran Desert. Average rainfall is between 3 – 15 inches per year in the Sonoran Desert and it is generally much wetter on the eastern edge. For this project, use 12.9 inches as your average rainfall total in the Tucson area.

There are two rainy seasons – November through February and July-August (the monsoons).

Humidity is generally very low except during the monsoon season. Temperatures can range from the 20s to over 110 degrees (Fahrenheit).

***

Helpful websites: www.noaa.com

Lesson #2: Energy Issues

Learning objectives:

- To teach students how energy is conserved, stored and transferred
- To introduce students to the concept of renewable and non-renewable resources
- To familiarize students with the advantages and disadvantages of the most common energy sources
- To teach students how to calculate an energy budget (in kilowatt hours) for their house
- To improve math skills

Key concepts:

- Some amount of energy is always lost with each transfer
- Calculating an energy budget for your house is like a checkbook – to be sustainable, energy in has to equal energy out
- Alternative energy options exist today but are not widely used because of economic, political and social reasons

Vocabulary

- ✓ Passive Solar
- ✓ Compact fluorescent Lights
- ✓ Solar Power
- ✓ Solar Panel
- ✓ Photovoltaic
- ✓ Hydropower
- ✓ Geothermal
- ✓ Wind Power
- ✓ Turbine
- ✓ Renewable Resource
- ✓ Non-renewable Resource
- ✓ Coal Energy
- ✓ Nuclear Energy
- ✓ Wave Energy
- ✓ Tidal Energy
- ✓ Biodiesel
- ✓ Fossil Fuel
- ✓ Energy Efficient

Materials and Resources Needed (including worksheets):

Household Energy Worksheet
Appliance Energy Usage (list downloaded from www.???)
Computers for web research
Copies of pages 404/405
Assigned reading from Global Science
Math Assignment #1 – Energy Conversions (p. 95/96, Global Science)
Math Assignment #2 – Calculating KWH output from PV Cells

Lesson Outline:

Engage/Explore – One period.
Local guest speaker (or possible field trip) to talk about alternative energy technologies. Possibilities include: The Solar Store, local off-the-grid rancher, Clean Cities Coalition (transportation), Sustainable Tucson (speakers bureau), Tucson Electric Power, City of Tucson Office of Sustainability …

Explain – One period. Lecture (20 min.) Begin house energy research (30 min.)
Additional reading (Homework).
Teacher lecture on energy flow – conservation/transfer/storage. Based on material in the textbook: Global Science by John Christensen, published by Kendall Hunt. Chapter 3 (Energy Flow) and Chapter 7 (Energy Alternatives). Following the lecture, teacher hands out copies of pages 404 and 405 (Designing an Environmental Home) and reviews them with students. Focus on passive solar, key elements of conservation and design. Students then begin to research the energy needs of their house and work on the energy worksheet. Additional reading from Global Science assigned as homework.

Expand – One period. Students research.
Students continue to research and compile the projected energy needs for their house. Then they begin to research possible energy sources. Math extension – one period. Students perform several energy calculations specifically related to their house as a way to improve math skills and develop understanding of calculate the kilowatt. Math assignment #1 – Energy units and conversions (p. 95/96 in Global Science.) Math assignment #2 – Calculating Power of a PV Cell. Begin with a brief review of electrical power generation (Global Science, 7.9) Review power, watts, volts, amps before handing out worksheet.

Evaluate/Wrap-up – One period. Field trip to Armory Park del Sol.
Students wrap up this lesson with a visit to a local sustainable housing development. Students will visit a net zero energy house, learn about alternative energy technologies (primarily solar), and get an opportunity to ask local experts any questions they may have about sustainable building.

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Name: _____ Date: _____

Household Energy Guidelines

Balancing the energy usage of your house is much like balancing a checkbook. The amount of energy input must equal the amount of energy output – that is, you must figure out a way to generate enough energy to run all the appliances you will need and want in your house. This worksheet will help you calculate the amount of energy you need to run your house, calculate where you are going to get it, and how you are going to store it (if appropriate),

House Location: _____

Energy Usage

List all the things that will need energy in your home.

-
-
-
-
-
-
-
-
-
-
-
-
-
-
-
-
-

Next to each of the items listed above, write down how you will get your energy to do these things. *(For example, next to hot water you might write solar water heater).*

Calculate the total number of kilowatt hours of electricity (KWH) you will need on a daily basis to run your house. To do this, multiply the number of watts each appliance uses by the total number of hours run per day. This gives you the watt hours/day for that appliance. Divide by 1000 (1,000 watts = 1 kilowatt) and add everything together to get the total daily energy usage for your house in KWH.

Note: To complete this table, you will need to find an energy usage chart for appliances. There are many online. One good one can be found at: www.otpco.com

Example:

Appliance	Usage Rate	Hrs. used/day	Watt hrs/day	KWH/day
1 light	75 watts	6 hours	450 watt hrs/day	.45 KWH/day

_____

Total Household Energy Usage (KWH/day)

Energy Supply Issues

Knowing the total number of KWH of energy needed per day is only part of the energy supply equation. There are two other main factors to consider: peak energy demand and energy storage capacity.

Peak energy demand is the highest amount of energy you will need at any given moment in time. For example, most houses need the most energy in the evening, when everyone is home and all the lights and computers and the heat/AC is on. Most businesses need energy during the day when people are working. If you get your energy from a continual source such as hydroelectric power, you will need to build a hydroelectric generator with enough capacity to meet the peak energy demand (and not the total energy demand).

You can calculate the peak energy demand (in kilowatts) by adding up all the energy consuming sources that could be running at the same time.

