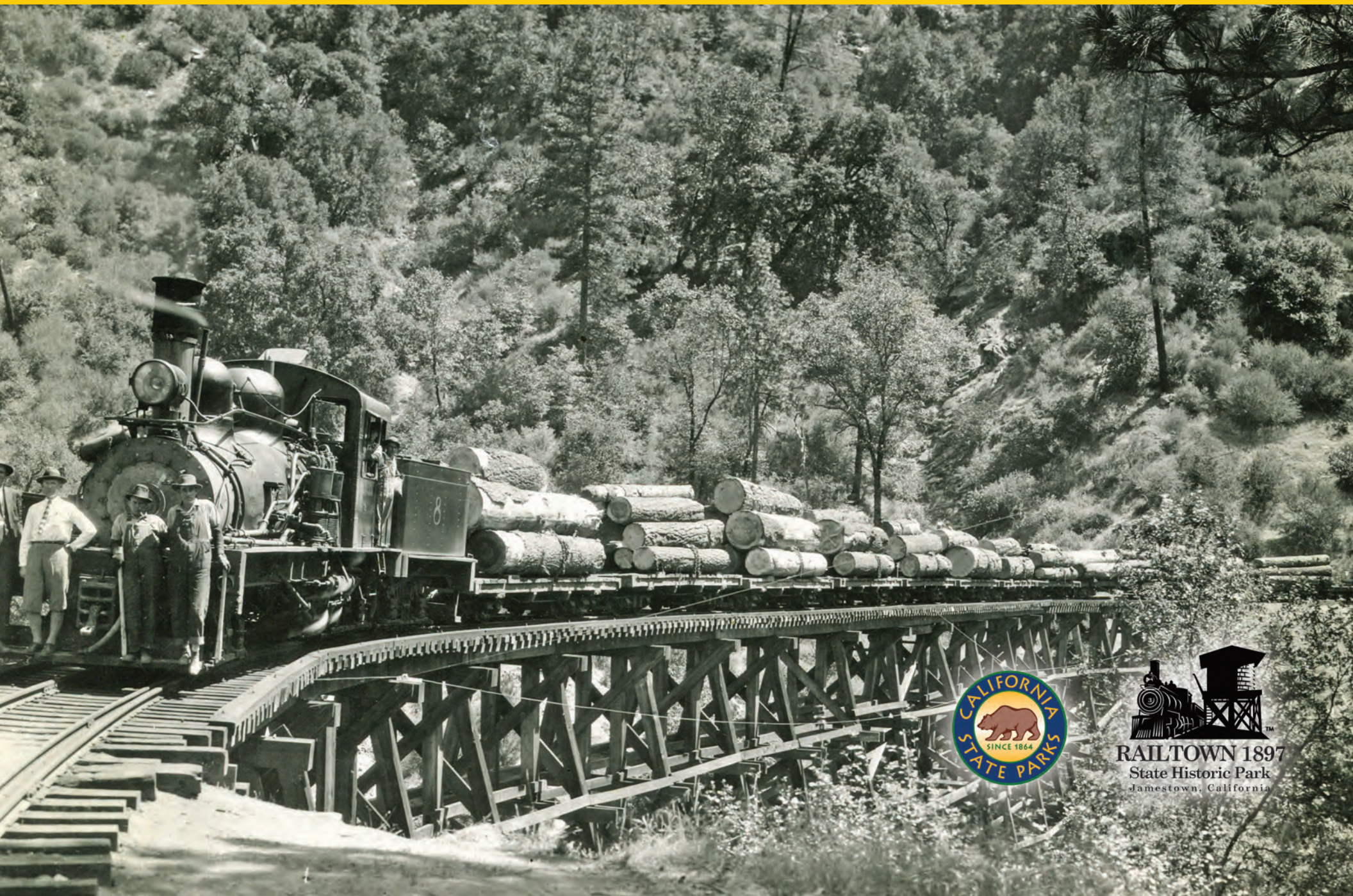
The Sierra Railway and Natural Systems

Grade 5 Teacher's Guide



Railtown 1897 State Historic Park
5th Grade Unit Plan: The Sierra Railway and Natural Systems

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Questions about this instructional unit should be directed to:
Railtown 1897 State Historic Park, 18115 5th Ave, Jamestown, CA 95327

Unit Subject Focus

Science

Primary Content Standard Addressed

Next Generation Science Standards

- 5-ESS3-1. Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.

Disciplinary Core Idea

- ESS3.C: Human Impacts on Earth Systems
- Human activities in agriculture, industry, and everyday life have had major effects on land, vegetation, streams, oceans, air, and even outer space. But individuals and communities are doing things to help protect Earth's resources and environments.

Secondary Content Standards Addressed

California Common Core State Standards English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects

- Reading Standards for Informational Text K–5, Grade 5
- Key Ideas and Details 3. Explain the relationships or interactions between two or more individuals, events, ideas, or concepts in a historical, scientific, or technical text, based on specific information in the text.
- Writing Standards K–5, Grade 5
- Text Types and Purposes 2. Write informative/explanatory texts to examine a topic and convey ideas and information clearly.

California Common Core State Standards Mathematics

- Grade 5, Measurement and Data: Convert like measurement units within a given measurement system.
- 1. Convert among different-sized standard measurement units within a given measurement system (e.g., convert 5 cm to 0.05 m), and use these conversions in solving multi-step, real-world problems.

Next Generation Science Standards

- 5-PS1-1. Develop a model to describe that matter is made of particles too small to be seen.
- 5-PS1-2. Measure and graph quantities to provide evidence that regardless of the type of change that occurs when heating, cooling, or mixing substances, the total weight of matter is conserved.

Education and the Environment Initiative — Environmental Principles and Concepts Addressed

Principle II: The long-term functioning and health of terrestrial, freshwater, coastal and marine ecosystems are influenced by their relationships with human societies.

- Concept a. Students need to know that direct and indirect changes to natural systems due to the growth of human populations and their consumption rates influence the geographic extent, composition, biological diversity, and viability of natural systems.
- Concept b. Students need to know that methods used to extract, harvest, transport and consume natural resources influence the geographic extent, composition, biological diversity, and viability of natural systems.
- Concept c. Students need to know that the expansion and operation of human communities influences the geographic extent, composition, biological diversity, and viability of natural systems.

Principle V: Decisions affecting resources and natural systems are based on a wide range of considerations and decision-making processes.

- Concept a. Students need to know the spectrum of what is considered in making decisions about resources and natural systems and how those factors influence decisions.
- Concept b. Students need to know the process of making decisions about resources and natural systems, and how the assessment of social, economic, political, and environmental factors has changed over time.

Unit Grade Level

Fifth Grade

Unit Duration

Lesson Number	Advanced Preparation (minutes)	Instructional Time (minutes)	Assessment Time (minutes)
1	15	60	30
2	45	150–180	30
3	15	60	60
4	15	135	30
5	15	75	30
6	15	150	30
Assessment: Traditional	15	N/A	60
Assessment: Alternative	15	N/A	Two sessions, the first of 60 minutes and the second of 90 minutes
Total	150	630	420

Unit Overview

In this unit, students explore the effects of human activities in industry and everyday life on the environment during the late 1800s and early 1900s and how science ideas were used to protect Earth's resources and the environment then, and today. The rapidly growing communities in Calaveras, Stanislaus, and Tuolumne Counties, and the Bay Area resulted in an increasing need to extract, harvest, and consume natural resources (ecosystem goods). The Sierra Railway of California (Sierra Railway) had an integral role in transporting these goods, as well as people, to provide communities with the resources and infrastructure they needed.

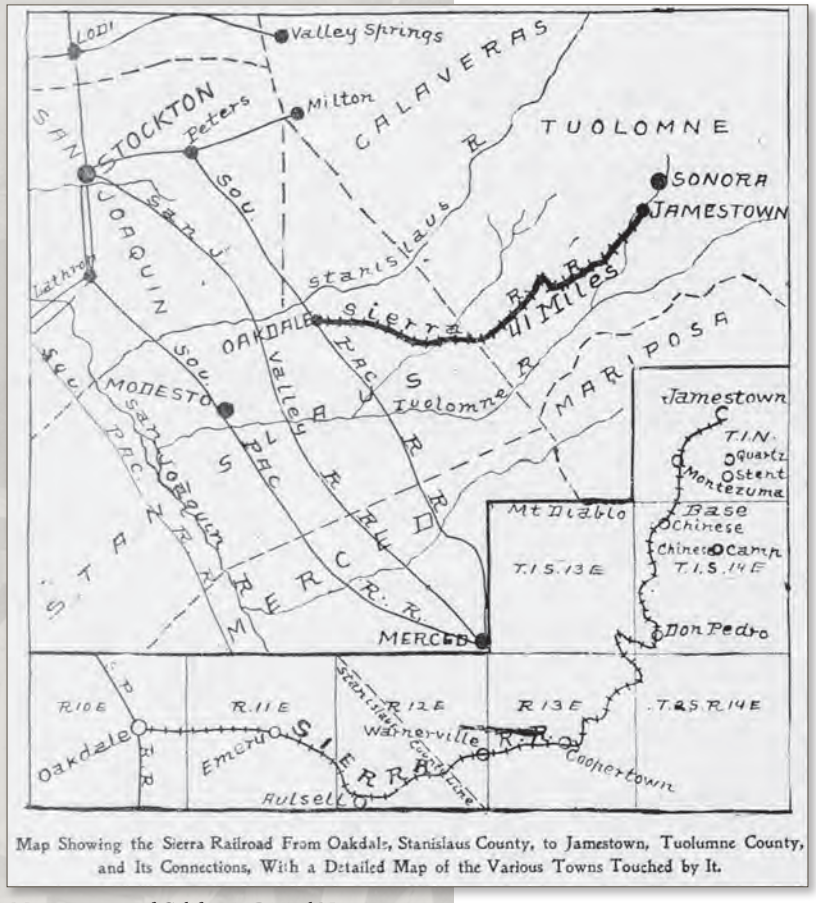
In the first lesson, students are introduced to Louise and William, two fictional siblings. The siblings moved to Jamestown from the East Coast in 1899. They kept a diary of events affecting their community, augmented with newspaper clippings that follow current events and the role the Sierra Railway plays in them. As students read the diary, they are introduced to timber in the context of an ecosystem good that is sold in a lumberyard but has its origins elsewhere. The questions the siblings ask their father about timber drive the remainder of the lessons in the unit.

In the second lesson, students learn through the siblings' diary that lumber is transported throughout the region by trains, including the Sierra Railway. The brother and sister visit the Sierra Railway roundhouse in Jamestown to learn about how the steam locomotive works. This serves as an introduction to a series of hands-on activities students explore to learn about the tiny particles that comprise matter and the fact that matter is conserved.

In the third lesson, students read in the siblings' diary about a visit to a logging camp where their uncle works as a lumberjack. While exploring the forest and logging camp, the siblings learn how trees are measured to determine how many board feet they contain. Students learn these calculations and practice calculating board feet for hypothetical woodlands.

In the fourth lesson, students view a diary entry that includes two aerial photographs of Jamestown, one dated pre-1897 and the other post-1897. The year 1897 marks the date the train depot was built and the Sierra Railway reached Jamestown. Students measure and compare the geographic extent of natural systems and development of the town as captured in the two photographs. They also learn some science ideas that foresters might use to determine how to cut timberland to manage for long-term sustainability and wildlife habitat. They revisit the hypothetical woodlands they harvested in lesson three to apply their new knowledge to their harvest.

The fifth lesson in the unit introduces another essential natural resource, water, to students through the siblings' diary. Students read a passage and learn about the 1906 San Francisco earthquake. This event caused significant devastation, in part due to the earthquake, but also due to the huge fires that erupted in the aftermath. Although the city of San Francisco had been searching



Map Showing the Sierra Railroad From Oakdale, Stanislaus County, to Jamestown, Tuolumne County, and Its Connections, With a Detailed Map of the Various Towns Touched by It.

Map courtesy of California Digital Newspaper Collection, Center for Bibliographic Studies and Research, University of California, Riverside, http://cdnc.ucr.edu.

for a reliable and constant source of water since the 1880s, the earthquake brought this need to the forefront. Sights turned once again to Hetch Hetchy Valley and Tuolumne River. The Sierra Railway was employed to transport workers and materials to construction sites for O'Shaughnessy Dam (Hetch Hetchy Reservoir) and later, Don Pedro and Melones Dams. In this lesson, students divide into groups to study one of these dams and then gather into different groups to share what they have learned.

The final lesson of the unit addresses the controversy surrounding Hetch Hetchy and the resulting O'Shaughnessy Dam. The siblings' diary reports that President Woodrow Wilson has signed a bill into law that allows the creation of a dam in the Hetch Hetchy Valley. Students use archived historical resources, containing actual position statements submitted or given by citizens in the early 1900s, to role play in a debate. Through this process they are introduced to the spectrum of factors, including social, economic, political, environmental, and scientific, that are considered in making decisions about natural systems. The lesson ends with a discussion about the modern-day perspectives on O'Shaughnessy Dam.

The unit helps students understand human impacts on earth systems and how science ideas can be used to protect Earth's resources and the environment.

Lessons at a Glance

Lesson 1: In Search of Lumber

Students read a passage from a diary written by a brother and sister who moved to Jamestown from New York. The siblings describe their experiences going to a lumberyard and a sawmill, and learn how trees are a natural resource. The teacher leads students in a classroom discussion regarding timber as an "ecosystem good" and poses factual, interpretive, and predictive questions about the text.

Lesson 2: Steam Matters

Students read the next entry in the siblings' diary and learn that lumber is transported throughout the region on trains, including the Sierra Railway. To learn how the steam engines work to transport lumber, students engage in various hands-on activities. Learning that matter is made of particles too small to be seen, and conserved in a closed system, students apply this knowledge about matter to understanding how a steam locomotive works.

Lesson 3: The Forest from the Trees

Students read a passage in the siblings' diary about their visit to a logging camp where their uncle works. The children describe how loggers approximate the amount of wood that can be harvested from each tree. Students use these same formulas to calculate how many board feet can be harvested from a hypothetical woodland.

Lesson 4: A Changing Landscape

Students use another entry from the siblings' diary as a launching point to learn that the development of towns and infrastructure influences the natural areas in those communities. After learning how science is applied to help conserve natural resources and the environment, they revisit their hypothetical harvest from the prior lesson.

Lesson 5: Role of the Sierra Railway in Building Three Dams

Students read a passage in the siblings' diary describing the 1906 San Francisco earthquake and fires. They read another passage, written decades later, briefly describing the Sierra Railway's role in

building three dams to serve the water and power needs of human communities. Working in teams, students focus on learning about one of those dams, the Sierra Railway's role in building it, and the influence of the dam's presence on natural systems. Students regroup and share what they have learned with their new teammates.

Lesson 6: Storing Water, Stirring Debate

Students read a passage from the siblings' diary and learn that the construction of a dam in the Hetch Hetchy Valley has been approved. However, the decision is surrounded by controversy. Students learn about the varying perspectives by assuming roles and participating in a dramatic role-play. Following the activity, students read about the modern-day debate regarding whether O'Shaughnessy Dam should be removed and Hetch Hetchy Valley restored. They learn how science informs decisions.

Background

The Sierra Railway of California, a standard gauge shortline traveling from the Sierra Nevada foothills to the Central Valley, had an important role in the region's history. It transported timber, other ecosystem goods, passengers, and materials not only throughout the local region, but also to the rest of the country through its connections with transcontinental railroads.

The Sierra Railway was incorporated on February 1, 1897 to "purchase, construct, maintain, operate and conduct a railroad of standard gauge in the state of California to be operated by steam, electricity or any other motive power, for the carrying of passengers and freight."[1] Four men were at the core of this company: Thomas S. Bullock, a railroad builder who already had completed three railroad projects; Sidney D. Freshman, a skilled business man; Prince André Poniatowski, the president of the California Exploration Company that had purchased many abandoned mines in Amador and Calaveras Counties and saw the advantage of getting low-cost electric power to the mines, and William H. Crocker, a banker who served as one of the financial backers of the new Sierra Railway. When the company was first incorporated, the exact route was not determined, but the men wanted to start in Stanislaus County and head east and northeast to the town of Angels Camp in Calaveras County. Not only would this serve many mines along the route, but it would also reach the Calaveras Big Trees region near to where the Crocker and Poniatowski families had timber holdings.

Originally, Crocker and Poniatowski wanted the line to begin in the Stockton area. Eventually, however, they decided to start the Sierra Railway line at Oakdale. This town was also a depot for the Southern Pacific Railroad, a transcontinental railroad, which resulted in a direct connection between the Sierra Railway and the rest of the country. Grading work began in Oakdale on March 24, 1897.

The first part of the line, a 19-mile stretch from Oakdale to Cooperstown, was completed on June 21, 1897. The second stretch of track was finished by August 12, 1897. Don Pedro, a new town created as a result of the railroad, became the new end of track.

Passenger service between Oakdale and Chinese Camp began on October 5, 1897, and the first freight shipment occurred on October 14, 1897. Jamestown was reached on November 8, 1897. Although the distance between Chinese Camp and Jamestown was only six miles, connecting the two towns by rail required constructing the largest bridge on the line thus far over Woods Creek. The arrival of the train into Jamestown was celebrated on November 10, 1897.

The arrival of the Sierra Railway into Jamestown resulted in immediate development and economic growth in the town. A two-story General Office building attached to the long freight depot was completed in November 1897. By the end of January 1898, the train's turntable was complete and the roundhouse was under

Thomas Bullock
Photo courtesy of Tuolumne County Historical Society

Downtown Jamestown
Photo courtesy of Tuolumne County Historical Society

1 *Minutes of the Board of Directors of the Sierra Railway Company of California, February 1, 1897 (Bancroft Library Collection). As quoted in Connery, "When the Railroad Came to Tuolumne," 1258.*

Hotel Nevills
Photo courtesy of Tuolumne County Historical Society

Sonora Depot
Photo courtesy of Tuolumne County Historical Society

Standard Lumber Company
Photo courtesy of Tuolumne County Historical Society

construction. On April 18, 1898, the Hotel Nevills, the largest hotel in Tuolumne County, had its grand opening. This hotel was meant to serve the Sierra Railway tourists coming into the area from San Francisco and other locales. Thomas Bullock and W.A. Nevills, a wealthy man who was the owner of a nearby quartz mine, formed a partnership to build the hotel. The Sierra Railway passenger offices were strategically located in the lobby of Hotel Nevills.

Bullock had made an agreement with Nevills to not extend the line beyond Jamestown for five years, thus ensuring the economic development of the town and additional wealth for Nevills and his hotel. However, with its terminus in Jamestown, the railroad still was not meeting the needs of area mines nor addressing the plans of Poniatowski, Crocker, and Bullock to develop the timber industry. Bullock reneged on his agreement with Nevills and began working to extend the line.

Where to go next and how to get there was not immediately obvious. The desire to extend the line to Angels Camp was strong, but the terrain was arduous. The railway's original engineer quit, saying that track could not be laid to the mining town.

At the same time, a decision had to be made. Other companies were poised to come in and take a share of the business. The Stockton and Tuolumne Railroad, dubbed the Women's Railroad because its president was female, was threatening to push its way towards the foothills in Tuolumne County. The owners of the Sierra Railway did not want to risk another rail company taking its customers. In addition, they had timber interests in the foothills of the Sierras and wanted to transport their freight using their own company.

In the town of Columbia, north of Sonora, marble, a highly desirable building material for locations such as the Bay Area, was being extracted from quarries. Poniatowski, Bullock, and two other Sierra Railway directors leased Columbia Marble Works, hoping that their investment would bring additional wealth. Transport of the marble would only be possible if their line to Sonora was completed.

In July 1898, William H. Newell was hired as Sierra Railway's Engineer in Charge of Location and Surveys. In the end, it was determined that the best option was to extend the line to Sonora, and then onto Carters/Summersville. This would allow access to the men's timber interests, as well as the transport of marble, quarried by Columbia Marble Works.

In early September 1898, work began on the line from Jamestown towards Carters/Summersville. William H. Newell, now the Chief Engineer of the Sierra Railway, worked on the new track. On February 26, 1899, the Sierra Railway arrived in Sonora. The first floor of the depot was sheathed with white Columbia marble and the second story was built with Tuolumne County wood, showcasing the natural resources—holdings of the directors of the Sierra Railway—the train would transport. As the Sierra Railway expanded, many of its directors acquired other businesses in the area. Soon after the line reached Sonora, the Sierra Railway owners purchased a mill site for their timber, and in May 1899, they incorporated the West Side Flume and Lumber Company. Bullock built a depot for the Sierra Railway near the site of their lumber company, knowing that the Sierra Railway would continue on to Carters/Summersville, which it reached on February 1, 1900. Later that same year, the West Side Flume and Lumber Company incorporated the Hetch Hetchy and Yosemite Valley Railroad that used a narrow gauge track to transport timber. Several Sierra Railway directors also had a hand in incorporating the Standard Lumber Company. With the railway now in service between the foothills and valley, there were profits to be made in the timber industry. There were also profits to be made in the tourism industry. In November 1901, Bullock opened Turnback Inn, in Tuolumne, hoping to host tourists traveling to Yosemite.

Work started on the Angels Camp line in August 1899, but many challenges arose. The first train traveled into Angels Camp on September 15, 1902. The Sierra Railway built four open-air excursion cars that traveled between Jamestown and Angels, carrying tourists on a remarkably scenic 19-mile route that included switchbacks and views from Gee Whiz Point down into a river canyon. Passengers traveled in these open-air cars between Tuolumne and Calaveras counties for special events such as dances, baseball games, and holiday celebrations.

Although the train did not reduce the transport cost of all freight, it did so for some. It also allowed for efficient transport of low-grade ores to the Selby smelter at Carquinez Straits on the San Francisco Bay in Contra Costa County. Several years later, the Sierra Railway was ordered to change its pricing structure because the California Railroad Commission found that it was favorably pricing its own goods (timber) while overcharging for other goods.

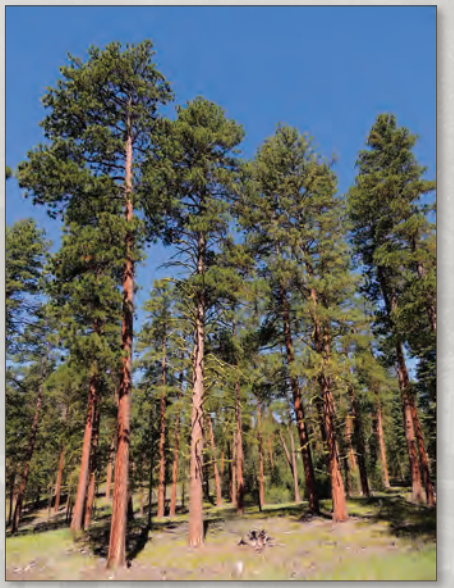
Through its connection to the transcontinental railroad network in Oakdale, the Sierra Railway played an integral role transporting goods from Tuolumne, Calaveras, and eastern Stanislaus counties throughout the country. The Southern Pacific Railroad and the Atchison, Topeka and Santa Fe Railway (Santa Fe Railway) had branch lines with stations in Oakdale. From there, the Southern Pacific traveled to Stockton, where it connected to San Francisco, Los Angeles, Portland, Ogden, and New Orleans, among other cities. The Santa Fe Railway ran from the Bay Area through the San Joaquin Valley. It continued on to Los Angeles and San Diego, before heading east to Arizona, New Mexico, Chicago, and Texas.

In the 1920s the Sierra Railway received an infusion of income due to its involvement in the construction of three dams. As the population in the area increased, and with it, the need for water for irrigation, agriculture, and city services, dams were constructed. After the Hetch Hetchy Railroad was built in 1916, the Sierra Railway transported construction equipment and materials to Hetch Hetchy Junction where the freight was transferred to the Hetch Hetchy Railroad. The freight then traveled to Hetch Hetchy Valley in Yosemite National Park where O'Shaughnessy Dam was being constructed. The dam would capture and store Tuolumne River water in the Hetch Hetchy Reservoir. The project was completed in 1923 with the support of the Sierra Railway. In 1921, an eight-mile spur was built by the Sierra Railway to serve the construction needs of Don Pedro Dam, which was completed in 1924. And in 1925, a seven-mile Sierra Railway spur was built to serve the Melones Dam site on the Stanislaus River. All three dams were also used to create hydropower. From May 1935 through 1938, the Sierra Railway was contracted to operate the Hetch Hetchy Railroad and transport materials needed to increase the height of O'Shaughnessy Dam to meet the increasing needs of the growing population in the Bay Area.

Old Don Pedro Dam
Photo courtesy of CA-A-0014, WaterArchives.org

O'Shaughnessy Dam
Photo courtesy of the San Francisco Public Utilities Commission

Throughout its life, the Sierra Railway was tied to the transport of goods produced in Calaveras, Stanislaus, and Tuolumne counties: gold, limestone and other minerals; marble and other cut stone; livestock, wheat, fruit and other agricultural products; and most especially lumber. The train itself was fueled by natural resources: first coal, then oil. The rise of the railway was followed by the economic and population growth of towns along its route. Townspeople could efficiently transport their freight across the foothills and valley or across the country. Today, the Sierra Railway's history is preserved by California State Parks at Railtown 1897 State Historic Park, as well as in many movies and television shows that feature the beautiful locomotives and boxcars of the historic Sierra Railway.



Ponderosa Pine Forest
Photo courtesy Christopher Christie

Mine Infrastructure
Photo Sebastien-Coell, iStock

Forestry and Science Ideas

Logging and harvesting practices have changed over time as the field of forestry science has developed and been applied to the industry to protect the Earth's environment and resources.

The history of logging in California reflects the state's changing population levels. Prior to the 1840s, American Indians comprised the dominant population in the foothills and valleys of the Sierra Nevada range. Settlers from the East did extract some of the trees in the foothills, but their impact was minimal. Spaniards and Mexicans did not venture into the rugged mountain range. The small population's demand for timber was relatively low. The composition of the Sierra Nevada forest included scattered large, old-growth coniferous trees, herbaceous plants and shrubs in the undergrowth, and some smaller deciduous trees that grew where the sun reached the forest floor. The smaller trees and undergrowth were thinned by mostly natural, although sometimes human-caused, small, frequent fires (on average every two to 15 years).[2]

The discovery of gold at Sutter's Mill near Coloma changed the course of history in California. Demand for timber rose dramatically as Euro-American settlers immigrated to the region beginning in 1848. With the ensuing Gold Rush and rise in population, which by 1852 had risen to 225,000[3], the geographic extent, composition, biological diversity, and viability of natural systems began to be affected. Land was cleared for grazing and for development of mines. Timber demand increased rapidly. Wood was used to construct homes and other buildings, and reinforce the mine infrastructure both above and below ground. Steam engines used in mine work required cordwood for burning. Steam locomotives also burned wood in their engines. Wooden flumes were built to transport water for use in mining towns and in hydraulic mining. All these wooden structures were vulnerable to fire. Fires frequently destroyed towns, forests, and mines since water was limited and advanced firefighting technology was not available. The communities and mines were then rebuilt using newly harvested wood.

In the late 1850s, silver ore was discovered in the Eastern Sierras. Immigrants quickly settled in Nevada, increasing the demand for timber from this mountain range. Across California between 1855 and 1860, the number of lumber mills increased from 80 to 320.[4]

Between 1860 and 1890, the mining, transportation, and timber industries continued to expand. During the year 1862, 167 steam sawmills and 162 water power mills cut 166,000,000 board feet (12 in. x 12 in. by 1 in.) of lumber and 28,000,000 shingles.[5] Many mines had their own sawmills to cut the timber they needed for construction and maintenance of their mine infrastructure. Railroad expansion also required lumber since rails and ties were crafted out of wood. Wood also appeared in sawmills, lumberyards, machines, tools, and other infrastructure in the timber industry. Lumber companies purchased forestland and harvested it using the manual tools and steam machines they had at their disposal.

Harvesting practices were wasteful. Clearcutting, in which all trees in an area are harvested, was common practice. Mature, valuable trees, such as ponderosa and sugar pines, were targeted for clearcutting. This changed the species composition of the old growth forest, which became dominated by trees adapted to grow in the shade of the underbrush such as white fir and cedar.[6] The wildlife community that lived in the ponderosa and sugar pine old growth forest no longer had suitable habitat as a result of the extent of the clearcuts. When trees were felled, they frequently hit other trees on the way down, damaging live trees and sometimes

2 Fregulia, Images of America: Logging in the Central Sierra, 28.
3 Clar, California Government and Forestry, 63.
4 Fregulia, Images of America: Logging in the Central Sierra, 23.
5 Clar, California Government and Forestry, 64.
6 Mount and Purdy, Confluence: A Natural and Human History of the Tuolumne River Watershed, 145.

rendering them unusable as timber. Slash, or waste from harvesting, such as tree crowns, tree limbs, and bits of wood, were left on the forest floor, increasing fire danger and making natural regeneration more difficult.

Starting in the 1860s, conservation measures were put into place. In 1864, President Lincoln approved a congressional act that put into public ownership and granted to the State of California the Mariposa Big Trees Grove and Yosemite Valley. On April 2, 1866, Frederick Low, the Governor of California, signed a law showing agreement with the congressional act, making Yosemite Valley the first state park in the United States.[7] Although Yosemite Valley was to receive protection, controversy surrounded the park and in 1906, the area was returned to the Federal Government.[8]

The population of California had surged to 600,000 by the early 1870s.[9] By 1872, 205 steam sawmills and 123 water power sawmills were cutting 265,000,000 feet of lumber and 191,000,000 shingles annually.[10] Also in 1872, California Governor Newton Booth did not take action on a bill to create a California State Forester and Board of Forestry. The bill had been created to begin to address some of the natural resource issues that conservation-minded individuals recognized.

In 1881 in California, a resolution passed both houses and was filed in March that read:

> *Whereas, the forests of this State are being rapidly destroyed by reckless and wasteful cutting; by the neglect to use any means of replacing the trees cut down; by the ravages of goats and sheep, preventing the growth of young saplings and brush . . . the direct effect of such destruction is to bring about the speedy extinction of many species of trees most valuable for timber . . . now therefore be it resolved that the officials and representatives of the State of California are hereby requested to do their utmost to endeavor to obtain legislation by Congress which will check such destruction of the forests and remove the causes thereof so far as may be practicable . . . the State of California shall cooperate with the General Government in taking such steps as shall lead to the preservation of forests and to the extension of the areas of distribution of more valuable species.*[11]

On February 6, 1883, Assemblyman James V. Coleman introduced a resolution that was passed by both houses and honored by Governor George Stoneman. It suggested creating a commission to develop a plan for the preservation of forests on the shore of Lake Tahoe (then called Lake Bigler). The resolution made the State responsible for preserving "the most noted, attractive, and available features of its natural scenery . . . for the health, pleasure and recreation of its citizens and tourists."[12] The resolution passed and commissioners were appointed. This commission was the progenitor of the California State Board of Forestry. Its final report concluded that a permanent State Forestry Commission should be created that would be involved in: "preventing the unlawful cutting of timber, encouraging the replanting of denuded land" and "determining the best method of planting, caring for and treatment of timber trees."[13] In 1885, a resolution to make Lake Tahoe a state park failed. However, the stage had been set for a statewide commission dedicated to California's forests.

Clearcut Hills behind a Logging Camp
Photo courtesy of the California History Room, California State Library, Sacramento, California

In March of 1885, the California State Forest Commission and State Board of Forestry were created.[14] There were to be three people appointed by the government to serve a four-year term, a secretary hired, and printed biennial reports issued.[15] Although

7 *Clar, California Government and Forestry, 69.*
8 *Clar, California Government and Forestry, 70.*
9 *Clar, California Government and Forestry, 74.*
10 *Clar, California Government and Forestry, 75.*
11 *Clar, California Government and Forestry, 83.*
12 *Clar, California Government and Forestry, 87–88.*
13 *Clar, California Government and Forestry, 89.*
14 *Clar, California Government and Forestry, 95.*
15 *Clar, California Government and Forestry, 96.*

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California State Board of Forestry. *Fourth Biennial Report of the State Forester of the State of California.* Sacramento: State Office, 1912. https://books.google.com/books?id=ONgPAQAAIAAJ

California State Board of Forestry. *Second Biennial Report of the California State Board of Forestry, for the Years 1887–88,* to Governor R. W. Waterman. Sacramento: State Office, 1888. https://books.google.com/books?id=35w_AQAAMAAJ.

at the time there were no trained foresters in the United States, the commissioners assessed the forests and created a forest map of California. Their duties included enforcing state and national forestry laws, although three people managing the forestry resources in the state of California was limiting. For instance, there were issues with public land being sold for $1.25 per acre, timber on it being cut (and eventually sold) by the new owner, and then the owner defaulting prior to completing payment.[16]

1n 1886, the *First Biennial Report of the California State Board of Forestry* was published. The report includes a letter circulated to the citizens of California, and directed towards farmers and irrigators, that emphasized the importance of forests because of the role they play in mitigating floods, allowing permeation of water into soil, and as wind breaks. The Secretary of the Board wrote that the forests' "thousand and one benefits that the animal and vegetable kingdom must be thankful for,"[17] as well as trees' effects on decreasing erosion, and others "[had] been . . . conclusively proven by the greatest scientists of the day."[18] The first Biennial Report also included a summary from a hired engineer who examined the Northern forests. In his report he included details about soil types, charts of the types of trees found at specific elevations, losses by forest fires, food crops, grazing, and more. He wrote, "the present line of timber fit for sawing is now twelve to fifteen miles east of its original location,"[19] indicating the change in the geographic extent of the resource. Removal of trees was occurring not only through logging, but also through extensive cattle and sheep grazing. Stock men would burn the forest so their animals could graze. But at the same time, there was growing awareness for the need to conserve California's resources and how to do that scientifically. The report includes the text of the Arbor Day Bill that was to be presented at the 1887 session of the legislature. It called for "the last Saturday of each month of January [to] be devoted to the planting of trees."[20] In a section titled "Forest Trees for Profit," Milton Thomas, Esq., reported on his personal experience with growing trees. He wrote, "I have noticed that trees planted at a reasonable distance are always larger than those very near together. I believe that it has been demonstrated beyond a question that almost all kinds of trees or vines pay better planted at some distance from each other than where they are too near."[21] The board reported that at their suggestion the University of Southern California at Los Angeles inaugurated a School of Forestry where forestry would be taught.[22] The science of forestry was just beginning to be developed formally.

The *Second Biennial Report of the California State Board of Forestry for the Years 1887 to 1888* was presented to Governor R. W. Waterman in 1888. The report began with the Forestry board members lamenting, "whenever the lumbermen did not own the lands over which they were cutting . . . everything in sight at all available was cut, and the waste left so that the fires sure to follow would, with so much material, destroy all seedlings and young trees remaining. No one thought of a scientific forest management, with a view to permanently maintaining our mountain forest lands for forest purposes."[23] However, as a result of the formation of the Board of Forestry, its activity, and the enforcement of laws, illegal activity was greatly reduced and almost all cutting was happening on private, rather than public, land. As a result, the lumbermen were taking better care and "in many cases looking to a permanent forest crop."[24] The Board was aware that mountain forests hosted the headwaters of vital water sources and recommended that legislation be enacted to preserve the water supply, which would in turn preserve the California's food-producing valleys. The men concluded their introduction to the report by recommending that "it be forbidden to all . . . to cut timber or wood from the public lands for any purpose whatever without a permit from the State or National Forest Officers."[25] Their intent was to create a "permanent preservation as a forest reserve for the protection of the watersheds

16 *Clar, California Government and Forestry, 103.*
17 *California State Board of Forestry, First Biennial Report 1885–86, 12.*
18 *California State Board of Forestry, First Biennial Report 1885–86, 12.*
19 *California State Board of Forestry, First Biennial Report 1885–86, 42.*
20 *California State Board of Forestry, First Biennial Report 1885–86, 223.*
21 *California State Board of Forestry, First Biennial Report 1885–86, 55.*
22 *California State Board of Forestry, First Biennial Report 1885–86, 7.*
23 *California State Board of Forestry, Second Biennial Report 1887–88, 5.*
24 *California State Board of Forestry, Second Biennial Report 1887–88, 6.*
25 *California State Board of Forestry, Second Biennial Report 1887–88, 11.*

of the State."[26] Their concern about protecting the mountain forests to protect watersheds demonstrates that they were aware of the dependence of the human community on the long-term functioning and health of these ecosystems.

The Sierra Nevada forests were commercially valuable. J. G. Lemmon, the botanist commissioned by the California State Board of Forestry, reported that the Sierra Nevada was the "headquarters of the largest and most abundant trees known, including most of our lumber-producing pines as well as most of the lumber trees of other families."[27]

The Forestry Board members reported in the *Third Biennial Report of the California State Board of Forestry for the Years 1889 to 1890* that "increased attention has been given to the forest fire service and development of resources looking to the permanency of present and rehabilitation of depleted forest areas."[28] The report stated the need for implementation of something like New York's Fire Warden program, but lamented that California was so large the cost would require significant taxation. Lemmon wrote that not only were seedlings and saplings destroyed by fire in an area, but also the "mold and other organic elements from the soil."[29] Lumbermen continued to improve their technique, and according to the report, "in some districts waste [in tree felling] of any kind is reduced almost to a minimum."[30] Reforestation of state lands was not underway yet because of the threat of fire as well as foraging by sheep. Experimental stations had been established, one in Chico and one in Santa Monica, to test the growth of various native and non-native species of trees and to provide seeds and young trees to various locations. The intention was to build a database of scientific information that could be used in future reforestation of denuded lands. Another experiment described in the report was planting the same species of trees in three different types of conditions.

In the *Fourth Biennial Report of the California State Board of Forestry for the Years 1891 to 1892* the Board members reported that the "President, through the Secretary of the Interior, has withdrawn from entry and sale large tracts of timber land in the Sierra Nevadas, and established several reservations and national parks."[31] In 1890, the Sequoia and Yosemite National Reserves were created by federal law.[32] The Board reported that cavalry had patrolled the park, grazing animals had been kept out of the boundaries, and fires had been prevented or extinguished, all resulting in an improvement in the health of the forests. Citizens of California had noticed the success and were asking for the reservation system to be expanded. In 1891, the Forest Reserve Act was cleared by the two houses and approved by President Harrison;[33] the law allowed the President to set aside forest land in the public domain. The text of the Paddock Bill, included in the report, stated that the purpose of reservations was to "secure 'favorable conditions of water flow and continuous supplies of timber' by protecting and improving the forests with the reservations."[34] The bill did not specifically exclude activities such as prospecting, hunting, fishing, and provided for cutting of timber under a system of licenses.

During the reporting time in 1892, the Sierra Club was formed, with John Muir as its President. He had first come to the Sierra Nevadas as a sheepherder and quickly realized the damage they did to the environment. The purposes of the Sierra Club, according to its articles of incorporation, are "to explore, enjoy, and render accessible the mountainous regions of the Pacific Coast; to publish authentic information concerning them; [and] to enlist the support and cooperation of the people and of the government in preserving the forests and other natural features of the Sierra Nevada Mountains."[35] John Muir and the Sierra Club would become key players in the fight against the Hetch Hetchy Project in Yosemite National Park.

26 California State Board of Forestry, Second Biennial Report 1887–88, 10.
27 California State Board of Forestry, Second Biennial Report 1887–88, 59.
28 California State Board of Forestry, Third Biennial Report 1889–90, 3.
29 California State Board of Forestry, Third Biennial Report 1889–90, 195.
30 California State Board of Forestry, Third Biennial Report 1889–90, 5.
31 California State Board of Forestry, Fourth Biennial Report 1891–92, 6.
32 Clar, California Government and Forestry, 142.
33 Clar, California Government and Forestry, 144.
34 California State Board of Forestry, Fourth Biennial Report 1891–92, 8.
35 Sierra Club, "Articles of Incorporation, Original Version June 4, 1892."

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National Park Service. "Organic Act of 1916." Accessed May 27, 2016. https://www.nps.gov/grba/learn/management/organic-act-of-1916.htm.

With the intention to educate about forestry science, the Board included an article, entitled "What is Forestry?" by B. E. Fernow, the third chief of the USDA's Division of the Forestry of the United States (1886 to 1898), containing the basic principles of forestry science. Fernow addressed the ecosystem goods derived from the forest, such as wood products used in construction, tanning materials, and maple sugar. He also addressed ecosystem services produced by forests, such as fostering soil suitable for growing food, preventing soil erosion, slowing down water, and regulating temperature by breaking the force of winds. Since humans had already been interfering with the natural system, then humans needed to implement scientific forest management to "reproduce certain useful materials… [and] to sustain or possibly improve certain advantageous natural conditions."[36] He wrote that forest management involved "avoiding unnecessary waste, in protecting against fire, in keeping out cattle where young growth is to be fostered, and in not preventing by malpractice the natural reforestation."[37] Reproduction could happen by replanting an area that had been cut, allowing stump sprouting from cut trees (although not all species will sprout from their stumps), and leaving some living trees, called seed trees, in a cut area so they could reseed. The latter could be accomplished by leaving seed trees scattered throughout a cut, or harvesting in strips with seed trees in adjacent strips. Fernow discussed the practice of thinning for the first ten to fifteen years to promote the growth of the best specimens in an area. He wrote the removal of undesirable trees gives "the remainder an opportunity to develop more quickly and with the least hinderance [sic] to desirable form and size."[38] He discussed the importance of maintaining appropriate light and soil requirements to produce good timber, which is the goal of forest management. Different species need different amounts of light and shade, and depending on the soil quality, the same species may need more or less light to grow better. Later in the article he specified how many square feet of growing area trees of various ages should be given, and how many trees per acre should be grown depending on their age. These numbers allowed for the "best result, not the greatest number."[39] He went on to write about the prevalence of mixed growth forest and that "there are various advantages resulting from this arrangement, and he [the forester] fosters the mixed growth, although the management of a mixed forest presents more difficulties and requires more knowledge and judgment than the forest formed of a single species."[40] Fernow recommended "that neither less nor more wood be cut than grows annually, so that there is a continuous production of about the same amount forever."[41] He admitted that this is a difficult calculation that requires extensive information about forest conditions and tree growth. He suggested that if the trees in a pine forest were to be cut when they reach 100 years old, but trees needed to be cut every year, then the forest should be populated with, for instance, "one hundred acres of pine, each acre differing in age by one year"[42] from one year old to 100 years old.