If you get your energy from a source like photovoltaic cells, they can only generate electricity when the sun is shining. So, to ensure you have energy when you need it, you will have to store the energy from PV cells in batteries. Storing electricity is difficult and expensive. (We are not going to address this topic in this project. See page 459/460 in Global Science for more information on energy storage techniques). For this assignment only, we have invented the SHP03 – a super small, super resilient battery that can store 80% of the energy used to charge it. For example, if you put 100 watts into the SHP03, you can withdraw 80 watts any time you want it.

To calculate the amount of energy (in KWH) you must produce if you have an intermittent energy source and need to store energy for later usage, take the KWH/day that you need and multiply it by 1.25.

Energy Generation

How (by what methods) do you plan to generate the energy (electricity) to meet your household needs? Do you need to calculate peak energy demand or factor in an energy conversion and storage factor? Or both?

Describe all the components of your energy generation system. Be sure to indicate how much energy they generate, and whether they are designed for peak demand or cumulative consumption with the miraculous SHP03 battery storage.

Approximately how much will it cost to build your energy system? Where did you get your figures?

What is the environmental impact of your energy plan?

Math worksheet #2

Calculating the Power Output of a PV Cell

Reminder:

Power = Energy/time So … Power (KW) == E (KWH)/Time(hr)

Example: An average house in the U.S. uses 15 kilowatt hours of energy/day (Global Science, 1996). To calculate the power needed to meet the energy needs of this house, using PV cells and the SHP03 super battery, you take the energy usage (15 KWH) and divide it by the number of hours of collecting time (let's say 9 hrs./day for the Sonoran Desert) then multiply that number by 1.25 to get the amount of power you would need to generate from PV cells. In this example, you would need to generate 2.08 kilowatts from your solar panel array to cover your energy needs.

Calculate how many kilowatts you would need to generate from a solar panel array to cover the energy needs of your sustainable house. If you live in the Sonoran Desert you can assume there is an average of 9 hours of light/day and if you live in the Costa Rican rainforest you can assume an average of 4 hours/day. Show your work.

If solar cell systems cost $7,000 per kilowatt, what is the cost of putting a solar cell system on your house?

How much energy can be obtained from a square meter of solar cells each day? Solar cells are approximately 10% efficient.

According to the textbook Global Science, the earth's surface receives approx. 4 KWH/square meter of sunlight each day. This is a 24-hour average figure for the U.S. This figure will obviously be higher in the Sonoran Desert (let's say 6.5 KWH/square meter/day) and lower in the Costa Rican rainforest (let's say 2.5 KWH/square meter/day).

Calculate the number of square meters of solar panels you would need to power an average house (15 KWH/day) and your proposed house (?? KWH/day) in both the Sonoran Desert and the Costa Rican rainforest (That's four different figures).

Lesson #3: Sustainable Materials and Building Design

Learning objectives:

- To introduce students to many different building materials and design options being used locally and in another part of the world
- To compare and contrast the utility, efficiency, and sustainability of different building materials

Key Concepts

- Efficiency and utility of building materials depends on the environment in which it is being used
- Many factors – climate, available resources, transportation, social constraints, economics – influence whether or not a material is considered sustainable

Vocabulary

- ✓ Concrete
- ✓ Rammed Earth
- ✓ Bamboo
- ✓ Hemp
- ✓ Earth Sheltered Design
- ✓ Daylighting
- ✓ Straw Bale Construction
- ✓ Volatile Organic Compounds
- ✓ LEED certification
- ✓ Toxicity
- ✓ Energy Star
- ✓ Rastra
- ✓ SmartWood Certification
- ✓ Renewable
- ✓ Recyclable
- ✓ Recycled
- ✓ Reprocessed

Materials and Resources Needed (including worksheets):

Handout listing possible sustainable building materials and web resources
Worksheet on sustainable building materials
Computers for research.
Tragedy of the Commons fishing exercise (M&M's, bowls, plastic spoons, worksheets)
Original copy of the Tragedy of the Commons article and discussion questions (honors option)

Lesson outline

Engage/Explore – one period.
Debrief visit to Armory Park del Sol (10 min.) KWL group brainstorm to determine what they already know about sustainable building materials. (10 min.) Review handout listing sustainable and alternative building materials and suggested websites. Students explore the subject by research possible sustainable building materials. and beginning to work on their sustainable building materials criteria worksheet. (30 min.)

Explore/Explain/Elaborate – Two periods
Students complete the sustainable building materials worksheet and begin to work on their final project. Students work in assigned groups, research and share information, and teacher assists by explaining, motivating, directing as needed. Teacher provides computer access, some model building materials, resources, etc.

Evaluate/Wrap up – One period
Conduct a fishing simulation with M&Ms to simulate unregulated competition for a common resource. There are several good examples on the web, including one by PBS (www.pbs.org/emptyoceans/educators/activities
Provide a summary of the article – Tragedy of the Commons. Honors/Advanced option includes having students read the original essay and then facilitating a discussion (see discussion guide at the end of this section). Two key (historical) points that arise from this article: 1) Does this exercise signify a need to regulate the commons? 2) Do we really have to worry about things like this? (i.e., some people contend that we will develop technological solutions to most of our current problems so we don't have to worry about things like nuclear waste, etc.)

Note: For a downloadable version of the original article "The Tragedy of the Commons," please visit: www.thegarretthardinsociety.org

List of Possible Sustainable Building Materials*

*This list is by no means complete and is meant to be a starting point from which you may do your own research on different materials that you might want to incorporate into your building design.

Hemp is natural, non-toxic, renewable, and low energy. No pesticide, low water and fertilizer, high in cellulose and 4 times as productive as trees for paper. Fibrous bark is used well as construction materials.

Straw is well used for wall systems, insulation, and is locally available, annually renewable, and environmentally sustainable.

Bamboo for flooring and furniture

Recycled denim as insulation for walls

Rammed Earth walls

Recycled glass for windows

Recycled carpet is available

Low toxin or toxin free paint for walls

Concrete is readily available and a good thermal sink

Straw Bale Construction is a popular alternative to traditional insulation

Reprocessed Plastic can be used as an alternative to wood for framework

Wool is a naturally insulating material that comes from sheep and can be used for carpeting

Marmoleum is an alternative to linoleum and is made from natural ingredients such as linseed oil

Paperstone is made from recycled paper, cashew nut oils, and water-based resins and is a good substitution for wood used as countertops

Cork is natural and a good alternative to wood for flooring

Local "green" Builders -- Contacts from Green Tuesday (Radio station 92.9)

Originate" Natural Building Materials Showroom
Natasha Winnick Owner/Operator 526 N. 9th Ave Tucson, AZ 85705 (520)792-4207 Natasha@OriginateNBM.com, www.OriginateNBM.com

Sustainable "Green" Interior Design
Juliann Berens and Adrienne GambaBerensGamba Interior Design
3958 E. Fort Lowell Rd. 85712 (520) 886-8932
www.BerensGamba.com

Solatube" . . . solar lighting for your home
Dana Wright Owner Highlight Enterprises, Inc. Authorized Dealer of **Solatube** 3924 West Ina Road, Suite 302 Tucson AZ 85741 (520) 298-4522 solatube@earthlink.net

The Solar Store
2833 N. Country Club 322-5180

Some Web Resources…

www.greenbuilder.com/sourcebook - this site has many options of building materials

www.arch.hku.hk/research/BEER/sustain.htm - this is an excellent site full of information defining key concepts of sustainable building and design

http://edc.uoregon.edu/resources - good site for links to other sustainable building materials pages

www.energstar.gov – good source to find listings of energy efficient appliances and electronics

www.nwf.org -- National Wildlife Federation – take a virtual tour of the Reston headquarters – a totally green building

www.strawsticksandbricks.com – good site for finding actual building materials to include in your house

www.compostingtoilet.org – site with information about composting toilets

www.gipo-rpi.com/lineal_plastic_lumber.html - site containing information about reprocessed plastic as a building alternative

www.greenbuildingsupply.com – has highly innovative "green" building materials to explore

Selecting Sustainable Building Materials

By now you have realized there are many different options available for building materials, and that much of what is available in a sustainable manner depends on where your house is located. This is a planning document to help you evaluate the materials you plan to use to make sure they are truly sustainable. Hint: You may want to include some this information in your final presentation when you explain why you chose the materials you did.

Efficiency/utility

- Are these materials energy and structurally efficient?
- Do they have the necessary insulation, conservation, and design qualities you need?

Source and Availability

- Are these materials available locally? If not, how far do they have to be transported to get to your location?
- Is the material in question worth the economic and environmental cost of transportating it to your location?
- Does it matter to you if you support the local economy or the small entrepreneurial businessperson versus the multi-national corporations?

Production costs

- What are the environmental (and economic and social) costs of producing this material (growing, harvesting, mining, manufacturing, etc.)?

Costs of usage and disposal

- What are the environmental (and economic and social) costs of using this material?
- How long does it last?
- What are the environmental (and economic and social) costs of disposal?

Offsets

- Are there ways to offset the impacts of using these materials (modifying usage patterns, planting trees for carbon offsets, etc.)?

Name: _____

The Tragedy of the Commons

Discussion Guide

Introduction

The article needs some historical perspective. When the article was written (1968) we were in the midst of an arms race and a space race with Russia. Nuclear weapons development and nuclear waste storage were big issues. Many people believed we would find technical solutions to most environmental problems and therefore we didn't need to worry about the impacts of greenhouse gases, pollution, etc. We were in the midst of a period of history where society valued science and many believed it would save the day (this is in contrast to other periods in history when scientists were outcasts and the church/king controlled everything).

Paragraph 1 – "If the great powers continue to look for solutions in the area of science and technology only, the result will be to worsen the situation.

One of the main questions posed by the article:

Is (or will be there always be) a scientific/technical solution to society's major problems?
Think of problems such as nuclear waste storage, limited water supplies, global warming, farming yields, etc. Note that the article defines a technical solution as one that requires a change only in the techniques of the natural sciences, demanding little or nothing in the way of change in human values or morality.

Where do you stand on the issue?

What Shall We Maximize? (The population problem)

Note: Population control and zero population growth, were contentious, public policy issues when this article was written.

Vocabulary: Use a dictionary to define the following words:

dissipation --

commensurable --

incommensurable --

implicit --

explicit --

Is ours a finite world or will technological advances allow us to continually expand the pie and increase population?

What is "the greatest good for the greatest number?" Can we achieve that goal? The author says no, for two reasons:

- It is not mathematically possible to maximize for two variables at the same time
- In order to maximize population, we must limit ourselves only to enough resources to survive, a condition we all agree will never be met.

**Note: This argument assumes that there is a limited supply of energy. But even with an infinite source of energy (nuclear energy), this is still not possible because of the problem of dissipation (what to do with all the energy that is released).

What is the "optimal population?" Is it the maximum (i.e., carrying capacity) or is it some number well below that where "quality of life" matters?

What is meant by the sentence: “Natural selection commensurates the incommensurables?”

What is meant by the sentence: “It is when the hidden decisions are made explicit that the arguments begin.”

Adam Smith – *The Wealth of Nations (an economics book published in 1776)*
This is a landmark book, one that has been used for the past 200+ years to justify unregulated capitalism. Smith writes about the “invisible hand,” the idea that an individual who “intends only his own gain,” is, as it were, “led by an invisible hand to promote the public interest.”