A series of Forest Reserves were created in California. In 1892, the San Gabriel Forest Reserve, containing 550,000 acres, was created. In 1893, the Sierra Forest Reserve, containing four million acres in the southern half of the Sierra Nevada, was formed, along with the San Bernardino and Trabuco Reserves, which included an additional 800,000 acres.[43] At the time of their creation, no forest management plan was in place, but the land in the reserve was withheld from private use.

In 1893, California Governor Markham recommended to the legislature the dissolution of the State Board of Forestry. He felt that the duties of the Board, which included dealing with fires in the state, could be distributed to other agencies, so there was no need for the Board. He recommended that the experimental

36 *California State Board of Forestry, Fourth Biennial Report 1891–92, 64.*
37 *California State Board of Forestry, Fourth Biennial Report 1891–92, 68.*
38 *California State Board of Forestry, Fourth Biennial Report 1891–92, 71.*
39 *California State Board of Forestry, Fourth Biennial Report 1891–92, 73.*
40 *California State Board of Forestry, Fourth Biennial Report 1891–92, 72.*
41 *California State Board of Forestry, Fourth Biennial Report 1891–92, 78.*
42 *California State Board of Forestry, Fourth Biennial Report 1891–92, 79.*
43 *Clar, California Government and Forestry, 144.*

stations be placed under care of the State Board of Agriculture or State University, and other tasks under the Fish Commission.[44] A series of bills were introduced recommending reorganization of the Forestry Commission, or distribution of their duties to other Boards. The Langford Bill was passed in 1893, which put an end to the Board of Forestry.

In 1897, President Cleveland signed a law that made setting fire to an area in the public domain a misdemeanor that could be accompanied by a significant fine or time in prison. In addition, President McKinley signed the Forest Service Organic Administration Act of 1897 that defined the administration and oversight of the reserves. The management and protection of the reserves was placed under the Department of the Interior. The Division of Forestry and Agriculture would provide technical advice, and the Geological Survey was responsible for surveying and mapping the reserves.[45]

In California, regional citizens groups formed and convened to support forestry and water concerns. Southern California formed the Water Association of Los Angeles, which focused on forests as well as water storage and watershed conservation. The California Water and Forest Association formed in Northern California. This group also intended to preserve forests, reforest denuded land, and improve the storage and transportation of water by soliciting funds and working with state and federal government. Meanwhile, Gifford Pinchot, the new Chief of the Division of Forestry in the U.S. Department of Agriculture, was busy initiating forest surveys of the United States.

In 1899, the reserve status of the forests in California backslid temporarily when the livestock industry was given permission by the Department of Interior to graze sheep, cattle, and horses on the Stanislaus, Mariposa and Sequoia Forest Reserves, created just two years prior.

In 1901, Theodore Roosevelt, an ardent conservationist, became the 26th President of the United States. The reserves of California had not yet been made permanent, and groups in California tried to have the lands' reserve status revoked because they felt that it was economically harmful to miners and other private interest groups. In December 1903, President Roosevelt created the 1,838,323-acre Santa Barbara Forest Reserve. He would go on to create his legacy as a conservationist president by establishing multiple national monuments and 21 national forests in California, and providing federal protection for almost 230 million acres of land in the United States.

California Governor George Pardee started his term in 1903. A strong supporter of stream and forest protection, he was concerned about the destructive force of fire in California. In 1903, he signed into law a bill that focused on water distribution and storage as well as forest surveying, conservation and establishment of a forestry policy. Pinchot's Bureau of Forestry became the U.S. Forest Service within the Department of Agriculture in 1905. The forest reserves became the responsibility of the Forest Service at this time. For the next few years the federal and state government worked to survey the water and forest situation in California. They conducted investigations and applied results to practice, for instance, regulating grazing in the forest reserves.

In 1905, laws passed in California that supported fire protection (leading to a century of fire suppression), extended the surveys being conducted on forest and water resources in the state, dedicated funding to the preservation and protection of forests, and receded the Yosemite Valley to the Federal Government. In that same year, the state government passed what came to be known as the Forest Protection Act (or the Act of March 18, 1905) that provided for the regulation of fires and re-established a state board of forestry with a technically trained forester functioning as the state forester. This was the first time someone with a scientific background in forestry had oversight of California's forests. The law also specified that lumber companies, when instructed by the state board of forestry, were to "carefully burn their slashings, by which is meant the tops, limbs, and general debris left after lumbering."[46]

44 Clar, California Government and Forestry, 153.
45 Clar, California Government and Forestry, 165.
46 Clar, California Government and Forestry, 229.

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In 1907, the reserves were designated as National Forests. They were under the jurisdiction of Gifford Pinchot who was at the helm of the U.S. Forest Service within the U.S. Department of Agriculture. The National Forests were used in multiple ways, including logging, grazing, mining, recreation, wildlife habitat, and hunting.

In 1916, the National Park Service (NPS) was created within the Department of the Interior. The National Parks and Monuments natural areas were to be conserved for enjoyment by future generations. At this time, NPS took over the administration of Yosemite National Park, leading to park improvements and increased tourism. Despite John Muir and Sierra Club's efforts, along with citizens all over the country, the Hetch Hetchy Valley, within Yosemite National Park, was unable to be preserved and the San Francisco built O'Shaughnessy Dam to provide water and power for the city.

Over the next several decades, the demand for wood ebbed and flowed. The Great Depression and two World Wars affected economic development here in the United States as well as abroad. After World War II, the demand for timber increased again, and clearcutting became a common harvest practice. In the 1950s and 1960s, the Forest Service added significantly to the miles of roads reaching deep into Northern California's National Forests. With such roads came increased presence of invasive plant species, wildlife mortality, habitat fragmentation, and migratory pathway fragmentation.[47] Driven by the logging industry and a robust economy, heavy logging continued in Tuolumne County through the 1980s.

Today the species composition within forests in the Sierra Nevada is different than it was in the 1800s prior to the logging boom. No longer dominated by old-growth conifers, forests are now comprised of younger trees, often of just a few species, growing close together and surrounded by brush. The result of harvesting and fire suppression practices, these conditions add to the stress brought about by years of drought, bark beetle infestations, and increased fire activity. The science of forestry continues to develop and inform decisions about how we manage and conserve forests and forest resources.

47 Mount and Purdy, Confluence: A Natural and Human History of the Tuolumne River Watershed, 147.

Unit Assessment — Traditional

Advanced Preparation Time

15 minutes

Materials

- Pencil (one per student)
- Unit assessment handout (one per student)
  See Appendix for reproducible handouts

Part 1. Choose the best answer (2 points each)

1. Throughout its history, the Sierra Railway was involved in transporting

   a. lumber

   b. materials for dam construction

   c. people

   d. *all of the above (answer)*

2. A balloon full of air will have _____ weight than the same balloon when it is empty.

   a. *more (answer)*

   b. less

   c. the same

3. Which of these tree harvesting options is most likely to result in a forest that will continue producing lumber long-term?

   a. clearcut

   b. *selective cut with seed trees (answer)*

   c. clearcut then plant many trees very close together

   d. selective cut then allow fires to burn the forest every few weeks

4. Calculating the number of board feet in a tree usually requires knowing the DBH of the tree. What does DBH stand for?

   a. draw a boundary height

   b. data at beaver height

   c. *diameter at breast height (answer)*

   c. diagonal of board height

5. Matter is:

   a. solid or liquid, but not gas, that has mass and takes up space

   b. large, visible particles that have mass and take up space

   c. *a physical substance that has mass and takes up space (answer)*

   d. weight that is not conserved when it is heated, cooled, or mixed

6. 72 inches is the same as

   a. 7.2 feet

   b. *6 feet (answer)*

   c. 2 feet

   d. 864 feet

Part 2. Answer each question with a sentence or short paragraph (5 points each)

7. Describe how forests can be used by people as ecosystem goods.

(answers will vary, but may include: Many trees together make a forest. Wood comes from trees. People have used wood to make houses, buildings, and machines. An ecosystem good is a material produced by natural systems that is used by humans. Since humans use the timber that comes from trees, forests can be ecosystem goods.)

8. Imagine that you could put a steam locomotive engine into a container that would allow you to weigh all the matter going into the system, and all the matter coming out of the system. What do you know would be true about the weights of the matter going in and coming out? How do you know this?

(answers will vary, but may include: The weight of the matter going into the system will be the same as the weight of the matter coming

Resources for Teachers

Boffobob. "Logging (revised version): Images of early 1900s logging." Video, 6:27. June 10, 2007. https://youtu.be/g01lYwJH1h4. ***Note — no sound needed.***

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out of the system. Even though the matter is heated, cooled, and mixed in the engine, its weight is conserved. I know this because we weighed different materials after mixing them or changing them chemically. The weight was the same before and after. Matter may change into a different form, but it does not disappear.)

Part 3. Follow the directions in the question below (10 points)

9. Describe positive and negative aspects of dam building on human and natural communities.

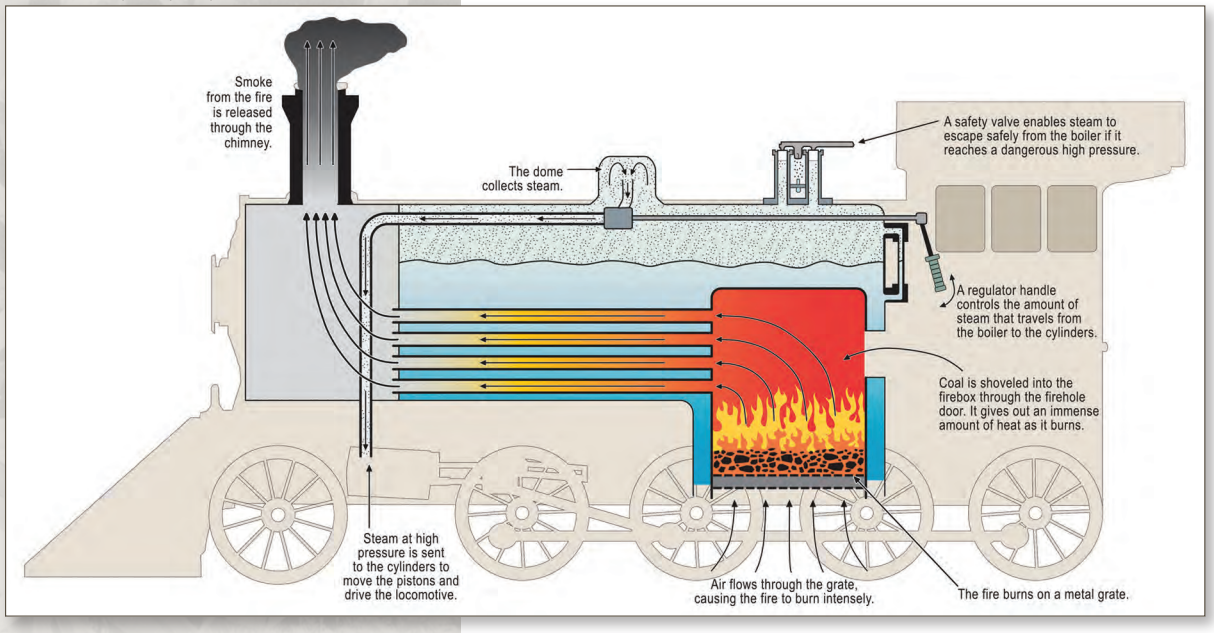
Positive:

(answers will vary, but may include: people get a constant source of water, people get a constant source of energy, water can be stored for when it is needed, a lake is formed behind the dam that can be habitat for some plants and animals, downstream floods are less likely)

Negative:

(answers will vary, but may include: human communities behind a dam will be flooded so people have to move and lose their property, animals and plants living in the valley may not be able to live there when it is a lake, animals and plants living downstream from a dam have less water in the river)

Illustration by Amy Hay



10. Imagine the place where you live. What do you think it looked like 200 years ago (the early 1800s)? Compare that image to what it looks like now. Describe the natural environment and the human community before and after.

200 years ago:

(answers will vary, but regardless, with them, students should demonstrate their knowledge of how human communities affect the biological composition and geographical extent of the natural area. Their answer could include: Two hundred years ago this area probably had many different plants and wild animals. Many trees grew naturally in the hills. Sometimes natural fires would burn the area. Many birds lived in the trees. Wild animals, like coyotes, mountain lions, and bears, lived in the forests. Rivers and streams may have flowed through the area. Very few people lived here. They had small houses made of wood amongst the big trees.)

Today:

(answers will vary, but may include: Today there are many houses and other buildings in our town. Paved streets and sidewalks connect all the blocks. Plants and animals still occur in town, but not naturally. Fewer trees grow on the hills. We have a little stream that goes through the town. The large rivers are dammed.)

11. Below is a diagram of a steam locomotive engine. Use small circles and arrows to show how matter (in this case, mostly gas) moves through the engine and eventually results in the trains' wheels turning.

In the lines below, describe how you know that matter is made of particles too small to be seen. You can use evidence from the hands-on activities you did in class.

(diagram — answers will vary)

(answers will vary and may include: Matter has mass and takes up space. I can see solids and liquids, but I can't see the particles that

make them up. I know there are tiny particles in matter because of experiments we did with gases. We can't see the air (gas) around us, but we know it is matter. When I blow up a balloon with air, and weigh it, it weighs more than a flat balloon. It also takes up more space. So I know the air is matter, even though I can't see it. I can see water and I can see salt. When I mix them together, it seems that some of the salt disappears. But I know it is still there because the weight of water and salt separate is equal to the weight of the water and salt mixed. That means that the salt is made up of tiny particles I can't see. When it's mixed with water, the grains of salt are broken into these tiny particles.)

12. If you could have voted on whether or not to build O'Shaughnessy Dam, would you have voted for or against it? Why? Include science ideas to support your decision.

(answers will vary, but should include science ideas to support their decision)

(Example answer:

I would have voted in favor of building O'Shaughnessy Dam. People in San Francisco and the Bay Area needed a reliable, consistent source of water. They needed water to drink. They also needed to use it in their homes, businesses, and to fight fires. Fires were very dangerous and often burned out of control. The lake that formed behind the dam could serve as habitat for many plants and animals. The people could move some animals and plants whose habitat would be flooded to different areas to keep them safe.

Example answer:

I would have voted against the building of O'Shaughnessy Dam. People in San Francisco and the Bay Area could get their water from somewhere else. They could fight fires with water from the ocean. Plants and animals living around the dam would lose their habitat. The beauty of the Hetch Hetchy Valley needed to be preserved. It produced ecosystem goods and services people needed. Once a natural area is developed, it cannot return to its original state.)

Part 4. Follow the directions in the question below (20 points)

13. Write one paragraph with at least ten sentences summarizing the ways individual communities use science ideas to protect the Earth's resources and environment. You can use multiple examples you learned in this unit.

(Individual communities use science ideas to protect the Earth's resources and environment. For example, tree harvests changed over time as science ideas were applied. When people first started cutting trees, they cut all of the trees in an area. This would leave an area without trees. Loggers would also leave the slash, the branches and broken tree pieces, on the forest floor. Fires would start and burn up the slash. The fires would grow out of control and damage forests and even reach surrounding towns. Some people realized we would run out of trees if these practices continued. Foresters learned that slash had to be burned safely. They also learned that living trees release seeds and regenerate forests. Or, the forest needed to be replanted by people. They learned that forests could be thinned so the healthy trees could grow bigger. Foresters could protect wildlife by leaving snags. They could also harvest smaller areas. These science ideas helped protect forests.)

Second example:

(Individual communities use science ideas to protect the Earth's resources and environment. For example, dams have changed over time. When dams were built a hundred years ago, they were built without protection for wildlife. Now dams can be built with fish ladders. Dams can also release cold water to support fish and wildlife downstream. Some dams have even been removed over time. Science studies show us that some dams are more harmful than beneficial. Now we know that damming a river is more than just water or beauty. The dam changes the surrounding environment. It creates a lake where there wasn't one. Animals and plants that lived there before may not be able to live there anymore. Downstream of the dam, the flow of water changes. Knowing all of this can help us make better decisions.)

14. Pretend you are a forester using science ideas to plan a harvest that would result in the forest being able to continue to produce timber for hundreds of years and at the same time provide habitat for wildlife. Draw your ideal harvested forest, label the parts, and describe why each part is necessary. Also describe what data you would collect.

(answers will vary but should include essential science ideas such as: leaving snags to provide wildlife habitat, leaving seed trees within the harvested area (selective cutting) or on the border of a small clearcut area, using harvest tools and techniques that cause the least soil compaction and damage to the forest floor. Data collection may include: number of trees removed per harvest, growth rate of new trees (natural reproduction or planting), presence/absence of wildlife species, numbers of specific wildlife species, presence/absence of plant species other than timber trees, location of nearest water source.)

Unit Assessment — Alternative — Applying Science Ideas to Earth's Environment Brochure

Students choose an environmental issue in their community and take a stand on the issue. They create a brochure describing the issue, their perspectives, others perspectives, and science ideas that can be applied to the issue.

Advanced Preparation Time

15 minutes

Assessment Time

One in-class session of 60 minutes

Additional out-of-class time as determined by teacher

One in-class session of 90 minutes

Materials

Handout: Applying Science Ideas to Earth's Environment Brochure Instructions (one per student)

Handout: Applying Science Ideas to Earth's Environment Brochure Sharing (one per student) *See Appendix for reproducible handouts*

Pencil (one per student)

Research materials: Internet, library

If students have access to computers and have the skills to create their brochure on the computer, this is encouraged. If students do not have access to computers, then the following materials will be needed:

Markers: colored, thin and thick (enough for students to share and have multiple colors)

Paper: blank 8.5 x 11 (one sheet per student)

Scratch paper (multiple sheets per student)

Procedures

Session 1

1. Explain to students they will choose an environmental issue present in their community. Examples include: removing lunch trash after lunch on school grounds, collecting rain water in rain barrels, avoiding use of the school's grass field after rain. They should be familiar with the issue or be affected by it personally. After their research, they will create brochures describing: the issue, their stance on the issue; evidence to support their stance, including science ideas; and multiple perspectives (other than their own) on the issue. They will share their completed brochures with their classmates in small groups.

2. Distribute a copy of Applying Science Ideas to Earth's Environment Brochure Instructions to each student. Read the instructions to them and answer any questions. Inform students when their brochures are due. Encourage them to create a draft on scratch paper of their brochure to clarify their thoughts first.

3. Distribute supplies to students.

4. Inform students if they are to complete their research and brochures during out-of-class time.

Session 2

1. Distribute a copy of Applying Science Ideas to Earth's Environment Brochure Sharing. Read the directions with them. Explain that each student will have eight minutes to share the brochure. After each student shares, the groups will be given seven minutes for questions and recording information on the handout.

2. Divide students into groups of four. Give each member of each group a number, one through four. Explain that students will present in numerical order, and you will time them to let them know when to move on.

3. While students are presenting, move throughout the classroom listening to students' reports and discussions.

4. Bring the class together and have several volunteers share what they learned during the brochure sharing session. Collect the posters and students' copies of Applying Science Ideas to Earth's Environment Brochure Sharing for use in assessment.

Extension Ideas

Lesson 3:

Provide students with the necessary measurement instruments and take them outside to cruise trees to determine the number of board feet the trees would provide if harvested.

Have students create their own clinometer and measure trees in the school yard. One example: http://nrich.maths.org/5382.

Applying Science Ideas to Earth's Environment Brochure Instructions

Many environmental issues affect our communities. Some might affect thousands of people, and some might affect just our school. As we learned during our study of tree harvesting and dam building, decisions affecting resources and natural systems are based on a wide range of considerations and decision-making processes. Every issue can be viewed from different perspectives, including social, economic, political, and environmental.

Directions:

Choose an environmental issue in your community. You should be familiar with the issue or affected by it. It can be something in your neighborhood, school, or larger community. Research the issue and identify the science ideas that are related to the issue. Consider other perspectives. Take a stand on the issue. Create a brochure to be shared with classmates in small groups.

Your brochure should include at least the following key elements:

- a description of the environmental issue (20 points)
- your stance on the issue (10 points)
- evidence to support your stance, including science ideas (30 points)
- multiple perspectives on the issue (40 points)

During our next class session, be prepared to share your brochure, answer questions by supporting your claims with evidence, and ask other students about their brochures.

Applying Science Ideas to Earth's Environment Brochure Sharing

Directions:

1. Listen carefully to your colleagues present their brochures.

2. In the spaces provided below, write one question for each of your colleagues. The questions should not be a "yes or no" question. Rather, they should lead to thoughtful discussions. Record your colleagues' responses.

Question 1 (20 points) Colleague's name: _____

Question asked: _____

_____

Response: _____

_____

Question 2 (20 points) Colleague's name: _____

Question asked: _____

_____

Response: _____

_____

Question 3 (20 points) Colleague's name: _____

Question asked: _____

_____

Response: _____

_____

Question 4 (20 points) Colleague's name: _____

Question asked: _____

_____

Response: _____

_____

Lesson 1: In Search of Lumber

Subject Areas

English Language Arts

Advanced Preparation Time

15 minutes

Instructional Time

60 minutes

Assessment Time

30 minutes

Standards Connections

California Common Core English Language Arts Standards

- Reading Standards for Informational Text K – 5, Grade 5
  Key Ideas and Details 3. Explain the relationships or interactions between two or more individuals, events, ideas, or concepts in a historical, scientific, or technical text based on specific information in the text.

Environmental Principles and Concepts

- Principle II: The long-term functioning and health of terrestrial, freshwater, coastal and marine ecosystems are influenced by their relationships with human societies.
- Concept c. Students need to know that the expansion and operation of human communities influences the geographic extent, composition, biological diversity, and viability of natural systems.

Summary

In this lesson students are introduced to Louise (10 years) and William (12 years), siblings who have just moved to Jamestown in 1899 and eagerly record in a new diary their experiences with, and thoughts about, the Sierra Railway and its role in the transportation of natural resources. Students read the siblings' first diary entry to learn about lumberyards, where the family buys wood they need, and mills, where large trees are processed into lumber. Once students have read the material, the teacher leads a classroom discussion by posing factual, interpretive, and predictive questions to students. This lesson provides the foundation for the remainder of the unit in which students will learn about the Sierra Railway's role in transporting natural resources, specifically lumber, as well as its role in transporting people and materials to construct dams to harness and convey additional natural resources.

Materials

- Digital projector, computer, and screen if projecting the reading
- List of discussion questions (included in Procedures)
- Pencils (one per student; consumable item)
- Projectable Lesson 1 reading if applicable
- Student workbook (one per student; consumable item)
- Word wall card: natural resources

Advanced Preparation

Familiarize yourself with the Lesson 1 reading as well as the suggested questions in the Procedures section. Adapt the questions as needed to accommodate your students' needs.

Prerequisite Knowledge

N/A

Background

The Sierra Railway played a critical role in expanding the Sierra foothills' logging industry by making transportation of timber more efficient. The Sierra Railway Company was incorporated on February 1, 1897 with the original intention, as per the Board of Directors' meeting, of creating a line that would serve the transportation needs of area mines in Calaveras and Stanislaus counties as well as the timber industry in Calaveras County. Although the minutes of the Board of Directors' meeting did not mention that the route would travel to Tuolumne County to serve the timber industry, this was also an apparent need. Mineral and timber extraction were the strongest regional industries at the time the Sierra Railway was incorporated. Eventually the Sierra Railway did reach Tuolumne County and transported timber from the foothills to the valley.

The Sierra Railway locomotives were steam engines fueled initially by the combustion of coal, then oil once oil-burning technology for locomotives was developed. Coal and oil, as well as timber and ore, are natural resources. They are also considered ecosystem goods—materials produced by natural systems that are essential to human life, economies, and cultures. Fueled by one ecosystem good while transporting others, the railway system was largely dependent on the region's natural systems. In turn, the expansion and operation of the human communities influenced the geographic extent and composition of these natural systems. The demand for lumber increased as communities grew and wood was used to build houses and other buildings, the infrastructure of mines, wooden flumes, and railroad tracks.

Narrow gauge railroads were built to travel in mountainous areas to transport timber out of the forest to a sawmill. At the sawmill, the wood was cut into lumber. From there the lumber was transported and sold at a lumberyard or sent across the state or country as needed. The Sierra Railway's line between Sonora and Carters/Summersville (later known as Tuolumne City) included a station at Standard. The Standard Lumber Company would eventually add a sawmill. The Sierra Railway provided freight and passenger service

to and from the Standard Lumber Company. In Tuolumne City, the West Side Flume and Lumber Company had a sawmill, drying kiln, planing mill, and box factory. This company owned 60,000 acres of timberland (they would eventually own more) that was south and east of Tuolumne City. The need to transport millions of board feet of lumber produced each year was one of the reasons the Sierra Railway line was extended to Tuolumne. The Hetch Hetchy and Yosemite Valley Railroad, a narrow gauge line that served the West Side Flume and Lumber Company, brought timber to the millsite at Tuolumne City from the forest. Once the timber had been cut into lumber, it was sold at the local lumberyard or transported by the Sierra Railway. When the Sierra Railway came into Tuolumne City in 1900, it had 58 miles of main line track. It carried boxcars from throughout the country, bringing coal, crude oil, dynamite, mining and lumbering machinery, as well as supplies for communities in the region. From Tuolumne City it returned to Oakdale, exporting timber, ores, cattle, and more.

In 1903, Bullock, one of the Sierra Railway's directors and founders of the West Side Flume and Lumber Company, sold the company's 60,000 acres of timberland. He then sought out additional lumber for his railroad to transport. He purchased more timberland, and bought a sawmill, planing mill, and sash and door factory. These properties and others came under ownership by the Standard Lumber Company, in which Bullock held an interest. Horse teams brought timber to these mills and factories in Sonora. In turn, the Sierra Railway transported the finished wood products to other areas.

By 1906, Sierra Railway had 79 miles of track. It carried passengers and freight, including lumber, between Oakdale and Tuolumne City. At Oakdale, it met up with the Southern Pacific and Santa Fe Railroads, two transcontinental railroads, creating a system to transport exports from the Sierra foothills' mining and timber industries to the rest of the country. Train carloads of merchandise and goods from the transcontinental railroads were transported by the Sierra Railway from Oakdale to the communities throughout its line ending in Tuolumne City.

After the San Francisco earthquake in April 1906, the Bay Area began rebuilding, although some businesses and industries were unable to recover from the losses suffered due to the earthquake and fire damage. The Sierra Railway Company remained financially insulated since its services, namely the transportation of freight, were still needed. In 1908 the Standard Lumber Company contracted with the Fruit Grower Supply Company of Los Angeles to make their fruit boxes. These were all transported on the Sierra Railway. The railway was also kept afloat by its continued transportation of lumber from the West Side Lumber Company and Standard Lumber Company. The latter was milling 100,000 board feet of lumber per day at just one of its millsites. In addition to lumber products, the Sierra Railway was exporting apples, cement, mining products, and much more out of the region.

In 1909, Bullock, representing the Standard Lumber Company, and the California Forestry Department negotiated an area of forest on public land. The lumber company would cut and log 600,000,000 board feet of timber and transport the lumber on the Sierra Railway. This was a large infusion of income into the company.

Fires were of major concern both in timberlands and in towns, as firefighting technology was still in its infant stages. In 1910, the Sierra Railway's roundhouse in Jamestown burned. Despite the loss, the roundhouse was rebuilt and made larger. In 1913, a large fire burned a forest woodland and nearby Empire Mill which were owned by the Standard Lumber Company. The losses affected the railroad due to the reduced volume of timber freight that resulted. Also in 1913, the Sierra Railway's Jamestown Depot burned, resulting in a tremendous loss of company records. The depot was rebuilt, but important documents were lost forever. In 1914, nearby Nevills Hotel burned to the ground. Sierra Railway passengers could no longer lodge in the hotel in their travels. In 1918, another hotel used by Sierra Railway passengers, the Turnback Inn in Tuolumne City, also burned to the ground. Another Standard Lumber Company mountain sawmill burned in 1920. A year later, after the sawmill and other buildings were rebuilt, the Standard Lumber Company was sold and became the Pickering Lumber Company.

Learning Outcomes

- Students will be able to define the term natural resources.
- Students will be able to explain that wood used in construction comes from trees.
- Students will be able to explain that trees are natural resources that provide an essential good to communities.

Key Vocabulary

Ecosystem goods: materials, such as timber and water that are produced by natural systems and used by humans.

Harvest: gather, catch, or otherwise collect crops, such as wheat, fish, and timber.

Natural resources: materials, such as water, minerals, energy, and soil that people use from nature and natural systems.

Transport: to move from one place to another.

The years before and during the Great Depression were hard on the Sierra Railway. When West Side Lumber Company closed its mill and sold its property to the Pickering Lumber Company in 1925, the Sierra Railway's freight volume was reduced. In 1930, the Pickering Lumber Company went into bankruptcy, further affecting the Sierra Railway. The railway went into bankruptcy in 1932. The West Side Lumber Company purchased one of its former, now idle, lumber plants back from Pickering in 1934, and the Sierra Railway was able to transport lumber again for a short period of time. Sierra Railway's role in the construction of O'Shaughnessy Dam from 1935 to 1938 helped to sustain the company a little longer. Also in 1937, the Pickering Lumber Company was reorganized as the Pickering Lumber Corporation and some of its operations were resumed when they logged public-land timberlands. The Sierra Railway shipped out the lumber from Pickering's Standard City mill. The automobile had begun to take hold in 1915 and passengers preferred the independence of their own cars to being passengers on the train. In 1937, the Sierra Railway Company was reorganized as the Sierra Railroad Company.

Procedures

Introductory Information

1. Have students turn to a neighbor and share the materials they think their houses are made out of. Have a few students share what their partners said. (Answers will vary.)

2. Explain to students that for the next (few weeks or several days) they will be learning about the Sierra Railway and its role in transporting goods such as lumber, as well as supplies and people to dam construction sites. Tell students they will read the diary of a brother and sister who lived in Jamestown, and learn along with the siblings.

Presenting the New Material/Practicing the New Material: Step-by-Step Procedures

1. Distribute a student workbook to each student. Have them write their names on the cover.

2. Have them turn to page 4 titled "In Search of Lumber." Explain that they will read this section and then answer questions through a class discussion. Review the questions they will be answering and encourage students to think about the answers as they read. Have them close read the selection: note things they see in the pictures, list any natural resources, and define any key vocabulary in context.

3. Give students time to read the story. (Note: The story can be projected and read out loud by you or students who are strong readers).

4. Ideally students should be seated in a circle for the class discussion so they can speak to, and engage with, each other in addition to you.

5. Facilitate a class discussion using the questions below as a script or as guidelines. Start with factual, then interpretive, and finally, predictive questions and encourage students to support their claims by identifying the supporting evidence in the text. Encourage students to use academic conversation strategies such as asking for clarification, summarizing, paraphrasing, and building on each other's ideas[1] to engage in rich, meaningful discussion. This class discussion provides students with an opportunity to practice reading an informational text and explaining it based on specific information in the text.

Factual Questions:

1. To which town have the siblings moved? *Jamestown*

2. Where did the siblings used to live? *New York, the East Coast*

3. What is the name of the train that has a stop in their town? *Sierra Railway*

4. What are the two places the siblings visit? *Lumberyard and sawmill*

Interpretive Questions:

1. Describe the relationship between the children and their father. *He cares about his family. The children get along well with their father. Interpretation based on this evidence: "he has been fixing [the house] for us so it's comfortable," "we helped father choose the wood,"*

1 Zwiers, Academic Language & Literacy, Zwiers, http://jeffzwiers.org/.

"we had many questions for Father," "if we help him make and hang the door, we could visit a sawmill."

2. Why do you think the siblings' father says that trees and minerals are essential goods? *Trees and minerals are essential goods because the family needs them to survive. The siblings' house is made of wood. The father works in a mine. This is how he makes his money. The mine makes money by selling the minerals. Wood and minerals make it possible for this family to live in Jamestown. Interpretation based on this evidence: "our house is made of wood," and "Father works in a mine to take out minerals. This is how he makes money. The minerals are sold to other people."*

3. Why are large trees cut into planks at sawmills? *Large trees are cut into planks at sawmills so they can be sold at lumberyards. Most people wouldn't be able to transport a large tree home. They also wouldn't have the tools to cut a tree into planks. Interpretation based on this evidence: "our house is made of wood," "today we are going to the lumberyard to buy wood," "sawmill is where big trees get cut into the planks we saw at the lumberyard," "people use these resources from nature in different ways."*

Predictive Questions:

1. How do you think lumber is transported to other towns in the area? *Answers will vary.*

2. Where do you think the trees grow that are cut down to make lumber? *Answers will vary.*

3. How much lumber do you think comes out of one tree? *Answers will vary.*

4. What do you think will happen with trees in the surrounding area if Jamestown continues to grow and more buildings are constructed? *Answers will vary.*

Assessing the Outcomes

1. Explain to students they are going to use the text to individually respond to a few questions to demonstrate what they have learned.

2. Have students turn to page 7 to "What I've Learned about the Search for Lumber" in their student workbooks. Have them answer the questions.

3. Once students have completed their assessments, have students put their pencils down and have a few students share their answers.

4. Collect student workbooks.

5. Explain to them that the next lesson on the Sierra Railway will teach them how lumber is transported and how that machine works.

Lesson 2: Steam Matters

Subject Areas

Science

Advanced Preparation Time

45 minutes

Instructional Time

Lesson Elements: Engage, Explore, Explain: 120 minutes

Extend: 30 minutes

Assessment Time

- 45 minutes

Standards Connections

Next Generation Science Standards

- 5-PS1-1. Develop a model to describe that matter is made of particles too small to be seen.
- 5-PS1-2. Measure and graph quantities to provide evidence that regardless of the type of change that occurs when heating, cooling, or mixing substances, the total weight of matter is conserved.

Learning Outcomes

- Students will be able to develop a model to describe that matter is made of particles too small to be seen.
- Students will be able to create a diagram showing that matter is conserved in the process of the functioning of a steam engine.

Key Vocabulary

Matter: a physical substance that has mass and takes up space.

Particles: a tiny bit of matter.

Summary

Students read another entry in Louise and William's diary in which they learn that lumber is transported throughout the region on trains, including the Sierra Railway. The siblings and their parents are going to visit the roundhouse in Jamestown to speak with train engineers to learn how a steam locomotive works. Students view a video to learn those steps. Through a series of hands-on stations, students learn the concept of conservation of matter and realize that matter is made of particles too small to be seen. Finally, students apply their knowledge of matter to how a steam locomotive works.

Materials

General Lesson Supplies

- Chart paper: 55 cm x 70 cm (eight per class; consumable item) (for alternative evaluation)
- Digital projector, computer, and screen if projecting the reading
- Markers: thick colored (eight packets per class) (for alternative evaluation)
- Pencils (one per student; consumable item)
- Projectable Lesson 2 reading if applicable
- Sticky notes: three colors (two pads of each of three colors; consumable item) (for alternative evaluation)
- Student workbook (one per student; from Lesson 1; consumable item)
- Video: "032 — How a Steam Locomotive Works:" https://youtu.be/wZSoMxTb1ZM
- Word wall card: matter
- Worksheet: Steam Matters—Explore Stations Worksheet (one per student; consumable item; see Appendix)

(see Explore Station Descriptions for material set up)

Station Supplies: In Addition to General Lesson Supplies

Station cards: printed and laminated (one per station per class) *See Appendix for reproducible Station Cards.*

Station 1

Balloon: standard round (one per student; have extras in case they pop)

Balloon pump: (one per class; optional)

Station 2

Balance scale with gram masses (one per class) (digital scale is also acceptable)

Balloon: deflated (one)

Balloon: inflated and tied closed (one)

Tub: plastic, large, deep (one per class) (to hold the balloons)

Station 3

Balance scale with gram masses (one per class) (digital scale is also acceptable)

Container: plastic, one-liter (three per class) (label one "water" and the other two "waste saltwater solution")

Container: plastic, 250 ml (one per class) (to hold salt)

Cups: clear plastic, 250 ml (eighteen per class; consumable item)

Eye dropper (one per class)

Graduated cylinder: 100 ml (one per class)

Measuring spoon: 25 ml (one per class)

Paper towels or reusable towel (one roll or towel per class)

Salt: 235 ml (per class; consumable item)

Stirring stick: glass or wooden (one per class) (skewer or chopstick are suitable)

Tub: plastic, approximately 23 cm x 30 cm or larger (two per class)

Water: room temperature, one-liter (per class; consumable item)

Station 4

Container: plastic, wide-mouth, one-liter (one per class) (to hold water)

Paper towels or reusable towel (one roll or towel per class)

Syringe: plastic, 20 ml (two per class; have extras in case they break) (mark one "water" and the other "air")

Tray: plastic, approximately 23 cm x 30 cm or larger (one per class)

Water: room temperature, 500 ml liter (per class; consumable item)

Station 5

Baking soda: 200 ml (per class; consumable item)

Balloon: standard round (fifteen per class; consumable item)

Container: plastic, one-liter (one per class) (to hold vinegar)

Container: plastic one-liter (one per class) (to hold waste)

Erlenmeyer flask: glass, 250 ml (one per class) (narrow-mouthed glass bottle such as a juice/coffee bottle is also acceptable)

Eye dropper (one per class)

Funnel: plastic, small (one per class)

Graduated cylinder: 25 ml (one per class)

Measuring spoon: one 15 ml (one per class)

Paper towels or reusable towel (one roll or towel per class)

Tray: plastic, approximately 23 cm x 30 cm or larger (two per class; optional)

Vinegar: 500 ml (per class; consumable item)

Station 6

Scratch/scrap paper: 10 pieces (per class; consumable item)

Straw: plastic (one per student; consumable item)

Trash can (one per class)

Station 7

Alka-Seltzer: tablet (ten tablets per class; consumable item)

Bag: plastic, quart-sized resealable (10 per class; consumable item)

Balance scale with gram masses (one per class) (digital scale is also acceptable)

Container: plastic, one-liter (one per class) (to hold water)

Cups: clear plastic, 250 ml (ten per class)

Eye dropper (one per class)

Graduated cylinder: 25 ml (one per class)

Paper towels or reusable towel (one roll or towel per class)

Tray: plastic, approximately 23 cm x 30 cm or larger (one per class)

Tub: plastic, large, deep (one per class)

Water: room temperature, 500 ml liter (per class; consumable item)

Station 8

Car: toy with wheels that roll (two per class) (any toy with wheels that roll is acceptable)

Flat surface: small (e.g., a desk or table top) (one per class)

Advanced Preparation

1. View the video "032 — How a Steam Locomotive Works" https://youtu.be/wZSoMxTb1ZM

2. Well before the lesson will be taught: gather all the materials necessary for the "Explore" stations.

3. Prior to lesson: print and cut the Station Cards. Laminating them will ensure they last longer. Prepare and set up all the Stations. See the Station descriptions for details.

4. Copy one Explore Stations Worksheet for each student.

Explore Station Descriptions

Station 1: Balloons Matter

Materials: at least one balloon per student, balloon pump (optional), station card

Set up: None. (If students are likely to take more than one balloon, hand one to each student prior to the station rotation.)

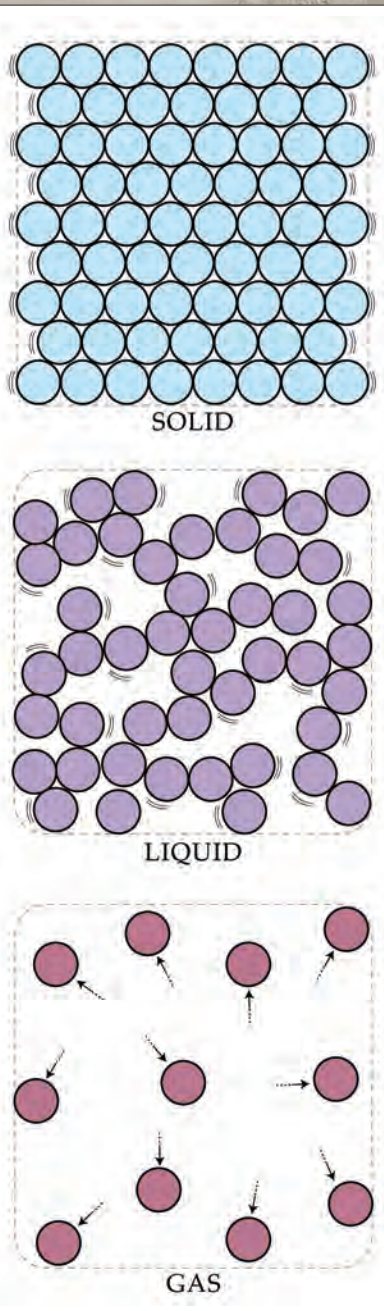


Illustration by Amy Hay

Station 2: Does Air Have Mass?

Materials: one inflated balloon that is tied closed, one deflated balloon, one balance scale with gram masses/digital scale, one container (such as a pie tin or tub) to keep the inflated balloon on the desk, station card

Set up: Place the inflated balloon and the deflated balloon in the tub. Place the weighing tool near the balloons.

Station 3: Where Did the Salt Go?