Do you think this is true? Will decisions reached independently by individual people result in the best decisions for the entire society? Is there an ecological basis for this thought as well?

Name: _____

The Tragedy of the Commons

Discussion Guide – Part Two

Tragedy of Freedom in a Commons

Explain the Tragedy of the Commons in your own words.

Reread the last two paragraphs of this section. How do you think we should manage the National Parks? Should we sell them off as private property or keep them as public property but limit access? If we limit access, how should we do it?

Pollution

How does the Tragedy of the Commons play out in a reverse way when dealing with problems of pollution?

How does Garrett Hardin suggest we address the pollution of community resources? Do you agree with his suggestions? If not, what would you propose?

Lesson #4A: Garden and Food Issues

Learning objectives:

- To teach students to analyze the basic requirements for growing food in any area (water, sun, soil, climate, pests, native/non-native species, etc.)
- To help students develop a specific garden plan for a particular climate (Sonoran Desert or Costa Rican rainforest)
- To introduce the concepts of sustainable farming

Key Concepts

- "Sustainable farming" involves many factors and is highly dependent on the specific conditions of a given area
- Transportation, genetically modified crops, labor conditions, and local environmental issues are key factors that make our current food supply system unsustainable

Vocabulary

- ✓ Pesticide Free
- ✓ Locally Produced
- ✓ Compost
- ✓ Fertilizer
- ✓ Herbicide
- ✓ Growing Season
- ✓ Land Management
- ✓ Irrigation
- ✓ Grow Plan
- ✓ Drought Resistant
- ✓ Native Species
- ✓ Introduced Species
- ✓ Invasive Species
- ✓ Decomposition

Materials and Resources Needed (including worksheets):

Tour of City High garden and/or a local farmer's market
Guest lecturer re: planting schedules and issues in the Sonoran Desert
Worksheet (requirements for the garden plan)

Lesson outline:

Engage – One period.
This lesson begins with a tour of the City High School garden and/or a local farmer's market.

Explore/Explain – One period.
Introduce requirements for garden plan. In house guest lecture re: planting schedules (Costa Rica and Sonoran Desert).

Division 1
Integrated Science
City High School

Sustainable House Project

Garden Requirements

The goal for your garden is to plant crops to supplement your diet (or your income). It will not be possible to grow enough food to be self-sufficient on one acre, but you should be able to supplement your diet with locally grown food. You can use as much of your one acre for the garden as you wish.

Along with your final report, you must submit an aerial view of your garden on 11" x 17" paper. This drawing must be to scale and include a key. All items should be clearly labeled.

In your final report (spoken or written), you must also include the following information:

- Garden calendar: Please indicate what plants will be growing at various times of the year.
- Soil: Indicate how you will improve your local soil (if necessary) and where you will get these soil improvers.
- Water: Explain how you intend to get the water for your garden.
- Pests: Explain how you intend to protect your crops from pests without using pesticides.

***

Guest lecture notes:

Lesson #4B: Scale Drawings:

Learning objectives:

- To teach students how to translate a verbal description of a property into an appropriately scaled drawing
- To teach students how to figure out an appropriate scale for a drawing, depending on the size of the area to be depicted and the size of the page

Key concepts:

- Maps are generally laid out with north at the top of the page
- Each map should contain a key to interpret the symbols and distances

Vocabulary

- ✓ Drawn to scale

Materials and Resources Needed (including worksheets):

Drawing guidelines
11" x 17" drawing paper
compasses, rulers
pencils, colored pencils
Math lecture on choosing appropriate scales

Lesson outline:

Explain/Explore – Three periods (two days).
During this lesson, students will complete three scale drawings of their property. Completing the drawings forces students to plan exactly what they need on their property, in their garden, and in their house. This is both a math lesson in scaling and proportions, and an activity that forces students to complete design of their house.

Name: _____ **Date:** _____

Drawing Guidelines

As part of your final grade, you will be required to submit three scaled drawings of your project. You will have to make, on 11" x 17" paper, scale drawings of:

- Your acre, including the footprint of your house and garden. You will also have to include any interesting or pertinent topographical features.
- Your house, including the size and location of all major interior features. If you have more than one floor, you will have to draw all of them on the same sheet of paper.
- Your garden, including where you plan to plant your crops and which seasons they will grow.

Each of you will have a one acre plot. One acre = 43,560 square feet. The plots come in one of three shapes – a square, a rectangle, or a trapezoid. You can choose which shape you want.

- Square = 208' x 208'
- Rectangle = 240' x 180'
- Trapezoid = Bases 300' and 184' and the height is 180'

Note: your drawings will be graded on neatness, level of detail, and accuracy of scale.

Shape of my plot: _____

How to choose a scale (notes from lecture):

Lesson #5: Water/wastewater:

Note: Division 1 students complete an entire unit on local water issues earlier in the year, so this lesson is abbreviated and focused specifically on this project.