Materials: 235 ml of salt in a container, 1,000 milliliters of water in a one-liter container, two empty one-liter containers, one stirring stick (a skewer or chopstick are suitable), two 23 cm x 30 cm tubs, one roll of paper towels, eighteen clear plastic 250 ml cups that are exactly the same, one 25 ml measuring spoon, one 100-milliliter graduated cylinder or container, one eye dropper, one balance scale with gram masses or digital scale, one station card

Set up: Place the salt, water, stirring stick, plastic cups, teaspoon, graduated cylinder and eye dropper on one tub. Place the two one-liter containers marked "waste saltwater solution" in the second tub.

Station 4: Squishing in a Syringe

Materials: two 20 ml plastic syringes, 500 milliliters of water in a one-liter wide-mouth container, one 23 cm x 30 cm tray (optional), roll of paper towels, station card

Set up: Place the syringes and water in the one-liter wide-mouth container on the tray.

Station 5: Automated Balloon Filler

Materials: fifteen balloons, 500 milliliters of vinegar in a one-liter container, 200 ml of baking soda, one 15 ml measuring spoon, one 25 milliliter graduated cylinder, one eye dropper, one glass 250 milliliter Erlenmeyer flask or narrow-mouthed glass bottle such as a juice/iced coffee bottle, one small plastic funnel, two 23 cm x 30 cm trays (optional), roll of paper towels, station card

Set up: Place the measuring spoon, funnel, graduated cylinder, eye dropper, and 250 milliliter Erlenmeyer flask on one tray. Place the one-liter container that will hold waste in the other tray.

Station 6: Straw Paper Spitter

Materials: one plastic straw per student, 10 pieces of scratch paper, trash can, station card

Set up: Place the trash can near the area where the straws and scratch paper are.

Station 7: What Changed?

Materials: 10 quart-size sealable plastic bags, 500 milliliters of water in a one-liter container, ten tablets of Alka-Seltzer, ten 250 ml clear plastic cups, one 25 milliliter graduated cylinder, one eye dropper, one balance scale and mass grams, one 23 cm x 30 cm tray (optional), one large tub, roll of paper towels, station card

Set up: Place the graduated cylinder and eye dropper on the tray.

Station 8: No Hands Car Race

Materials: two small toy cars with wheels that roll (or any other toy), flat surface, station card

Set up: None

Prerequisite Knowledge

Familiarity with the definition of matter is useful, but not absolutely necessary.

Students need to know how to use a balance scale / digital scale.

Students need to know how to read the measurements on a graduated cylinder.

Background

Matter, which is everything that has volume and mass, is made of particles that are too small for the naked eye to see. The presence of these particles can be detected by their effects on other objects and by their weight. Tiny air particles can be expelled forcefully from the mouth and be used to move an object. Similarly, releasing the tiny particles of air from a filled balloon will result in the balloon moving. A filled balloon will weigh more than an empty balloon because the particles of air have volume and mass. When sugar

is dissolved in water, the sugar seems to disappear. However, the weight of the two substances will be the same before they have been mixed and after the sugar has dissolved in the water. The sugar is still present, but it has been broken into particles that are too small to be seen. This also demonstrates the conservation of matter.

The particles in solids, liquids, and gases vary in their proximity to one another and their movement. These particles have space between them, they are always moving, and adding heat makes the particles move faster. The particles in a gas have more space between them, so they can be compressed. For instance, if air is drawn into a syringe, the particles in the gas can be compressed by pushing down on the plunger while plugging the syringe's tip. On the other hand, if the same is done with a liquid, the particles will not compress as much as the air because liquid particles are closer together than air particles. Particles in a solid are already packed tightly and therefore cannot be compressed.

Within a closed system, matter is conserved. The amount of matter before a chemical or physical reaction will be the same amount after the reaction. The matter may be in a different form or phase, but matter cannot be created or destroyed in a physical or chemical process.

A steam engine is able to operate because of the action of particles in the solids, liquids, and gases that are integral parts of the engine. In the heyday of the Sierra Railway, the locomotives used coal or oil as their fuel source. The fuel was combusted, or burned, heating up the air particles. The hot air traveled through fire tubes that passed through a boiler filled with water. The hot air heated the water in the boiler, speeding up the particles in the water and causing it to boil and create steam.

The steam (gas) was collected in the steam dome. From the steam dome, the gas was forced down a large pipe to two cylinders, one on each side of the locomotive. When the steam was forced into the cylinders, the gas particles collided with the solid particles in the piston moving it. Because the piston was attached to the wheel of the train by way of driving rods, the movement of the piston would move the driving rod, which would cause the wheel to turn.

Once the rod had moved in one direction, the gas (steam) was pushed into the other side of the cylinder, moving the piston and therefore the rod back to its starting position and causing further rotation of the wheel. The steam released out from the cylinders traveled upwards through the smokebox and was forcibly released out the chimney creating a steam locomotive's characteristic "choo, choo" sound.

Procedures

Introductory Information

Engage

1. Tell students they are going to participate in a lab that will help them understand a science concept that applies to all the matter that is around us.

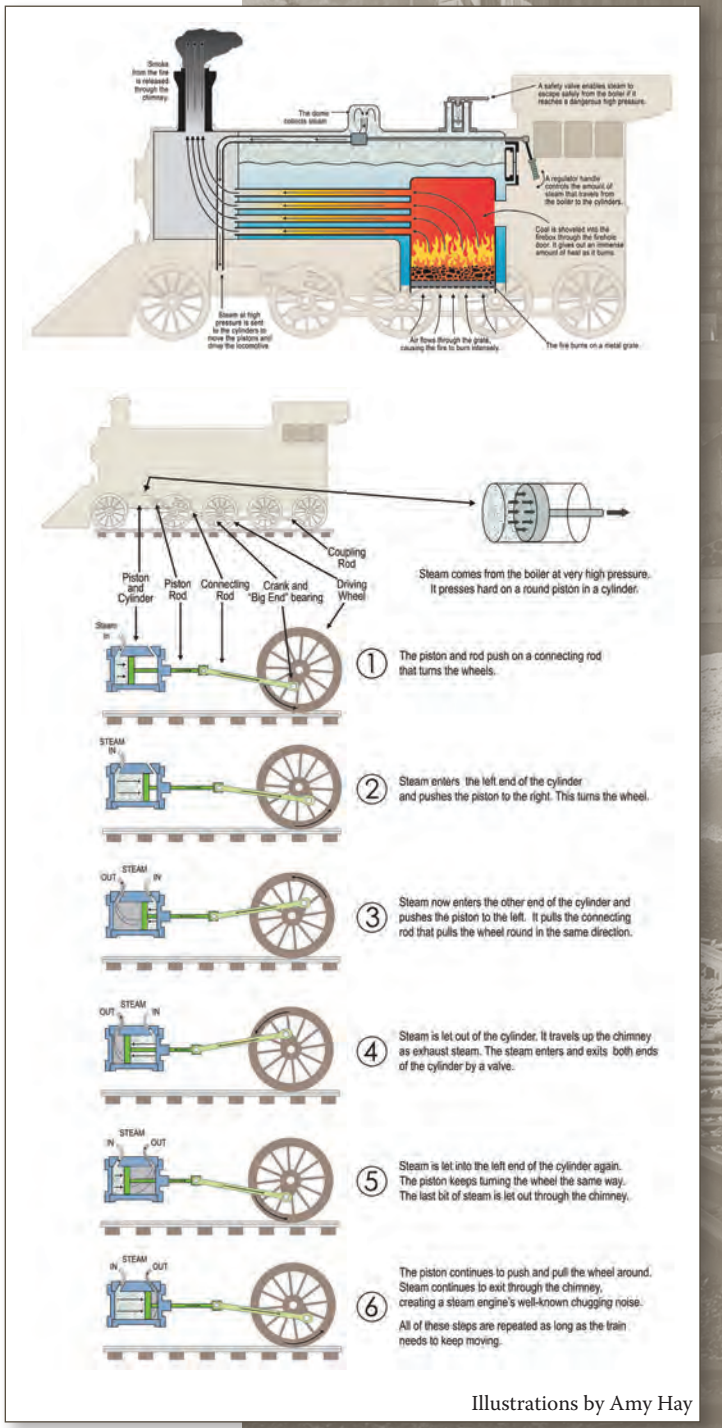
2. Explain they first will read the next passage in Louise and William's diary about the Sierra Railway. Then, after viewing a video about how a steam locomotive works, they will participate in hands-on activities.

3. Distribute student workbooks.

4. Have them turn to page 8 to the section entitled, "Steam Matters."

5. Give students time to read the story. (Note: The story may be projected and read out loud by the teacher or students who are strong readers.)

6. Ask a few student volunteers to share what they learned from Louise and William and what the siblings wanted to know. *(How a steam locomotive works)*



Illustrations by Amy Hay

7. Show students the video "032 — How a Steam Locomotive Works" https://youtu.be/wZSoMxTb1ZM. Tell them to focus on the roles that water and air play in the process.

Presenting the New Material/Practicing the New Material: Step-by-Step Procedures

Explore

1. Pass out one Explore Stations Worksheet to each student.

2. Explain to students they will participate in activities that will help them understand more about matter.

3. Tell students they will visit eight different stations. At each station, they are to read the station card, do the activity, and answer the questions on their worksheets. (Note: If time, space, or materials are not available to complete eight stations, choose at least four of them for students to complete.)

4. Show students where the eight stations are.

5. Demonstrate the tools at the various stations (as needed for your students; see station descriptions to determine which materials to demonstrate) so students know how to use them (but not how to do the activity). For instance, show students how to use a stirring stick properly.

6. Divide students into groups, and give each a role within the group, by counting off students 1A – 8A, then 1B – 8B, 1C – 8C, and 1D – 8D (letter them as necessary depending on the number of students in the group, ideally four). All the 1s (i.e., 1A, 1B, 1C, 1D) will work together, the 2s (i.e., 2A, 2B, 2C, 2D), and so on. Each group will have students A – D as well.

7. If necessary, assign roles for each person in the group and write it on the board. For instance, "The As will read the station card. The Bs will do the experiment first. The Cs will guide the discussion to fill in the worksheet at each station. The Ds will put the station back neatly so it is ready for the next group." Another option is to have the students alternate jobs at each station.

8. Tell students they will have approximately five to 10 minutes (depending on the needs of the students) at each station. When you tell them to, they should rotate clockwise (e.g., Station 1 to 2, 2 to 3, etc. and 8 to 1). (If you think your students are capable of it, you may choose to let them flow freely from station to station.)

9. Tell them that at the end of the explore time, each group will share their observations and explanations for the station where they started. They should designate one person to do this (or teacher can assign person C).

10. Assign Group 1 to Station 1, Group 2 to Station 2, and so on. Tell students they may start working at their first assigned station, which will also be the one they share at the end of the Explore portion of the lesson.

11. While students are working, walk around the room interacting with students, posing questions, or helping students with materials. If they share misinformation, encourage them to redo the experiment or use prompting questions to guide them. Do not give any answers or content to them as they are discovering this on their own. Possible questions:

- What happened?
- Why do you think it happened?
- What do you think it is made of?
- Can you see what is making that happen?

12. Keep track of the five (ten) -minute rotations and help students find their next stations, if needed.

13. Once students have visited all eight stations, have them return to the station where they started (i.e., Group 1 at Station 1). Tell them to decide what they would like to share about their observations and explanations of their first station. Encourage them to use information they learned from other stations to help inform what they observed at their first station. They should not describe the activity, but rather what they learned from it and/or observed as it relates to matter. Give them five minutes to prepare what they will share.

Explain

1. Have students return to their seats, or, if appropriate, have them sit at the station where they started (i.e., Group 1 at Station 1).

2. Remind students that when other classmates are sharing, they need to be quiet listeners.

3. Starting with Station 1, ask Group 1 to share their observations and explanations. Select one particular student (e.g., A), or have any volunteer from the group share, then other group members can add information as necessary. Ask the rest of the class if they agree, disagree, had a different observation, or have other ideas. Document their ideas on the board. Help students arrive to information that supports the activities they did. Continue with the rest of the groups. If any stations did not have a designated group, ask for volunteers to share their observations regarding those stations.

4. Have students look at the information they shared that you captured on the board. Ask them if they notice any trends, similarities, or patterns.

5. Based on the observations students shared, fill in any missing or additional information, or correct misconceptions as necessary.

6. Introduce the vocabulary word "particle" as a tiny bit of matter.

7. Students should understand that matter is made of particles too small to be seen. They should also be able to describe that the total weight of matter is conserved even after a physical or chemical reaction occurs.

Extend

1. Ask students what they think all of these activities about matter have to do with the Sierra Railway and steam locomotives. Have a few students share their ideas. *(Steam locomotives are made of matter. They also require matter to move. Water and air are matter. The particles in the water and air make the particles in other parts of the engine move. Matter is heated and cooled, but the total weight of matter is conserved within the system.)*

2. For a second time, show students the video "032 — How a Steam Locomotive Works": https://youtu.be/wZSoMxTb1ZM . Tell them to focus on the steps in which tiny particles of air and water affect the functioning of the system. Tell students to raise their hands when they identify a step, pause the video, and have them share their thoughts. *(Heated particles of air and water, and their movement, affect multiple processes.)*

3. After the video, allow students time to discuss with one or two neighbors how the science behind a steam locomotive is related to matter and the activities they did. Have a few students share their ideas. *(By this point they should realize that some of the activities they did showed that matter is made of particles too small to be seen and other activities showed that the total weight of matter is conserved. These two concepts apply to the functioning of a steam engine.)*

Assessing the Outcomes

Evaluate

1. Explain to students they are going to work individually to develop an initial model to describe that matter is made of particles. Their model can incorporate the hands-on activities in which they learned this concept. They will also create a diagram showing that matter is conserved in the process of the functioning of a steam engine.

2. Have students turn to page 9 to "What I've Learned about Steam Matters" in their student workbooks.

3. Once students have completed their assessments, have students put their pencils down and have a few students share their answers.

4. Collect student workbooks.

5. Explain to them that the next lesson on the Sierra Railway will involve a trip Louise and William take to visit their uncle at a logging camp where he works. There they will find out how much usable lumber comes out of a tree.

Alternative to Individual Evaluation

1. Student groups work together to draw a model on chart paper to describe that matter is made of particles. Their model can incorporate the hands-on activities in which they learned this concept. They will also create a small diagram on the poster showing that matter is conserved in the process of the functioning of a steam engine.

2. All student groups do a gallery walk by looking at each other's posters. As they walk around, they use different colored sticky

notes to provide feedback on their peers' models. For instance, yellow sticky notes are for clarification questions, pink sticky notes are for agreements, and blue sticky notes are for disagreements.

3. Students finish the gallery walk and return to their own group posters.

4. Students review their peers' feedback.

5. Using their knowledge and their peers' feedback, they revise their models.

6. Students engage in another gallery walk.

Lesson 2: Steam Matters — Worksheet: Answer Key

Note to the teacher: The answers provided are the expected answers. Students' answers will vary and some may also be wrong. Also note that they will likely not use relevant science vocabulary (e.g., particles) since they have not learned it. This is acceptable. As students move through the stations during the "Explore" phase, and then share their ideas in the "Explain" phase, they will develop a better understanding of the concept of matter. During the "Explain" phase you will introduce them to relevant vocabulary.

Station 1: Balloons Matter

1. Can you see the air you're exhaling? *(No.)*

2. What is filling the balloon? Does it take up space? *(Air. Yes, it takes up space.)*

3. Can you see the air coming out of the balloon? What happened to the balloon after the air was let out? *(No. The balloon deflated and became smaller.)*

Station 2: Does Air Have Mass?

1. Inflated balloon mass: *(Answers will vary.)*

2. Deflated balloon mass: *(Answers will vary. The deflated balloon should have a lower mass than the inflated balloon.)*

3. Do they have the same mass? Why or why not? *(No. The inflated balloon's mass includes the mass of the balloon plus the mass of the air inside it. The deflated balloon does not have air in it so its mass is less.)*

Station 3: Where Did the Salt Go?

1. Mass of the salt in the plastic cup: *(Answers will vary.)*

2. Mass of the water in the plastic cup: *(Answers will vary.)*

3. What do you observe? *(The salt seems to be disappearing. The water is not as clear as it was before.)*

4. Mass of the saltwater solution and two cups: *(Answers will vary.)*

5. Is the mass of the saltwater solution the same or different from the original mass of the salt plus the original mass of the water?

Why or why not? *(The mass of the saltwater solution is the same as the original mass of the salt plus the original mass of the water. They have the same masses because the same amounts of salt and water are still there. The salt did not disappear. It just dissolved in the water.)*

Station 4: Squishing in a Syringe

1. Describe your observations of the syringe with air. *(I can push the plunger of the syringe a little further down. The air squishes easily.)*

2. Describe your observations of the syringe with water. *(I cannot push the plunger of the syringe further down. The water does not squish easily.)*

3. Did you feel a difference between the air and water? Why do you think this is happening? *(Yes, I felt the difference between the air and water. I think this is happening because air is a gas and water is a liquid. Gas is more squishy than liquid. Whatever gas is made of can be squished together more easily than whatever liquid is made of.)*

Station 5: Automated Balloon Filler

1. Describe what you see happening in the flask. What is filling the balloon? Where did that come from? Describe the appearance of the vinegar and baking soda. *(The vinegar and baking soda bubbled and made fizzing noises. Air is filling the balloon. The air came from the reaction between vinegar and baking soda. The vinegar is fizzy but still looks like vinegar. The baking soda is no longer a solid. It seems to have disappeared or changed into something else.)*

Station 6: Straw Paper Spitter

1. Describe your observations. What moved the paper? Describe the evidence you have to support your idea. *(My breath moved the paper. I know it was my breath because the crumpled paper shot out of the straw and my breath was the only other thing in the straw that could have moved the paper.)*

Station 7: What Changed?

1. Mass of the plastic bag that contains 20 milliliters of water in the cup and one Alka-Seltzer tablet: *(Answers will vary.)*

2. Describe what you see happening in the cup and the bag. What is filling the bag? Where did that come from? Describe the appearance of the water and Alka-Seltzer tablet. *(The water and Alka-Seltzer bubbled and made fizzing sounds. Air is filling the bag. The air came from the reaction between the water and the Alka-Seltzer. The water fizzed and then looked like liquid. The Alka-Seltzer tablet seems to have disappeared.)*

3. Mass of the plastic bag with everything inside it after the reaction. *(Answers will vary.)*

4. Are the two masses the same or different? Why do you think this is the case? *(The two masses are the same. I think this happened because even though the water and Alka-Seltzer bubbled and fizzed, they are still there, just in a different form.)*

Station 8: No Hands Car Race

1. What moved the car? Describe the evidence you have to support your idea. *(My breath moved the car. I know it was my breath because the car rolled and my breath was the only thing that could have pushed the car.)*

Lesson 3: The Forest from the Trees

Subject Areas

Mathematics, Science

Advanced Preparation Time

15 minutes

Instructional Time

60 minutes

Assessment Time

60 minutes

Standards Connections

California Common Core State Standards Mathematics

- Measurement and Data, Grade 5

  Convert like measurement units within a given measurement system.

  1. Convert among different-sized standard measurement units within a given measurement system (e.g., convert 5 cm to 0.05 m), and use these conversions in solving multi-step, real-world problems.

Next Generation Science Standards

- 5-ESS3-1. Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.

Environmental Principles and Concepts

- Principle II: The long-term functioning and health of terrestrial, freshwater, coastal and marine ecosystems are influenced by their relationships with human societies.
- Concept a. Students need to know that direct and indirect changes to

Summary

Students read another entry from Louise and William's diary in which the children describe visiting their uncle at a logging camp. Their father takes them to the forest so they can see the natural area where trees are harvested. The children ask their uncle how much wood comes from each tree. The uncle responds by describing the mathematics involved. Students use these same formulas to calculate how many board feet they will be able to harvest from a hypothetical woodland. They use mathematics and a chart to calculate the answer. The students' knowledge is assessed in small groups in which they are told a certain number of board feet that must be harvested from a particular area. Using science ideas they are currently aware of, students determine which trees to harvest to maximize the board feet harvested while minimizing the impact on the forest.

Materials

- Calculators (one per student)
- Digital projector, computer, and screen if projecting the reading
- Pencils (one per student; consumable item)
- Projectable Lesson 3 reading if applicable
- Projectable Louise and William's Forest worksheet
- Student workbook (one per student; consumable item)
- Word wall card: board-foot, ecosystem goods, harvest, natural systems

Advanced Preparation

1. Review how to calculate the number of board feet that can be obtained from a tree so you can help students as they are completing the activity.

Prerequisite Knowledge

Students need to know how to use a calculator.

Students need to know the following mathematical concepts: area, diameter, height, radius, and volume.

Background

Foresters conduct a "timber cruise" in order to estimate how much standing timber is in a forest. Logging companies need to know this prior to buying timberland to make sure they can cover expenses and still make a profit. When the Sierra Railway was transporting timber, timber cruises were conducted manually. Now they are conducted through aerial surveys and by using electronic technology such as global positioning systems (GPS), and other means.