Learning objectives:

- Teach students about onsite methods of wastewater treatment, including septic systems, composting toilets, harvesting methane gas from wastewater treatment systems, etc.
- Introduce students to the concept of rainwater harvesting
- Introduce students to the concept of designing the landscape to maximize the water resource

Key Concepts Addressed

- The process of wastewater treatment is relatively the same whether it's done in a big industrial setting or on a small scale
- Rainwater harvesting is an untapped resource in both the Sonoran Desert and the Costa Rican rainforest
- Landscape architecture is a complicated, interesting, and beneficial field

Vocabulary

- ✓ Cistern
- ✓ Gray Water
- ✓ Reclaimed Water
- ✓ Potable Water
- ✓ Water Table
- ✓ Septic Tank
- ✓ Aquifer
- ✓ Water Catchments
- ✓ Drought

Materials and Resources Needed (including worksheets):

Worksheet on water/wastewater system requirements
Worksheet (math) on rainwater harvesting
Info/lecture from Global Science textbook on wastewater treatment systems

Lesson outline

Explore/explain/expand.
At this point in the project, students should be well on their way to designing their house and completing their presentation. Teacher will handout the information on water system requirements, and present information on septic systems and rainwater harvesting to the entire class, but since the students have already completed a water unit they should be familiar with much of this. The teacher's role, at this point in the project, is to answer questions, provide research leads and support, and motivate. Math integration – To extend the science lesson into math and demonstrate the value of rainwater harvesting, students will work on several calculations related to rainwater harvesting during math.

Division 1
Integrated Science
City High School

Sustainable House Project

Water/wastewater Requirements

Water presents very different challenges in the Costa Rican rainforest than it does in the Sonoran Desert. To make your house sustainable, you must identify a realistic source of water that will meet the needs of your house and garden, as well as an environmentally responsible way to treat the wastewater. In addition, you must research and calculate an approximate cost for your water/wastewater treatment system.

In your final presentation, you must include the following information (either written or spoken):

- Where you will get water for your house
- Where you will get water for your garden
- How you will treat your wastewater
- The approximate cost of building your water/wastewater system
- The water conservation measures you used in designing your house (consider exterior features such as rainwater harvesting and landscaping as well as interior features such as low flow toilets, faucet aerators, etc.)

Possible resources:

www.envirolet.com (products)
www.compostingtoilet.org
www.biolet.com

www.clearstreamsystems.com
www.greywater.com
www.rmi.org/sitepages/pid287.php
www.epa.gov/owm/spetic.index.html
www.compostguide.com

Rainwater Harvesting

Rainwater harvesting is an excellent way to take full advantage of the natural rainfall in your area. One way to do this is to directly harvest the water that falls on the roof of your house and store it for later use. Another way is to landscape your property to store and direct the water to take full advantage of the rain. Or you could get creative …..

In this assignment you will calculate the amount of water you could harvest from the roof of your house. To do this you need to know:

1) the square footage of your roof: _____
2) the average rainfall (in inches/yr.) where your property is located: _____
   (Tucson = 12.9 inches/yr.; Turrialba = 137 inches/yr.)
3) the conversion factor: 1 gallon = .134 cubic feet

#1) Calculate the amount of water, in gallons, you could harvest from the roof of your house.

#2) Calculate the amount of water, in gallons, you could harvest in Turrialba with a roof that is 890 square feet.

#3) How big would a roof have to be in Tucson to harvest 50,000 gallons/yr?

Student Presentations and Final Evaluations:

Evaluate – 2 to 3 periods, as needed.
This is the culmination of the project. Students present their final plans to the entire class and a panel of guests (some from within the school, others from the community). Students give a 4-6 minute verbal presentation that is supplemented by a powerpoint, a poster (storyboard), or a model. Students are also evaluated on how well they can answer questions after their presentation.

A presentation evaluation form, student feedback form, and the rubric for the final grade is included in this section. The grading rubric can be handed out near the end of the project to help students plan their final presentation.

Division 1 Sustainable House Research Project

Presentation Evaluation Sheet

Evaluator's name: _____

Student(s) presenting: _____

Location of house (circle one): Sonoran Desert Costa Rican rainforest

Each student will make a verbal presentation of what they learned during their Sustainable House Research Project. The presentation should last approximately 5 minutes and must be supported by a model, a tri-fold poster, or a powerpoint presentation.

Supporting materials (check one): model ____ tri-fold (poster) ____ powerpoint _____

Students will be evaluated on the clarity, organization, and creativity of their presentation, as well as how well they addressed the following issues:

House Design

____ Does it meet the basic design requirements? (1,500 to 3,000 square feet, "off the grid," plan for a family of 5)
___ Does it seem to fit with the local environment?
____ Does the design show creativity?

Energy

____ Did the presentation include a well-designed energy plan?
_____ Did the presentation include a rough estimate of the cost of building such an energy system?
____ Is the energy plan sustainable and does it make sense for the local environment?
_____ Did the presentation include at least three specific measures to conserve energy?

Water/wastewater

____ Did the presentation include a realistic way to get enough water for the house?
____ Did the presentation include an environmentally responsible way to deal with wastewater?
____ Did the presentation include any water conservation measures?

Building Materials

____ Did the house design incorporate sustainable building materials?
____ Did the building materials come from the local environment?

Garden

____ Does the plan include a year round garden to grow crops to supplement the inhabitants diet or income?
____ Do the chosen crops make sense for the local environment?
____ Did the presentation include a pest control plan that is free of chemical herbicides?

Please comment on the clarity, organization, and creativity of the overall presentation:

Please rate the quality of the supporting materials. If you are unable to evaluate a particular category, simply write N/A.