Using information gathered during a timber cruise, a forester estimates the number of board feet that can be harvested from the stand. A board-foot unit is the volume of wood in a twelve inch by twelve inch by one inch piece of wood, or, 144 cubic inches. Two measurements need to be made to calculate how many board-foot units are in a standing tree: the diameter at breast height and the height of the tree. The diameter at breast height (DBH) of the tree is measured in inches around the trunk of the tree four and one-half feet above the ground. However, many circumstances will change where the DBH is measured, such as whether the tree is growing on a slope, has two trunks, or is damaged at that particular height. In addition, some volume formulas and charts are based on the diameter inside the bark (DIB) rather than the DBH, and others are based on the DIB at the middle or top of the tree.

The height, in feet, of the tree is also measured. Depending on the formulas or charts used in the volume calculation, the total height or the merchantable height of the tree is measured. The

Ranger Hamm Measuring DBH of a Large Pine, 1958
U.S. Forest Service, Eastern Region. Photograph courtesy of the Forest History Society, Durham, NC

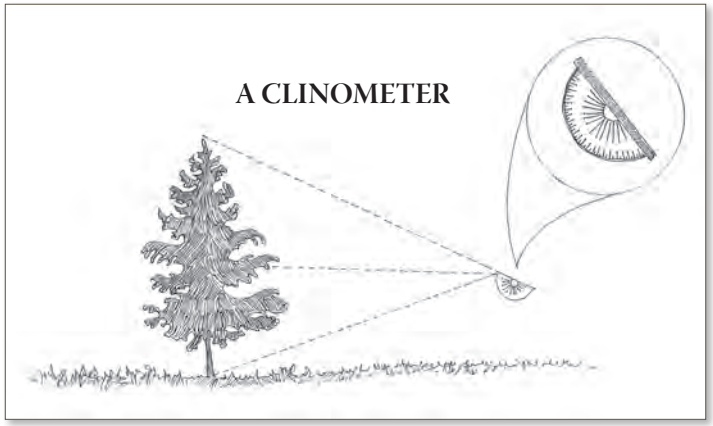
merchantable height is the part of the tree that can be used for timber. This typically excludes the crown of the tree which is usually too narrow and too branched.

There are several ways to measure the height of a tree using tools like yardsticks or clinometers. A tree scaler stands 100 feet away from the tree's base then turns towards the tree holding a yardstick vertically and twenty-five inches away from the front of the body. The zero-inch mark on the yardstick is matched with the bottom of the tree. The inch mark that matches the top of the tree is read and multiplied by four. This gives the tree's height in feet. A tree scaler can also stand one "chain," which is 100 links or 66 feet, away from the base of the tree. Using a clinometer and applying geometry, the scaler can calculate the height of one side of the triangle created between the tree and scaler. This is the tree's height.

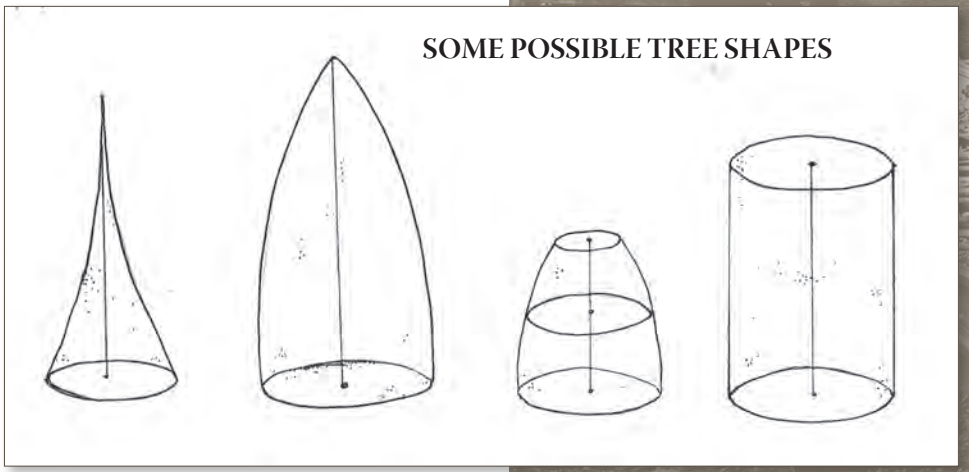
Once the height and DBH of the tree are known, the board feet can be calculated using mathematical formulas or a chart. Unfortunately there is not one agency that controls which rule charts are used. In addition, common rule charts, such as Scribner Decimal C Rule, Doyle Rule, and International Log Rule, may be modified for a specific region or species, and the mathematical formulas used to derive the board-foot volume are based on a different amount of kerf (the saw cut width), the thickness of the boards, taper allowance (the shape of the tree and how it narrows), and other factors.

More simple mathematical formulas that can be used for calculating board feet are based on the shape, or form of a tree, and no other variables such as tree species or bark width. The volume of a cylinder is $V = \pi r^2 h$ where r is the radius of the tree in feet, and h is the height of the tree in feet. However, very few trees are straight cylinders throughout their entire merchantable height. Some species are more like a paraboloid ($V = 1/2\pi r^2 h$), cone ($V = 1/3\pi r^2 h$), or neiloid ($V = 1/4\pi r^2 h$). These mathematical formulas result in the volume of the tree in feet cubed. However, a board foot is not one foot by one foot by one foot, but rather one foot by one foot by one inch. Mathematically, there are twelve board feet in one cubed foot. Therefore, the volume needs to be multiplied by twelve. In a sawmill, this is not the case, and in fact there may be only four to eight board-feet in one cubic foot of wood due to saw kerf and other issues with cutting the wood.[1]

Tree scalers do not measure each tree in a timberland as the process would be tedious. Instead, they use various sampling methods that allow them to determine the board-feet of some of the trees and then estimate the amount in the total forest.



All illustrations by Julia Rigby



1 Hailemariam Temesgen, Ph.D., personal communication to author, April 4, 2016.

natural systems due to the growth of human populations and their consumption rates influence the geographic extent, composition, biological diversity, and viability of natural systems.

- Concept b. Students need to know that methods used to extract, harvest, transport and consume natural resources influence the geographic extent, composition, biological diversity, and viability of natural systems.

Learning Outcomes

- Students will be able to apply their knowledge of converting among different-sized standard measurement units to calculate number of harvestable board feet in a standing tree.

Key Vocabulary

Board-foot: The volume of wood in a twelve inch by twelve inch by one inch piece of wood, or, 144 cubic inches.

Ecosystem goods: materials, such as timber and water that are produced by natural systems and used by humans.

Harvest: gather, catch, or otherwise collect crops, such as wheat, fish, and timber.

Natural systems: the parts, processes, and cycles in an environment, and the interactions among plants, animals, and other organisms with their environment.

Procedures

Introductory Information

1. Tell students today they are going to read the next passage from Louise and William's diary about their adventures learning about the lumber industry, specifically harvesting ecosystem goods such as trees.

2. Distribute student workbooks.

3. Have them turn to page 10 to the section titled, "The Forest from the Trees."

4. Give students time to read the story. (Note: The story may be projected and read out loud by the teacher or students who are strong readers.)

5. Ask a few student volunteers to share what they learned from Louise and William and what they wanted to know. *(They wanted to know how much wood comes from each tree. Their Uncle Joshua explained the process to the children.)*

Presenting the New Material/Practicing the New Material: Step-by-Step Procedures

1. Assign students to work with a partner. Give each student a calculator.

2. Tell students to turn to page 14 in their student workbook titled, "Louise and William's Forest."

3. Read the instructions with students and then give them 20 minutes to calculate the number of board feet that can be harvested from this forest.

4. After 20 minutes, have one student group volunteer to share their answer and describe how they arrived to it. Ask other students if they agree or disagree. If any student pair has a different answer, have them share what they did and discuss the process so all students understand how to correctly complete the calculations.

5. Ask students to examine the drawing of the forest in their workbook and share their thoughts with their partners about how the trees may have been selected for harvest. *(A dead tree, called a snag, was left standing; a very large tree with an owl's nest was left standing; three trees were in a cluster and the two that were starting to bump into each other at the top were harvested; the remaining trees in the forest are scattered, not clumped.)* Students most likely will not be familiar with the science ideas that inform modern harvesting, so any thoughts are acceptable at this time. Ask a few students to share their ideas.

6. Have students talk with their partners about why they think the harvesting was done in this way. *(To allow the forest to continue growing, to protect wildlife and wildlife habitat.)*

Assessing the Outcomes

1. Divide students into groups of three or four. Give each student a calculator.

2. Tell students to turn to page 17 in their student workbook titled, "What I've Learned about the Forest from the Trees."

3. Read the instructions with students and then give them 30 minutes to complete the project. Tell them they will share with their classmates their reasons for harvesting the trees they chose and the total number of board feet harvested from the area. The students should maximize the board feet harvested and minimize the impact on the forest.

4. After 30 minutes, have each group share their harvesting strategy. They should describe why they chose the trees they did, and share the total number of board feet harvested from the area.

5. In lesson four, students will revisit this woodland and reconsider their harvesting strategy based on new science ideas they learn during the lesson.


3

Lesson 4: A Changing Landscape

Subject Areas

Science

Advanced Preparation Time

15 minutes

Instructional Time

Part 1: 60 minutes

Part 2: 75 minutes

Assessment Time

30 minutes

Standards Connections

Next Generation Science Standards

- 5-ESS3-1. Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.

Environmental Principles and Concepts

- Principle II: The long-term functioning and health of terrestrial, freshwater, coastal and marine ecosystems are influenced by their relationships with human societies.
- Concept a. Students need to know that direct and indirect changes to natural systems due to the growth of human populations and their consumption rates influence the geographic extent, composition, biological diversity, and viability of natural systems.
- Concept b. Students need to know that methods used to extract, harvest, transport and consume natural resources influence the geographic extent, composition, biological diversity, and viability of natural systems.

Summary

Students once again read another entry from Louise and William's diary. The siblings describe their visit to the woodland and their observations about cleared areas of land. They also notice that in their own town, the landscape has changed since they moved there as boundaries expand and buildings are constructed. Students learn how the expansion and operation of human communities influences the geographic extent of natural systems by comparing and contrasting aerial images, pre-1897 and post-1897, of the area around routes of the Sierra Railway. They use a 100-square unit overlay tool to calculate the percentage of natural areas versus developed areas in the two aerial images. Students also learn about historical harvesting methods and compare and contrast those with present-day harvesting methods based on science ideas that support long-term sustainability of forests and wildlife habitat. They revisit the hypothetical woodland from the previous lesson and apply new information to revise their harvesting strategies.

Materials

- Digital projector, computer, and screen if projecting the reading
- Pencils (one per student; consumable item)
- Projectable Lesson 4 reading if applicable
- Student workbook (one per student; from Lesson 1; consumable item)
- Transparency with 100-square grid (one per group of four students)
  (Note: reproducible 100-square grid in the Appendix)
- Word wall card: ecosystem goods, harvest, natural systems, understory

Advanced Preparation

1. Copy or create the 100-square grid onto one transparency per student group. Alternatively, students can create their own 100-square grids.

2. Organize students into groups of three of four.

Prerequisite Knowledge

Students should have completed Lesson 3 of this unit.

Background

In the absence of regulations to control harvesting practices in the 1800s and early 1900s, the environmental consequences of logging were significant. The geographic extent, composition, and diversity of surrounding natural areas were reduced. According to a University of California, Davis report,

> *The economic realities of logging by rail, and a generalized lack of concern about ecological conditions, resulted in millions of acres of clear cuts throughout the Sierra Nevada. This wrought intense environmental destruction. There were tremendous impacts from deforestation in the basins where intensive logging took place. The rugged topography of the west slope with its steep slopes, and erodible soils behaved in a predictable fashion when deforested. Massive erosion, sedimentation, and altered stream flow patterns resulted from the denuded landscape and put tons of sediment into the streams and rivers.*[1]

Splash dams, which were temporary dams built to back up sufficient water to transport logs downstream to a mill, were built in riparian areas. When they were in place, water would not flow downstream, influencing the natural area. When they were removed, a rush of water and logs would flood downstream causing erosion and most likely killing plants and animals in the riparian area. Many early sawmills were water powered via stream diversion. Sawdust from some mills was dumped into rivers to avoid fires, detrimentally affecting the riparian community.[2] The geographic extent of the old growth forests of ponderosa and sugar pines in the Sierras was reduced dramatically after the logging

1 Mount and Purdy, Confluence: A Natural and Human History of the Tuolumne River Watershed, 144.
2 Mount and Purdy, Confluence: A Natural and Human History of the Tuolumne River Watershed, 144.

boom in the late 1800s. The composition and diversity of the forest was also changed as valuable species were harvested and non-desirable species were left.

Historical Harvesting Methods

Historically, timber harvesting was guided by economics. Beginning in 1848, because of California's Gold Rush and rapid immigration to the area, the timber industry expanded rapidly. Wood was needed in the construction of mines, houses, and other buildings. The goal of logging companies was to extract as much merchantable timber as possible. Science ideas and laws did not apply to timber harvesting until later in the 1900s. Once the merchantable trees had been removed from a woodland, the loggers moved to the next area and continued cutting. These harvesting practices resulted in great extents of bare land.

Harvesting of trees was originally done by hand using tools. First, trees were felled using saws and axes. An axe could be used to remove a wedge from the trunk of the tree being felled. Two people could then use a crosscut saw to cut perpendicular to the tree to further weaken it. Finally the tree, no longer able to sustain itself upright, would fall. In this process, the falling tree would sometimes hit and break other trees or branches on the way down. Once the tree had fallen, it was limbed by people who cut the branches off the tree. The tree was then bucked, either where it had fallen or sometimes once it had been transported to the mill. Bucking was the process of cutting the tree into specific-length logs, typically by way of a two-person whip-saw.

Loggers used oxen teams to yard, or move the tree from the stump to a landing or yard area. When logs were dragged on the ground, however, they damaged the understory—the smaller plants and younger trees that grow beneath larger trees. Oxen, mule, and horse teams also pulled timber on carts. Once steam-powered engines were developed, new machines made logging easier. These included a steam-powered "donkey" that pulled logs towards it, moving them to a landing or yard. This machine allowed loggers to harvest trees that previously were inaccessible. Another machine, the traction engine, was developed in 1881. It could haul very heavy loads and was often used where railroads could not be built. Once the logs had been yarded, they were transported to sawmills by way of railroads, animal teams, or wooden flumes filled with water.

As the timber industry began to expand, the California Board of Forestry was aware that many harvesting practices were wasteful. The Board was not necessarily applying new ideas in science, but it was aware the industry as currently managed was not sustainable in the long-term. In the *Second Biennial Report of the California State Board of Forestry for the Years 1887 to 1888,* the Former Head Forester, Thomas H. Douglas, wrote, "even now over one half of the accessible timber of the State has been cut … the sooner we begin to spare the young timber … and preserve the forests now standing, as well as commence planting new ones, the better it will be for the present and future generations."[3] Some science ideas were known, but they were not yet being applied. For instance, later in this same report, Milton Thomas, Esq. wrote that he noticed that trees grew larger when they were spaced out. Slash, the left over branches and unusable wood after a harvest, were usually left behind. When lightening or human-caused fires came through, the slash added fuel for the fire,

Brennan Creek Log Flume
Mendocino Coast Model Railroad and Historical Society

A Mule Team Pulling a Timber Cart
Photo courtesy of Tuolumne County Historical Society

Felling A Tree with Axes and a Crosscut Saw
Photo courtesy of Old Oregon

Steam Donkey
Photo courtesy of Tuolumne County Historical Society

Logging Crew with Oxen and Steam Donkey c 1900
Photo courtesy of Old Oregon

3 *California State Board of Forestry, Second Biennial Report 1887–87, 39.*

- Concept c. Students need to know that the expansion and operation of human communities influences the geographic extent, composition, biological diversity, and viability of natural systems.

Learning Outcomes

- Students will be able to describe the influence of the expansion and operation of human communities on the geographic extent of natural systems.
- Students will be able to illustrate the effects of different harvest methods on the geographic extent of natural systems.

Key Vocabulary

Ecosystem goods: materials, such as timber and water that are produced by natural systems and used by humans.

Harvest: gather, catch, or otherwise collect crops, such as wheat, fish, and timber.

Natural systems: the parts, processes, and cycles in an environment, and the interactions among plants, animals, and other organisms with their environment.

Understory: plants growing between the ground cover and main canopy of a forest

increasing its size and intensity. By the early 1900s, forestry research began to be conducted. One of the findings was that slash should be piled and reduced in a controlled burn. As time passed, loggers were encouraged to do this after harvest.

Modern Harvesting Methods

Today, timber harvesting is guided by science ideas, laws that protect the environment, and modern technology. Since the days of the Sierra Railway, forestry research has advanced. Many universities have forestry courses of study and active research departments. Studies have been conducted to determine how long trees take to grow to a certain height, the habitat conditions they need, and how to best repopulate after an area is harvested or burned. In second-growth areas, where old-growth trees have already been harvested, research is being conducted on even-age stands (all the trees in the stand are the same age due to a clearcut harvest followed by planting) and on uneven-age stands (the trees are different ages due to selection harvest). This knowledge informs harvest and sustainability practices.

Scientists better understand forest ecosystems after a century of research. Certain wildlife species require specific habitat conditions to survive. Policies that regulate harvesting practice have been developed to support these conditions. For instance, during the nesting season of the California spotted owl, no harvesting activity can occur near their nests. Snags, standing dead trees, must be retained during a harvest because many animals use them for shelter. River (riparian) areas have to be protected and water quality maintained since many plants and animals depend on healthy streams and rivers. Some foresters engage in the practice of mechanical thinning to remove some trees in a woodland to provide remaining trees more resources, like sunlight, water, and soil nutrients, which in turn help them grow stronger and contribute to the overall health of the forest.

We now understand that fire is a natural process and an integral part of the forest ecosystem. It allows cones to open, seeds to germinate, nutrients to be released in the soil, and dead and diseased trees to be removed. But while naturally-caused fires tend to be small in size and less intense in terms of heat, human-caused fires have the potential to become uncontrolled firestorms that can destroy forests. Due to a century of fire suppression and now years of drought, fuel has accumulated in our western forests, making conditions ripe for firestorms. Based on the knowledge gained from studying fire ecology, foresters now use prescribed fires on private and public-owned land. Mimicking natural, lightning-caused fires, these fires are small and controlled to burn specific areas. They create clearings for new growth, remove diseased trees, and naturally thin forests.

The U.S. Forest Service manages and regulates logging in national forests, which are public lands. The California Department of Forestry and Fire Protection (CAL FIRE) regulates privately-owned lands in the state by enforcing the laws that apply to forestry. These include the Forest Practices Act (1973). This and other state and federal laws require foresters to protect and restore riparian areas, and protect and restore native plants and animals, especially endangered species. Other laws protect air and water quality. Before a harvest on privately-owned land, foresters need to complete a Timber Harvest Plan (THP). This document details exactly what they will be doing and how they are following the laws to protect the environment. These plans help protect the environment as long as they are thorough, adequately reviewed, and accurately followed.

Foresters can take advantage of advanced tools and technology to harvest timber more sustainably. For instance, they can use helicopters and cables to transport logs out of a forest. These systems cause the least disturbance to the streams and soil, but they are also the most expensive. Foresters also use mechanized tools to harvest timberlands on the ground, like chain saws and feller bunchers to fell trees, and grapple skidders to move the logs to the yard.

Clearcutting continues to be the most popular harvest practice used in the logging industry, although it has been banned in the Sierra Nevada's national (public land) forests. Clearcuts today look very different than clearcuts from the last century. Whereas historical clearcuts consisted of large swaths of denuded land, today's clearcuts are smaller, have irregular boundaries (benefitting wildlife), and, by law, have trees growing on them again within five years. Laws also require that wildlife habitat and water quality be protected. Slash is burned after harvest, the soil is prepared, and

new trees are planted or natural regeneration from surrounding trees occurs. Planting or regeneration of only marketable species results in even-aged stands with less biological diversity than natural forests.

Some forestry companies use selective cutting harvest methods on their private lands. This means that only some trees in a woodland are harvested each time. This harvest method is more expensive. The A-frame crane from the 1950s was used to do selective harvests. Selective cutting results in uneven-aged stands, and more biological diversity.

The largest landowner in California, Sierra Pacific Industries (SPI), owns 1.7 million acres. Their main harvest method is clearcutting. They are certified under the Sustainable Forestry Initiative. They retain professional foresters and natural resource specialists and rely on recent reports and scientific reviews to guide their resource management.[4] Laws and regulations require logging companies to plan for and implement sustainable practices that will result in long-term tree availability and maintain forest, wildlife, and aquatic habitat health. Sierra Pacific Industries' clearcuts in California average 17.5 acres, which are relatively small compared to historical clearcuts.