Category	Exceptional	Meets Expectations	Satisfactory	Needs Improvement
Exhibit Materials: Trifold (Poster)	Trifold is visually pleasing & carefully designed & executed. Trifold includes details, photos & descriptions that highlight major features of the house.	Trifold is generally well designed & executed. Trifold includes some details, photos & descriptions that highlight major features of the house.	Trifold shows some thought and care in terms of design & execution. Trifold includes a few details, photos and descriptions that highlight major features of the house.	Trifold is confusing & shows little thought or care in terms of design & execution. Trifold includes no details, photos or description that highlight major features of the house.
Exhibit Materials: Powerpoint Slideshow	Slideshow is visually pleasing, gives the viewer a well developed sense of the house, and highlights all the key features.	Slideshow is easy to watch, gives the viewer a good sense of the house, and highlights most of the key features.	Slideshow gives the viewer some idea of the house and addresses most of the key features.	Slideshow gives the viewer a vague idea of the house and addresses few of the key features.
Exhibit Materials: Model	Model is creative, visually pleasing, and gives the viewer a well developed sense of the house and it's key features.	Model is visually pleasing and gives the viewer a good sense of the house and it's key features.	Model gives the viewer some idea of what the house is like and includes some key features.	Model gives the viewer a vague idea of the house and its key features.
Ability to answer questions	Student is willing and able to respond clearly and with details to all questions.	Student is willing and able to respond clearly and with detail to most questions.	Student is willing and able to respond to questions, but with little detail.	Student is unable to respond to all questions, almost never with detail.

Additional comments:

Peer Feedback – Sustainable House Project

Your Name: _____

****

Student Presenter(s): _____

What I liked best about this sustainable house/presentation:

_____
_____
_____
_____
_____
_____
_____
_____

One thing I learned:

_____
_____
_____
_____

****

Student Presenter(s): _____

What I liked best about this sustainable house/presentation:

_____
_____
_____
_____
_____
_____
_____

One thing I learned:

_____
_____
_____
_____

Appendix: References and other resources

Extended lesson on The Lorax
List of references from the textbook Global Science
List of web resources for the entire unit
Brainstorming Questions for Farmer's Market visit

Note: This lesson plan was provided by a teacher friend who received it from another teacher who received it from another teacher...

Ecology Lesson Plan – The Lorax

Focus: **Sustainable Development**

Benchmark/Standards: SC.G.1.4.1, SC.G.2.4.2

Materials Needed:

* worksheet: Dr. Seuss' The Lorax
* Video: *The Lorax*
* Written copy of The Lorax
* Handout: Sustainable Development for the Manufacture of Thneeds.

Activities:

- Watch *The Lorax* on video *approx. 30 minutes*
- Student completion of worksheet *approx. 30 minutes*
- In groups students work on a Sustainable Development Plan for the Manufacture of Thneeds. a*pprox. 30 minutes*
- Group presentations of Plans a*pprox. 30 minutes*

Dr. Seuss' *The Lorax*

The focus of this activity is to introduce and understand the concept of sustainable development by using ideas found in *The LORAX.*

The LORAX is a fictional story about a man whose activities abused the environment and about what he learned from the experience. The story contains many common components found in the environmental problems and issues facing humans around the world. Further, *The LORAX* also contains many of the components associated with sustainable development (SD).

Sustainable development is an important (and complicated) idea for all human beings to understand. SD is the current worldwide attempt by planners, leaders, and scientists to conduct human activities in such a way that the environment is preserved. Although there is still much confusion and discussion, there appear to be four basic parts of SD - human needs, technology needs, economics needs, and environmental needs.

Sustainable development is a tricky idea. It suggests that humans "sustain" the environment by preserving, protecting, and conserving. Yet, economic development is still necessary in all countries, regardless of their current economic status. Many experts believe that this apparent conflict between outcomes is the key to the quality of future human life on the planet and that economic development using environmentally-friendly technology can help promote economic development that sustains the environment. The central SD focus is to balance quality of life with quality of the environment.

Questions

1. The Once-ler used the land's natural resource to start a business which made and sold a product. What was the product? How was it used by buyers?
   The Once-ler's Product: _____
   The Product's Uses: _____

2. The product made out of what natural resource?
   _____
   _____

3. Dr. Seuss was trying to give an important warning that was geared to young people (children). What was the lesson that he was trying to give?
   _____
   _____
   _____

4. Why do you think that the author chose children as the target audience for this purpose?
   _____
   _____
   _____

5. This book was written many years ago. Do you think that the lesson is as important today as it was in 1971 when the book was written? Why or why not?
   _____
   _____
   _____
   _____
   _____
   _____

6. The use of technology often requires the use of natural resources. This utilization of natural resources can have an effect on the environment. How did the production of thneeds effect important natural resource(s) in the story?

_____
_____
_____
_____

7. According to the author, certain animals depended on truffula trees. Name the animals. Explain why these animals needed truffula trees.

Animals: _____
The need for the trees: _____

8. Often, technological production creates "byproducts". For example, a byproduct of sawing wood is sawdust. Sometimes the byproducts of technology are unwanted or dangerous (ex: poisonous chemicals). Name two byproducts that resulted from making thneeds.

Byproduct 1: _____
Byproduct 2: _____

9. Were these two byproducts helpful or harmful to the environment?

Byproduct 1: _____
Byproduct 2: _____

10. Did the Once-ler try to prevent the environmental effects of producing thneeds? Explain.

_____
_____
_____
_____

11. The Once-ler's business failed. What happened to cause this failure?

_____
_____
_____
_____
_____

12. The Once-ler learned that he had made a serious mistake. What, in your opinion, was that mistake?

_____
_____
_____
_____
_____
_____
_____

Sustainable Development for the Manufacture of Thneeds

Now it is your turn to help the Once-ler. You must prepare a sustainable development plan for the manufacture of thneeds, one that will eliminate the social and environmental effects described in the story. Your plan should attempt to meet the important parts of sustainable development – meeting human, economic, technological and environmental needs. Be prepared to report and defend your plan to the class. Use the format below to assist in the development of your plan. One final thought: you can imagine that all of your changes (within reason) are possible!

- How will your plan meet the Once-ler and his town citizens' economic needs?
- How can you use environmentally-friendly technologies? Be specific and give examples.
- How will your plan protect and conserve the environment, including the biotic and abiotic resources?
- How will your plan meet the social needs that insure a quality of life for human beings?
- How does your plan balance the quality of the environment with the quality of human life?

Sustainable Development for the Manufacture of Thneeds

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- How will your plan meet the social needs that insure a quality of life for human beings?
- How does your plan balance the quality of the environment with the quality of human life?

Dr. Seuss' *The Lorax*

At the far end of town
where the Grickle-grass grows
and the wind smells slow-and-sour when it blows
and no birds ever sing excepting old crows...
is the Street of the Lifted Lorax.

And deep in the Grickle-grass, some people say,
if you look deep enough you can still see, today,
where the Lorax once stood
just as long as it could
before somebody lifted the Lorax away.

What was the Lorax?
Any why was it there?
And why was it lifted and taken somewhere
from the far end of town where the Grickle-grass grows?
The old Once-ler still lives here.
Ask him. He knows.

You won't see the Once-ler.
Don't knock at his door.
He stays in his Lerkim on top of his store.
He stays in his Lerkim, cold under the roor,
where he makes his own clothes
out of miff-muffered moof.
And on special dank midnights in August,
he peeks out of the shutters
and sometimes he speaks
and tells how the Lorax was lifted away.
He'll tell you, perhaps...
if you're willing to pay.

On the end of a rope
he lets down a tin pail
and you have to toss in fifteen cents
and a nail
and the shell of a great-great-great-
grandfather snail.

Then he pulls up the pail,
makes a most careful count
to see if you've paid him
the proper amount.

Then he hides what you paid him
away in his Snuvv,
his secret strange hole
in his gruvvulous glove.
Then he grunts, I will call you by Whisper-ma-Phone,
for the secrets I tell you are for your ears alone.

SLUPP

Down slupps the Whisper-ma-Phone to your ear
and the old Once-ler's whispers are not very clear,
since they have to come down
through a snergelly hose,
and he sounds
as if he had
smallish bees up his nose.
Now I'll tell you, he says, with his teeth sounding gray,
how the Lorax got lifted and taken away...
It all started way back...
such a long, long time back...

Way back in the days when the grass was still green
and the pond was still wet
and the clouds were still clean,
and the song of the Swomee-Swans rang out in space...
one morning, I came to this glorious place.
And I first saw the trees!
The Truffula Trees!
The bright-colored tufts of the Truffula Trees!
Mile after mile in the fresh morning breeze.

And under the trees, I saw Brown Bar-ba-loots
frisking about in their Bar-ba-loot suits
as the played in the shade and ate Truffula Fruits.

From the rippulous pond
came the comfortable sound
of the Humming-Fish humming
while splashing around.

But those trees! Those trees!
Those Truffula Trees!
All my life I'd been searching
for trees such as these.
The touch of their tufts
was much softer than silk.
And they had the sweet smell
of fresh butterfly milk.

I felt a great leaping
of joy in my heart.
I knew just what I'd do!
I unloaded my cart.

In no time at all, I had built a small shop.
Then I chopped down a Truffula Tree with one chop.
And with great skillful skill and with great speedy speed,
I took the soft tuft. And I knitted a Thneed!

The instand I'd finished, I heard a ga-Zump!
I looked.
I saw something pop out of the stump
of the tree I'd chopped down. It was sort of a man.
Describe him?...That's hard. I don't know if I can.

He was shortish. And oldish.
And brownish. And mossy.
And he spoke with a voice
that was sharpish and bossy.

Mister! he said with a sawdusty sneeze,
I am the Lorax. I speak for the trees.
I speak for the trees, for the trees have no tongues.
And I'm asking you, sir, at the top of my lungs--
he was very upset as he shouted and puffed--
What's that THING you've made out of my Truffula tuft?

Look, Lorax, I said. There's no cause for alarm.
I chopped just one tree. I am doing no harm.
I'm being quite useful. This thing is a Thneed.
A Thneed's a Fine-Something-That-All-People-Need!
It«s a shirt. It's a sock. It's a glove. It's a hat.
But it has other uses. Yes, far beyond that.
You can use it for carpets. For pillows! For sheets!
Or curtains! Or covers for bicycle seats!
The Lorax said,
Sir! You are crazy with greed.
There is no one on earth
who would buy that fool Thneed!

But the very next minute I proved he was wrong.
For, just at that minute, a chap came along,
and he thought that the Thneed I had knitted was great.
He happily bought it for three ninety-eight.
I laughed at the Lorax, You poor stupid guy!
You never can tell what some people will buy.

I repeat, cried the Lorax,
I speak for the trees!

I'm busy, I told him.
Shut up, if you please.
I rushed 'cross the room, and in no time at all,
built a radio-phone. I put in a quick call.
I called all my brothers and uncles and aunts
and I said, Listen here! Here's a wonderful chance
for the whole Once-ler Family to get mighty rich!
Get over here fast! Take the road to North Nitch.
Turn left at Weehawken. Sharp right at South Stich.

And, in no time at all,
in the factory I built,
the whole Once-ler Family
was working full tilt.
We were all knitting Thneeds
just as busy as bees,
to the sound of the chopping
of Truffula Trees.

Then...
Oh! Baby! Oh!

How my business did grow!
Now, chopping one tree
at a time was too slow.

So I quickly invented my Super-Axe-Hacker
which whacked off four Truffula Trees at one smacker.
We were making Thneeds
four times as fast as before!
And that Lorax?... He didn't show up any more.

But the next week
he knocked
on my new office door.
He snapped, I'm the Lorax who speaks for the trees
which you seem to be chopping as fast as you please.
But I'm also in charge of the Brown Bar-ba-loots
who played in the shade in their Bar-ba-loot suits
and happily lived, eating Truffula Fruits.
NOW...thanks to your hacking my trees to the ground,
there's not enough Truffula Fruit to go 'round.
And my poor Bar-ba-loots are all getting the crummies
because they have gas, and no food, in their tummies!