On SPI's website they provide a photo series depicting their clearcutting practices that illustrates the differences between modern clearcutting practices and those from the late 1800s and early 1900s. From airplane flying height, the clearcuts look like small empty patches in the landscape. However, as they write on their website, "these ground level images depict the significant number of planted trees growing in the harvested area and they also show the diversity of tree species and shrubs. The planted trees have been growing for 10 years and show recent pre-commercial thinning to maintain forest health and stand growth rates."[5] As with any other large company involved in making decisions about the environment, Sierra Pacific Industries also has its detractors.[6][7]

Collins Pine Company owns Almanor Forest, 94,000 acres of land in the Sierra Nevadas. They are certified under the Forest Stewardship Council (FSC). According to their website, to obtain the FSC certification "a forest is scientifically evaluated based on management practices in three areas: sustainable harvest,

Helio-logging
Photo courtesy of Idaho Department of Lands

Cable Logging
Photo courtesy of the Forest History Society, Durham, NC

A Grapple Skidder Moves Logs
Photo courtesy of John Deere

Loggers Use a Chain Saw to Fell a Tree
Photo iStock/edelmar

Loggers Can Use a Feller Buncher to Fell a Tree
Photo courtesy of John Deere

4 Sierra Pacific Industries, "Research and Monitoring."
5 Sierra Pacific Industries, "Down to Earth Perspective."

6 Foothill Conservancy, "Clearcutting in Local Forests."
7 Sierra Forest Legacy, "Industrial Logging in the Sierra Nevada."

Selective Cut
Photo courtesy of Michael De Lasaux, University of California Cooperative Extension

Clearcut Logging Site
Shutterstock/TTPhoto

ecosystem health, and community benefits. Biologists, ecologists, silviculturists, and foresters examine and measure the impact of forest practices on wildlife and their habitat, water quality, soil and plant conservation, natural forest sustainability and biodiversity, visual aesthetics, and the total ecological integrity of the forest."[8] Their only harvest method is selective logging (uneven-age stand management) which they have practiced since they acquired this land in 1902. Despite their FSC certification, in 2015 they settled a lawsuit that "alleged that the Collins Pine knowingly allowed toxic discharge into drinking water sources, forested land, and surrounding areas"[9] from their sawmill and biomass incinerator operations. They subsequently made changes to their operations to ensure safety for the community.

The science of forestry continues to grow, informing decisions, and providing justification for regulation.

8 *Collins, "Certification."*
9 *Fisher, "Collins Pine Company Settles Lawsuit."*

Procedures

Part 1:

Introductory Information

1. Tell students they are going to read the next passage from Louise and William's diary about the Sierra Railway and the growth of towns along the Sierra Railway route.

2. Distribute student workbooks.

3. Have them turn to page 18 to the section entitled, "A Changing Landscape."

4. Give students time to read the story. (Note: The story may be projected and read out loud by the teacher or students who are strong readers.)

5. Ask a few student volunteers to share what they learned from Louise and William. *(The towns in the area have changed over the years. People are moving into the area. There are more houses and other buildings in the area.)*

6. Ask students if they would like to make observations of the photographs that Louise and William saw in the newspaper.

Presenting the New Material/Practicing the New Material: Step-by-Step Procedures

1. Assign students to work in groups of three to four members. Give each group a 100-square grid transparency. Each student should have a pencil.

2. Tell students to turn to page 19 in their student workbook titled, "A Changing Landscape: Images."

3. Read the directions with students and then give them 25 minutes to complete the activity. Tell them each group will share their thoughts after they are done with the activity.

4. After 25 minutes, have one student per group share their answer about one of the image sets.

Part 2: (may complete on a different day)

5. Remind students about the hypothetical woodland they harvested during the last lesson. Ask them if they harvested every

tree or just some trees in the forest. *(Some trees.)* Ask students what houses and other buildings in this region were made out of in the early 1900s. *(Wood.)*

6. Tell them to discuss in their groups how human development and natural systems affect each other. Have a few students share their discussions.

7. Tell students to turn to page 22 to "Harvesting Methods" in their student workbook. Read it as a class and provide vocabulary support as needed.

8. Guide students in a class discussion using the following questions to facilitate it. Encourage students to engage in academic conversations.

- What types of tools did people use to harvest trees in the late 1800s and early 1900s? *(Hand tools such as saws and axes. Animals, such as mule and oxen, pulled carts to transport the timber to the sawmill where it would be cut. Flumes, built out of wood, were also used to transport logs. When steam engines became available, logging became easier. Machines with steam engines replaced some of the manual tools. Railroads were used to transport lumber.)*
- What types of tools do people use to harvest trees today in the 2000s? *(Machines. Electric chain saws. Tractors. Helicopters.)*
- What has been the most popular method of harvesting trees? *(Clearcutting.)*
- Describe clearcutting. *(Cutting down all of the trees in one area.)*
- How has harvesting changed in modern days? *(Snags are left standing for wildlife. Streams are protected. Clearcuts are smaller. Clearcuts are irregularly shaped. Trees are replanted in clearcut areas. Some forestry companies practice selective harvesting. This means only some trees are harvested. The standing trees are seed trees that will help regenerate the logged area. These trees also serve as wildlife habitat.)*
- What do you think has led to the changes in how we harvest today? *(Scientists have done research to learn more. Science ideas have been applied to harvest practices. Laws protect natural areas.)*

9. Tell students to regroup with the same students they worked with originally on the lesson three assessment called "What I've Learned about the Forest for the Trees."

10. Have them turn to page 17 in the student workbook and review the woodland they harvested. They should discuss their original reasons for choosing to harvest the way they did. Give them a few minutes to do so.

11. Explain to students that in this lesson they learned more about harvesting techniques and reasons why foresters might select different ways to harvest a woodland. Tell them to apply these science ideas and revise their original harvesting plan. Have them write down their new thoughts in their workbooks and label it with "revised thinking" or have them use a different color.

12. Have a few students share their new harvesting plans and why they made these revisions.

Assessing the Outcomes

1. Have students turn to page 24 to "What I've Learned about a Changing Landscape" in their workbooks and answer the two questions to demonstrate what they have learned.

2. Once students have completed their assessments, have students put their pencils down and have a few students share their answers.

3. Collect student workbooks.

4. Explain to students that the next lesson on Sierra Railway will help them understand how it was involved in harvesting and transporting other ecosystem goods besides timber.

Lesson 5: Role of the Sierra Railway in Building Three Dams

Subject Areas
Science

Advanced Preparation Time
15 minutes

Instructional Time
75 minutes

Assessment Time
30 minutes

Standards Connections

Next Generation Science Standards

- 5-ESS3-1. Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.

Summary

In Louise and William's diary, students read a passage about the 1906 San Francisco earthquake, fires, and resulting damage to the city. Although the city had been searching for a more reliable and constant source of water since the 1880s, the earthquake and fire made the need to augment water supplies even more apparent. In a second diary passage written decades later, students learn that the Sierra Railway played a crucial role in the building of three dams in the area to serve the needs of growing communities. Students work in groups, using informational text and photographs to learn more about O'Shaughnessy, Don Pedro, and Melones Dams. Students share with a different group what they have learned about the dams and their influence on the geographic extent of natural systems.

Materials

- Digital projector, computer, and screen if projecting the reading
- Pencils (one per student; consumable item)
- Projectable Lesson 5 reading if applicable
- Student workbook (one per student; from Lesson 1; consumable item)
- Word wall card: cause and effect relationship, dam, ecosystem goods, harvest, natural systems

Old Don Pedro Dam
Photo courtesy of CA-A-0014, WaterArchives.org

Old Melones Dam
Photo courtesy of Calaveras County Historical Society

Advanced Preparation

1. Create "Expert Groups" and "Home Groups" by doing the following:

Number and letter students 1 through 6 and A through F. For instance, 1A, 2A, 3A, 4A, 5A, 6A, and 1E, 2E, 3E, 4E, 5E, 6E.

Expert Groups will become experts on the following materials:

Group 1: O'Shaughnessy Dam

Group 2: Don Pedro Dam

Group 3: Melones Dam

Group 4: O'Shaughnessy Dam

Group 5: Don Pedro Dam

Group 6: Melones Dam

Home Groups will consist of all the students with the same letter. For instance: 1A, 2A, 3A, 4A, 5A, 6A.

Prerequisite Knowledge

None needed, although students will benefit from having completed Lesson 4.

Background

The history of the Sierra Railway demonstrates a web of cause-and-effect relationships. As the abundance of, and demand for, ecosystem goods, such as minerals and timber, diminished, and more people used personal automobiles for transport, the Sierra Railway turned to other industries. With growing populations in the surrounding region and Bay Area, the need for a reliable and constant source of water became more pressing. Between 1910 and 1940, the Sierra Railway supported the construction of three dams.

Railroad work began at Hetch Hetchy Junction in 1916 in order to assist in construction of O'Shaughnessy Dam on Tuolumne River. The new track met up with the Sierra Railway line at milepost twenty-six at Hetch Hetchy Junction. There, construction materials were transferred from the Sierra Railway to the Hetch Hetchy Railroad.

In 1921, the Sierra Railway completed an eight-mile spur to serve the Don Pedro Dam construction site. This dam was finished in 1924. In 1925, the Sierra Railway added another seven-mile spur to its line to reach the Melones Dam site on the Stanislaus River. Melones Dam and powerhouse were completed by 1926. In 1935, the Sierra Railway was contracted to operate the Hetch Hetchy Railroad to increase the height of O'Shaughnessy Dam. The water from these dams was used for agriculture, domestic use, and/or power generation, depending on the needs of the communities each dam was serving.

The detrimental effects of dams on natural areas are documented, and include: changes in seasonal water flows, changes in water temperature both upstream (in the reservoir or lake) and downstream, increases in nutrient load in the reservoir; disruption of migratory species, such as salmon that migrate up and down the river throughout their life cycle; reduction of natural flooding resulting in a decrease in soil deposition downstream, reduction of water supply downstream, and increased erosion of stream banks leading to deterioration of habitat and reduction in seedling recruitment.[1]

In the case of O'Shaughnessy Dam, the Hetch Hetchy Reservoir is in a granite basin. Prior to the construction of the dam, very little sedimentation resulted from the hard granite bedrock, so there has not been a reduction in sedimentation downstream due to the dam's presence. The nutrient load in Hetch Hetchy Reservoir has not increased as a result of the dam because the water source is almost pollutant-free.

Both Don Pedro and Melones Dams have since been replaced by respective new dams, resulting in flooding of the old dams. Don Pedro Dam is further down Tuolumne River and is at a lower elevation than O'Shaughnessy Dam. Sediments flow in the river upstream from Don Pedro Dam, and because of this, sedimentation results when the flowing river hits the standing Don Pedro Reservoir. The sediment drops at the juncture between the two, reducing the capacity of the reservoir and also resulting in a loss of needed sediment downstream.

When New Melones Dam was built downstream from Old Melones Dam, the old dam was flooded in the reservoir of the new dam. In drier years when there is less rain and the reservoir is less full, cold water gets trapped behind the old dam and sinks since cold water is denser than warmer water. Only the warmer water flows over the old dam. While water is released from the base of the new dam to support fish migration, it is too warm for fish. In the summer months, water at the surface of the reservoir can be 77 degrees Fahrenheit, while deep in the reservoir it is 50 degrees Fahrenheit. The fish need the cooler water, but it is trapped behind the old dam.[2]

Not all the consequences of dam construction are negative. Positive effects include protection of towns from downstream flooding and provision of reliable and consistent water and hydropower. Sometimes plant and animal species benefit from changes in water volumes upstream and downstream from the dam.

Due to present day laws and regulations, dams must meet certain criteria. To protect fish habitat, and aquatic and riparian ecosystems downstream, for example, a certain level of water flow must be maintained and varied throughout the year to mimic natural seasonal flows. Some dams have built-in fish ladders that facilitate the movement of migrating fish over the dam in order to spawn upstream and allow juveniles to travel past the dam on their way downstream.[3] Although fish ladders may not be as effective as once thought for certain species in certain regions,[4] they demonstrate the application of science ideas to decisions affecting the environment. As people continue to develop new knowledge, they apply new ideas to their decision-making processes.

Fish Ladder
iStock/Tammy Fullum

1 *Mount and Purdy, Confluence: A Natural and Human History of the Tuolumne River Watershed, 157.*

2 *Nichols, "Will Drought Reveal Old Melones Dam?"*
3 *Harrison, "Fish Passage at Dams."*
4 *Waldman, "Blocked Migration: Fish Ladders On U.S. Dams Are Not Effective."*

Environmental Principles and Concepts

- Principle II: The long-term functioning and health of terrestrial, freshwater, coastal and marine ecosystems are influenced by their relationships with human societies.
- Concept a. Students need to know that direct and indirect changes to natural systems due to the growth of human populations and their consumption rates influence the geographic extent, composition, biological diversity, and viability of natural systems.
- Concept b. Students need to know that methods used to extract, harvest, transport and consume natural resources influence the geographic extent, composition, biological diversity, and viability of natural systems.
- Concept c. Students need to know that the expansion and operation of human communities influences the geographic extent, composition, biological diversity, and viability of natural systems.

O'Shaughnessy Dam
Photo courtesy of the San Francisco Public Utilities Commission

Lesson 5: Role of the Sierra Railway in Building Three Dams

Learning Outcomes

- Students will be able to describe the Sierra Railway's involvement in the building of three local dams.
- Students will be able to describe the influence of the expansion and operation of human communities on the geographic extent of natural systems.
- Students will be able to describe the influence of the method of harvesting and consumption of water on the composition of natural systems.

Key Vocabulary

Cause-and-effect-relationship: a relationship between events or things in which one results from the other.

Dam: a barrier built to hold back water. The water held behind it can be used for energy production, recreation, drinking, irrigation, or a combination of uses.

Ecosystem goods: materials, such as timber and water that are produced by natural systems and used by humans.

Harvest: gather, catch, or otherwise collect crops, such as wheat, fish, and timber.

Natural systems: the parts, processes, and cycles in an environment, and the interactions among plants, animals, and other organisms with their environment.

Procedures

Introductory Information

1. Tell students they are going to read the next passage from Louise and William's diary about the Sierra Railway and its role in the building of three local dams.

2. Distribute student workbooks.

3. Have them turn to page 26 to the section entitled, "Role of the Sierra Railway in Building Three Dams."

4. Give students time to read the story. (Note: The story may be projected and read out loud by the teacher or students who are strong readers.)

5. Ask a few student volunteers to share what they learned from Louise and William. *(On April 18, 1906, there was a very large earthquake in San Francisco. It started many fires. Firefighters did not have adequate water to put out the fires. Many people were missing. Decades later, three dams were built in the area. They supply water and power to many communities, but they also changed the natural landscapes.)*

6. Ask students to brainstorm with a partner how San Francisco can get water. Have a few students share their ideas. *(Accept any answers.)*

7. Explain to students they are going to learn how San Francisco, and other areas around the Sierra Railway's routes, solved their water problems.

Presenting the New Material/Practicing the New Material: Step-by-Step Procedures

1. Have students turn to page 28 to the section titled "Information Cards: Sierra Railway's Role in Building Three Dams."

2. Divide students into their groups by numbering and lettering them off from 1 through 6 and A through F. For instance, 1A, 2A, 3A, 4A, 5A, 6A. (See Advanced Preparation for additional instructions.) Encourage students to write their numbers and letters in the Lesson 5 section of their workbooks.

3. Explain that students will gather with their expert groups to read an information card focused on one of three dams involving use of the Sierra Railway. After they read the information card, they should answer in their own words the questions in their workbooks about their specific dam in the section titled "Sierra Railway's Role in Dam Building" on page 32. Once they have completed this, they will gather in home groups in which they will share what they learned and discussed in their expert groups.

4. Assign the information cards as follows:

Group 1: O'Shaughnessy Dam

Group 2: Don Pedro Dam

Group 3: Melones Dam

Group 4: O'Shaughnessy Dam

Group 5: Don Pedro Dam

Group 6: Melones Dam

Assign each group to a certain location in the classroom.

5. Give students 30 minutes to complete their work as an expert group. Assist them as necessary.

6. After 30 minutes have passed, gather all the As together, the Bs together, and so on. Remind them that they will share with their home group team what they learned during their expert group work. Explain to them that they will have two people in each group that read about one dam, so they can help each other share the information they learned. While students are sharing, the other home group members should listen carefully.

7. Give the home groups 15–20 minutes to share what they learned with their expert groups.

8. Capture students' attention and facilitate a 10-minute discussion about the building of dams and the geographic extent of natural systems. You may use the following questions to facilitate the discussion:

- Remember when we looked at the photographs of Jamestown before and after the railroad? What did you notice about

natural systems? *(As human communities grew, the space for nature shrank.)*

- How is that situation similar or different than the building of dams? *(It is similar in that dams change natural systems. The area behind the dam is flooded. Animals and plants that lived there before the dam was built probably can't live there afterwards. Different animals and plants can live in the lake formed by the dam. It is different because water needs to be dammed where it is already flowing whereas houses can be built in different places.)*

Assessing the Outcomes

1. Have students turn to page 33 to "What I've Learned about the Role of the Sierra Railway in Building Three Dams" in their student workbooks. Tell them they will answer two questions to demonstrate what they have learned.

2. Once students have completed their assessments, have students put their pencils down and have a few students share their answers.

3. Collect student workbooks.

Lesson 6: Storing Water, Stirring Debate

Subject Areas

Science

Advanced Preparation Time

15 minutes

Instructional Time

Part 1: 60 minutes

Part 2: 90 minutes

Assessment Time

30 minutes

Standards Connections

Next Generation Science Standards

- 5-ESS3-1. Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.

San Francisco 1906 Earthquake
Photo courtesy of The Bancroft Library, University of California, Berkeley BANC PIC 19xx.169:057

Summary

Students read in Louise and Williams' diary that President Woodrow Wilson signed a bill into law that would allow O'Shaughnessy Dam to be built in the Hetch Hetchy Valley. This 1913 decision was surrounded by controversy and was the first of its kind in the United States in which environmental preservation was pitted against the expansion and operation of human communities. Students experience the controversy for themselves by assuming roles of various groups and individuals, based on primary sources such as those found in the National Archives, and participating in a dramatic role-play highlighting the perspectives involved. Afterwards, students read an informational text describing the modern-day controversy surrounding the Hetch Hetchy project and the science ideas that inform it.

Materials

- Computers (one per partner group) (optional)
- Digital projector, computer, and screen if projecting the reading
- Pencils (one per student; consumable item)
- Projectable Lesson 6 reading if applicable
- Role playing cards (one per partner group) *(Note: reproducible role-playing cards in the Appendix)*
- Student workbook (one per student; from Lesson 1; consumable item)
- Word wall card: cause-and-effect relationship, dam, ecosystem goods, harvest, natural systems

Advanced Preparation

1. Divide students into pairs in advance.

2. Make a copy of the role playing cards and cut them out. There should be enough for one role play card for each pair of students.

Prerequisite Knowledge

Although not mandatory, students will better understand this lesson if they have completed Lesson 5.

Background

"I never handled any proposition where the engineering problems were so simple and the political ones so complex." — Michael O'Shaughnessy, Chief Engineer for the Hetch Hetchy Project[1]

The Hetch Hetchy Project was, and continues to be, surrounded by controversy since it was first considered. In 1849, as a result of the Gold Rush, the population of San Francisco rose to more than 100,000, by 1880 to more than 200,000, by 1890 almost to 300,000, and by 1913 to around 415,000. The water supplied by creeks and streams, and delivered on horse-drawn carts to residents, was no longer sufficient. Even the regional dams built in the next few decades by the Spring Valley Water Company proved insufficient. In the late 1800s and early 1900s, the city of San Francisco explored 14 possible water sources. The conclusion was that the Tuolumne River watershed would provide the highest quality and quantity of water, as well as an optimal site for a reservoir uncomplicated by other water claims associated with it.[2] James D. Phelan, the Mayor of San Francisco, was able to secure some water rights, filed in his own name, in 1901. The federal government had to be involved in granting the city water rights within a National Park since it involved federal land. In 1903, Mayor Phelan applied for a permit for water storage in Hetch Hetchy Valley to Secretary of the Interior Ethan Hitchcock who denied the request. The Mayor's request was again denied in 1905.

The Great San Francisco Earthquake of 1906 resulted in destructive fires that burned the city for three days, partially due to a shortage of water. In addition, hundreds of Spring Valley Water Company's pipes had broken in the earthquake and fires. Support grew for seeking an alternative, reliable, and consistent source of water for the city of San Francisco. In 1906, the Chief Forester of the United

1 O'Shaughnessy, 1934. As quoted in Hennessy, Images of America: Hetch Hetchy, 7.
2 Hennessy, Images of America: Hetch Hetchy, 8, 17.

States Forest Service, Gifford Pinchot, wrote a letter to Marsden Manson, San Francisco's city engineer, to encourage him to ask the new Secretary of the Interior, James R. Garfield, about the Hetch Hetchy Valley. He wrote, "If the possibility of a supply from the Sierras is still open, you should, I think, by all means go ahead with the idea of getting it."[3]

In 1908 when the city applied for water rights, Secretary Garfield granted San Francisco the right to store the water of Lake Eleanor, and when that could no longer meet the needs of the city, to store water in Hetch Hetchy Valley by creating a dam. By then, John Muir and the Sierra Club had launched a campaign to oppose the damming of Hetch Hetchy Valley, particularly because it was located in a national park. In 1909, the Sierra Club testified at Senate hearings on the issue. People from all over the country wrote letters in opposition to the project. The Sierra Club formed a new organization, the Society for the Preservation of National Parks, with prominent leadership, to expand their outreach across the country and garner support against the dam.