They loved living here. But I can't let them stay.
They'll have to find food. And I hope that they may.
Good luck, boys, he cried. And he sent them away.

I, the Once-ler, felt sad
as I watched them all go.
BUT...
business is business!
And business must grow
regardless of crummies in tummies, you know.

I meant no harm. I most truly did not.
But I had to grow bigger. So bigger I got.
I biggered my factory. I biggered my roads.
I biggered my wagons. I biggered the loads
of the Thneeds I shipped out. I was shipping them forth
to the South! To the East! To the West! To the North!
I went right on biggering...selling more Thneeds.
And I biggered my money, which everyone needs.

Then again he came back! I was fixing some pipes
when that old nuisance Lorax came back with more gripes.
I am the Lorax, he coughed and he whiffed.
He sneezed and he snuffled. He snarggled. He sniffed.
Once-ler! he cried with a cruffulous croak.
Once-ler! You're making such smogulous smoke!
My poor Swomee-Swans...why, they can't sing a note!
No one can sing who has smog in his throat.

And so, said the Lorax,
--please pardon my cough--
they cannot live here.
So I'm sending them off.

Where will they go?...
I don't hopefully know.
They may have to fly for a month...or a year...
To escape from the smog you've smogged-up around here.

What's more, snapped the Lorax. (His dander was up.)
Let me say a few words about Gluppity-Glupp.
Your machinery chugs on, day and night without stop
making Gluppity-Glup. Also Schloppity-Schlopp.
And what do you do with this leftover goo?...
I'll show you. You dirty old Once-ler man, you!

You're glumping the pond where the Humming-Fish hummed!
No more can they hum, for their gills are all gummed.
So I'm sending them off. Oh, their future is dreary.
They'll walk on their fins and get woefully weary
in search of some water that isn't so smeary.

And then I got mad.
I got terribly mad.
I yelled at the Lorax, Now listen here, Dad!
All you do is yap-yap and say, Bad! Bad! Bad! Bad!
Well, I have my rights, sir, and I'm telling you
I intend to go on doing just what I do!
And, for your information, you Lorax, I'm figgering
on biggering
and Biggering
and BIGGERING
and **BIGGERING!!**
turning MORE Truffula Trees into Thneeds
which everyone, EVERYONE, **EVERYONE** needs!

And at that very moment, we heard a loud whack!
From outside in the fields came a sickening smack
af an axe on a tree. Then we heard the tree fall.
The very last Truffula Tree of them all!

No more trees. No more Thneeds. No more work to be done.
So, in no time, my uncles and aunts, every one,
all waved my good-bye. They jumped into my cars
and drove away under the smoke-smuggered stars.

Now all that was left 'neath the bad-smelling sky
was my big empty factory...
the Lorax...
and I.

The Lorax said nothing. Just gave me a glance...
just gave me a very sad, sad backward glance...
as he lifted himself by the seat of his pants.
And I'll never forget the grim look on his face
when he hoisted himself and took leave of this place,
through a hole in the smog, without leaving a trace.

And all that the Lorax left here in this mess

was a small pile of rocks, with one word...
UNLESS.
Whatever that meant, well, I just couldn't guess.

That was long, long ago.
But each day since that day
I've sat here and worried
and worried away.
Through the years, while my buildings
have fallen apart,
I've worried about it
with all of my heart.

But now, says the Once-ler,
Now that you're here,
the word of the Lorax seems perfectly clear.
UNLESS someone like you
cares a whole awful lot,
nothing is going to get better.
It's not.

SO...
Catch! calls the Once-ler.
He lets something fall.
It's a Truffula Seed.
It's the last one of all!
You're in charge of the last of the Truffula Seeds.
And Truffula Trees are what everyone needs.
Plant a new Truffula. Treat it with care.
Give it clean water. And feed it fresh air.
Grow a forest. Protect it from axes that hack.
Then the Lorax
and all of his friends
may come back.

Division 1
Integrated Science
City High School

Sustainability Project Resources

Global Science Textbook:

Energy
- Chapter 3: Entire chapter is an overview of energy issues.

Gardening
- Chapter 6: Sustainable Agriculture: Looking at Soil, Seeds, and Nutrition (p215)
  - How much food energy do I need 237
  - Food and Resources 241
  - Politics of Hunger 257
  - Carrying Capacity 260

Gardening/Housing
- Chapter 7: Energy Today
  - How we use energy 271
- Chapter 14: Resource Management: Land (p569)
  - Disposing of our solid waste p587 –
  - Disposing of Municipal Solid Waste p610

Housing
- Chapter 10: Energy Alternatives (p391)
  - Designing an Environmental Home p404
  - Solar Ovens p411
- Chapter 11: Strategies for Using Energy (p441)
  - Conservation p442
- Chapter 12:
  - On-Site Sewage Treatment p520

Notes:

Possible Questions for Vendors/Experts at the Farmer's Market

Food/Garden

Possible contacts:

What food crops grow well in Tucson? Costa Rican rainforest?

What kind of soil do you need to grow these crops?

How can you deal with pests in a sustainable (pesticide-free) manner?

How do seasons affect what you grow?

How does global climate change affect what you grow?

Greenhouse vs. field grown?

How do you deal with food waste?

Ask about goats and beef production – how much land is needed, etc.

Sustainable House:

Possible contacts/resources:

How do you get your power?

What building methods do you use to conserve energy?

How much power do you use relative to a "normal' home?

How do you deal with water/wastewater?

What kind of things do you recycle/reuse?