President William Howard Taft requested a commission to study the Hetch Hetchy Valley proposal further. In 1910, the Secretary of the Interior, Richard Ballinger, reviewed the commission's report, visited Hetch Hetchy Valley, and decided to put former Secretary Garfield's grant on hold, questioning why Hetch Hetchy Valley had to be dammed and requesting additional data from the city. In 1912, a new Secretary of the Interior, Walter Fisher, requested further investigation of the Hetch Hetchy Valley proposal. San Francisco city hired a hydraulic engineer, John R. Freeman from Rhode Island, to study the situation. His report indicated that this water source was the least expensive and least complicated in regards to water rights and that Hetch Hetchy Valley should be developed prior to Lake Eleanor and Cherry Valley.[4] Secretary Fisher also convened a hearing on Hetch Hetchy Valley in which people in favor and opposed to the dam testified. His board of engineers was given the responsibility of reviewing the testimony and writing a report with its recommendations. The board's 1913 report supported the damming of Hetch Hetchy Valley but also acknowledged that other options were available.[5] Secretary Fisher decided he would not make a decision and instead recommended that Congress take action. As a result, California Congressman John E. Raker wrote and introduced the Raker Bill in 1913.

Hetch Hetchy Railroad Route
Illustration by Amy Hay

Hetch Hetchy Valley before the Dam Was Built
Photo courtesy of the Yosemite National Park Archives, Museum, and Library

Throughout 1913, San Francisco city continued to pursue the water rights for Hetch Hetchy Valley. Congress held multiple hearings throughout the year. Letters from across the country mostly opposing the dam were sent to Senators and the majority of press outlets came out against the dam as well. After significant discussion and controversy, President Woodrow Wilson signed the Raker Act of 1913 that same year. It "granted to the city and county of San Francisco certain rights of way in, over, and through certain public lands, the Yosemite National Park, and Stanislaus National Forest . . . for the purpose of constructing, operating, and maintaining aqueducts, canals, ditches, pipes, pipe lines, flumes, tunnels, and conduits for conveying water for domestic purposes and uses to the city and county of San Francisco [and] for the purpose of constructing, operating and maintaining power and electric plants, poles and lines for generation . . . of electric energy."[6] It also gave permission to build O'Shaughnessy Dam and Eleanor Dam, required San Francisco to provide public electricity to the city, and specified that water and power could not be resold for a profit.

The Hetch Hetchy Railroad was built to transport construction equipment and workers to the dam site. Its track branched off from the Sierra Railway main line at milepost twenty-six. The Sierra Railway connected with the Southern Pacific, which came from San Francisco, at Oakdale. Other roads and infrastructure were completed before construction on O'Shaughnessy Dam began in 1919. At the time of the construction, outlet conduits and valves

3 National Committee for the Preservation of the Yosemite National Park Bulletin #2.
4 Vilas, "Water and Power for San Francisco," I.
5 "Timeline of the Ongoing Battle Over Hetch Hetchy," Sierra Club.
6 The Raker Act of 1913.

Environmental Principles and Concepts

- Principle V: Decisions affecting resources and natural systems are based on a wide range of considerations and decision-making processes.
- Concept a. Students need to know the spectrum of what is considered in making decisions about resources and natural systems and how those factors influence decisions.
- Concept b. Students need to know the process of making decisions about resources and natural systems, and how the assessment of social, economic, political, and environmental factors has changed over time.

Learning Outcomes

- Students will be able to describe the spectrum of perspectives that were considered when O'Shaughnessy Dam was originally built.
- Students will be able to describe the role that science and other perspectives can have in making decisions that affect the environment.

were built to control water releases from the dam to support wildlife and recreational activities.[7] The dam was completed in 1923. It stood at 226.5 feet with a capacity of 206,000 acre-feet[8] of water.[9] Afterwards, construction on the aqueduct to the Bay Area was started. The first water was delivered to San Francisco in 1934. By then, however, the demand for water and hydropower had increased. Between 1935 and 1938, with the use of the Sierra Railway engines, cars, and resources, the dam was raised 85.5 feet, which increased the reservoir's capacity to 360,360 acre-feet of water.[10] The Hetch Hetchy Reservoir spans eight miles along Tuolumne River.

Although the opponents of O'Shaughnessy Dam and Hetch Hetchy Reservoir did not achieve their goals of keeping Yosemite National Park free of a dam, they created an awareness of environmental issues and a conservationist movement that would influence other decisions in the nation. Later efforts to dam the Colorado River in Grand Canyon National Park and the Green River in Dinosaur National Monument were defeated because of the awareness that had been raised as a result of outcry over Hetch Hetchy Valley. The public recognized that some natural areas needed to remain intact in order to preserve their natural beauty and so the public could benefit from the ecosystem services they naturally provide. Just three years after the Raker Act of 1913 was signed into law, the Organic Act of 1916 created the National Park Service (NPS) within the Department of the Interior. The director of NPS was to control, manage, and supervise the nation's national parks and monuments "to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations."[11] Existing legislation to protect natural areas includes the Wild and Scenic Rivers Act of 1968 (protects rivers that have exceptional scenic, fisheries, wildlife, and recreational value), the Clean Water Quality Act of 1972, and the Endangered Species Act of 1973. The Tuolumne River received designation as a National Wild and Scenic River in 1984.

Hetchy Hetchy System Today

The headwaters of Tuolumne River lie at Mount Lyell, at 13,120 feet in Yosemite National Park. Fed by glacial melt and spring snowmelt, Tuolumne River extends 149 miles before joining the San Joaquin River in the Central Valley. The river water that is captured in the Hetch Hetchy Reservoir does not require filtration; it is only one of a handful of major water systems that meets filtration avoidance criteria from the Environmental Protection Agency. The water source is protected and people are not allowed in the reservoir water,[12] although fishing from shore, hiking, and wildlife viewing around the perimeter are permissible. In the Bay Area, two water treatment plants treat the water before it is provided to consumers.

Powerhouses along the Hetch Hetchy Project provide renewable energy in the form of hydroelectricity to human communities in the region, including the city of San Francisco. The Project produces 1.7 billion kilowatt hours of electricity, or enough to power 200,000 homes for a year.[13] As it stands now, the Hetch Hetchy Aqueduct "is an extraordinary water and power system that is comprised of 60 miles of tunnels (some excavated through solid granite), 280 miles of pipelines, four major dams, four powerhouses, two treatment plants, and 11 reservoirs."[14] The water is transported approximately 160 miles across California and delivered to 2.4 million people in Tuolumne, Alameda, Santa Clara, San Mateo, and San Francisco counties.[15]

Controversy continues to surround the Hetch Hetchy Project today.[16] The Raker Act of 1913 stipulated that San Francisco had to provide public electricity to the city, and specified that water and power could not be resold for a profit. Since the 1920s, there have

7 Hennessy, Images of America: Hetch Hetchy, 55.
8 1 acre-foot of water = 325,851 gallons = volume of water necessary to flood one acre of land under one foot of water = provides for a family of 4-5 people for one year
9 Hennessy, Images of America: Hetch Hetchy, 66.
10 Hennessy, Images of America: Hetch Hetchy, 67.
11 National Park Service, "Organic Act of 1916."
12 Hennessy, Images of America: Hetch Hetchy, 67.
13 Hennessy, Images of America: Hetch Hetchy, 106.
14 Hennessy, Images of America: Hetch Hetchy, 7.
15 Hennessy, Images of America: Hetch Hetchy, 8.
16 Hennessy, Images of America: Hetch Hetchy, 8.

been concerns that the city is not providing public power without profit. Pacific Gas & Electric's (PG&E) power lines are used to carry power to the city produced through the Hetch Hetchy Project. Before 1945, the city sold power to PG&E who then sold it back to the public. After 1945, the city was deemed the official retailer of Hetch Hetchy power. However, the city still pays PG&E for their transmission system.[17]

Another controversy that surrounds the Hetch Hetchy Project is the minimal amount the city of San Francisco pays for "rental" of the Hetch Hetchy Valley. Beginning in 1918, the city paid $15,000 annually. This amount increased to $30,000[18] in the late 1920s and has been the annual rent the city has paid for over 75 years. Rental fee increases have been proposed to force San Francisco to pay millions of dollars to the federal government, the most recent being in 2004 and proposed by President Bush, but none have been supported. Senators Barbara Boxer and Diane Feinstein have been opposed to the fee increase proposals.[19]

For economic and environmental reasons, some groups, including the Sierra Club and Restore Hetch Hetchy (formed by leaders from the Sierra Club and other environmental groups), champion the removal of O'Shaughnessy Dam to restore the Hetch Hetchy Valley as it was prior to development of the Hetch Hetchy Project. Multiple studies have concluded that the city of San Francisco could obtain reliable and consistent water from other sources so it would not be affected by the removal of the dam.[20] [21] Similarly, sufficient renewable hydropower could continue to be generated by the power plants along the Hetch Hetchy Project without O'Shaughnessy Dam. In 2004, a *Sacramento Bee* writer wrote a series of articles on the restoration of Hetch Hetchy Valley that won him a Pulitzer Prize in 2005.[22] This caught the attention of then Governor Schwarzenegger who asked the California Department of Water Resources to analyze the situation. Their report agreed with the results of prior studies and included an estimated cost for restoration ranging from three to 10 billion dollars. Another reason some groups support the removal of O'Shaughnessy Dam is because Yosemite Valley is heavily impacted by recreation and tourism with four million visitors each year.[23] Restoring the Hetch Hetchy Valley would alleviate and share some of that human use and produce additional income for the park. National Park Service studies predict that the valley would be restored within 150 years. Others in favor of dam removal are concerned about the use of a National Park, which is meant to be open to, and owned by, the public, for private use by the city of San Francisco and surrounding communities for their water and power.[24] The number of visitors to Yosemite National Park is larger than the number of people who receive water from the project. One of the arguments used in the 1900s in favor of damming the valley was that fewer people visited the area than would benefit from the water and power. This is no longer true.

Reasons to keep O'Shaughnessy Dam are economic and environmental. The system is already in place and provides reliable water and hydropower, and the "rental fee" for the city of San Francisco is inexpensive. Removal of the dam would require that an alternate source for water and renewable power be located. If O'Shaughnessy Dam was removed, the filtration avoidance status for the Hetch Hetchy System would likely be lost. Consequently, the city would have to filter the water and incur an expense.[25] The area under the reservoir is relatively small in size, and no endangered or threatened species would benefit from its restoration. Funds are limited and the expense may not be worth the benefit of the restored valley.[26] In addition, the meadow that existed in the valley prior to the dam being built had been created through controlled burning and intensive management

17 Mount and Purdy, Confluence: A Natural and Human History of the Tuolumne River Watershed, 157.
18 Vilas, "Water and Power for San Francisco," II.
19 Mount and Purdy, Confluence: A Natural and Human History of the Tuolumne River Watershed, 167.
20 Null, "Time to Give a Dam: "O'Shaughnessy Dam is No Longer Needed."
21 Environmental Defense Fund, "Environmental Defense Releases Hetch Hetchy Valley Study."
22 The Pulitzer Prizes, "The 2005 Pulitzer Prize Winner in Editorial Writing."
23 Null, "Time to Give a Dam: "O'Shaughnessy Dam is No Longer Needed."
24 Mount and Purdy, Confluence: A Natural and Human History of the Tuolumne River Watershed, 169 – 170.
25 Null, "Time to Give a Dam: O'Shaughnessy Dam is No Longer Needed."
26 Mount and Purdy, Confluence: A Natural and Human History of the Tuolumne River Watershed, 169 – 170.

Key Vocabulary

Cause-and-effect-relationship: a relationship between events or things in which one results from the other.

Dam: a barrier built to hold back water. The water held behind it can be used for energy production, recreation, drinking, irrigation, or a combination of uses.

Ecosystem goods: materials, such as timber and water that are produced by natural systems and used by humans.

Harvest: gather, catch, or otherwise collect crops, such as wheat, fish, and timber.

Natural systems: the parts, processes, and cycles in an environment, and the interactions among plants, animals, and other organisms with their environment.

by the Miwok and Paiute people that once lived in the area. It is possible that without that human influence, a forest, rather than a meadow, would grow instead. In 2012, the majority of people in San Francisco voted down a proposition that would have required a feasibility study regarding removing O'Shaughnessy Dam.

Economic, environmental, ethical, political, scientific, social, and other perspectives affect decisions human communities make daily about natural systems. Over time, these points of view often evolve based on additional research, knowledge, ideas, or situations. Our role as responsible citizens is to be informed and critical consumers so we make wise choices with our actions and behavior.

Procedures

Part 1:

Introductory Information

1. Tell students today they are going to read what is happening in Louise and William's diary in late 1913.

2. Distribute student workbooks.

3. Have them turn to page 34 to the section entitled, "Storing Water, Stirring Debate."

4. Give them time to read the story. (Note: The story may be projected and read out loud by the teacher or students who are strong readers.)

5. Ask a few student volunteers to share what they learned from Louise and William. *(On December 20, 1913 President Woodrow Wilson signed a bill into law. It will allow a dam to be built in the Hetch Hetchy Valley. People in the San Francisco area have been talking about needing water since before the earthquake. But the earthquake made the need more obvious. Some people want the dam; others do not.)*

6. Ask students to share with a partner how they feel about a dam being built in Hetch Hetchy Valley. Have a few students share their ideas. *(Accept any answers.)*

7. Explain to students they are going to recreate the debate that happened around the dam in Hetch Hetchy Valley. They will work with a partner. They will be assigned to a person's or group's position and given the real words written about Hetch Hetchy. Students will study their positions, and conduct further research on the person or group and/or the position. Then students will come together in a town hall meeting to share their positions.

Presenting the New Material/Practicing the New Material: Step-by-Step Procedures

1. Assign students to their partners.

2. Explain they have 30 minutes to study their group's position and to conduct further research (if computers are not available, the latter can be eliminated). Students should identify the group's claim and the evidence the group provided to support it. This is the information students will share during the town hall meeting. They should be prepared to speak to the other participants in the town hall meeting.

3. Give each group their role playing card and a computer (if available).

4. Provide assistance to students as needed as they work for 30 minutes.

Part 2:

5. If possible, rearrange students' chairs so they are all seated in a circle. To present, partners will stand in front of their seats.

6. Describe to students that during this town hall they are to be respectful of one another, listen carefully, and be ready to discuss the various positions of the groups after everyone has spoken. They will also decide which side of the issue they personally stand on and be able to provide evidence supporting their respective position.

7. Facilitate each partner group sharing their position.

8. Once all have presented, facilitate a discussion highlighting the claims and evidence that were brought up by the various groups. Encourage them to engage in an academic conversation by asking for clarification, summarizing, paraphrasing, and building on each other's ideas.[27] The following questions can be used:

27 Zwiers, http://jeffzwiers.org/.

- What were the claims made by the groups that supported building of the dam?
- What evidence did they have to support their claims?
- What were the claims made by the groups that did not support building the dam?
- What evidence did they have to support their claims?
- What are the effects of building a dam on the environment? *(The land behind the dam is flooded, resulting in animals and plants possibly dying or needing to move. Food and water sources for animals and plants change; fish that lived in the river can no longer migrate up and down the river; silt and sediment that once flowed down the river will now be trapped in the lake behind the dam.)*
- What are the effects of building a dam on human communities? *(Water is captured and stored for drinking and irrigation. Communities behind the dam become flooded. There are changes to the availability of water. Hydropower harnesses energy and the resulting electricity can change lifestyles, e.g., staying up later because of indoor lighting, improving efficiency with machinery and kitchen appliances. There is a change in the visual landscape. Jobs are created during construction and operation of the dam. Water rights may change and fishing in the river downstream from the dam changes.)*
- Was any scientific evidence used to support any of the groups' claims? If so, what was it?
- Do you think that now, more than 100 years later, we know more about natural systems and how dams affect them?

9. Have students turn to page 35 to "Science Perspectives: Storing Water, Stirring Debate" in their student workbooks.

10. Give students time to read the story. (Note: The story may be projected and read out loud by the teacher or students who are strong readers.)

11. Ask a few volunteers to share what they learned. *(We now have science ideas to help us build dams that have less impact on the environment. Fish ladders help fish cross the dam. Water is released to match the natural flood cycle. Some groups still want to remove O'Shaughnessy Dam. They say San Francisco can get water and power from other places. Some people want the dam to stay. They say that removing it will cost money.)*

Assessing the Outcomes

1. Have students turn to page 36 to "What I've Learned about Storing Water, Stirring Debate" in their student workbooks. Tell them they will answer three questions to demonstrate what they have learned.

2. Once students have completed their assessments, have them put their pencils down and call upon a few students share their answers.

3. Collect student workbooks.

4. Explain to students they have completed the unit on the Sierra Railway and in the final lesson of the unit they will synthesize, or put together, everything they have learned over the last several lessons.


3

Appendix: Reproducibles

Railtown 5th Grade Unit Plan — Unit Assessment Traditional
The Sierra Railway and Natural Systems

Part 1. Choose the best answer (2 points each)

1. Throughout its history, the Sierra Railway was involved in transporting

   a. lumber

   b. materials for dam construction

   c. people

   d. all of the above

2. A balloon full of air will have _____ weight than the same balloon when it is empty.

   a. more

   b. less

   c. the same

3. Which of these tree harvesting options is most likely to result in a forest that will continue producing lumber long-term?

   a. clearcut

   b. selective cut with seed trees

   c. clearcut then plant many trees very close together

   d. selective cut then allow fires to burn the forest every few weeks

4. Calculating the number of board feet in a tree usually requires knowing the DBH of the tree. What does DBH stand for?

   a. draw a boundary height

   b. data at beaver height

   c. diameter at breast height

   c. diagonal of board height

5. Matter is:

   a. solid or liquid, but not gas, that has mass and takes up space

   b. large, visible particles that have mass and take up space

   c. a physical substance that has mass and takes up space

   d. weight that is not conserved when it is heated, cooled, or mixed

6. 72 inches is the same as

   a. 7.2 feet

   b. 6 feet

   c. 2 feet

   d. 864 feet

Part 2. Answer each question with a sentence or short paragraph (5 points each)

7. Describe how forests can be used by people as ecosystem goods.

_____

_____

_____

8. Imagine that you could put a steam locomotive engine into a container that would allow you to weigh all the matter going into the system, and all the matter coming out of the system. What do you know would be true about the weights of the matter going in and coming out? How do you know this?

_____

_____

_____

Part 3. Follow the directions in the question below (10 points)

9. Describe positive and negative aspects of dam building on human and natural communities.

Positive: _____

_____

_____

Negative: _____

_____

_____

10. Imagine the place where you live. What do you think it looked like 200 years ago (the early 1800s)? Compare that image to what it looks like now. Describe the natural environment and the human community before and after.

200 years ago: _____

_____

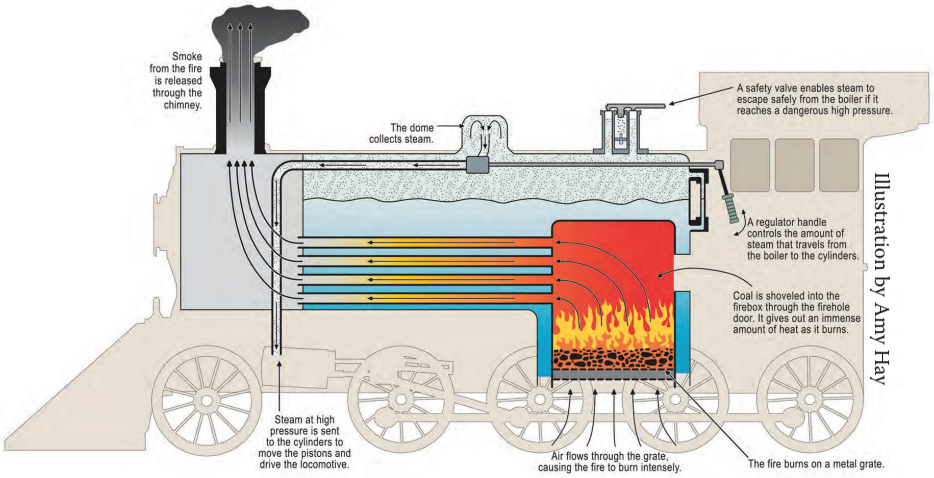
_____

Today: _____

_____

_____

11. Below is a diagram of a steam locomotive engine. Use small circles and arrows to show how matter (in this case, mostly gas) moves through the engine and eventually results in the trains' wheels turning.



In the lines below, describe how you know that matter is made of particles too small to be seen. You can use evidence from the hands-on activities you did in class.

_____

_____

_____

_____

_____

12. If you could have voted on whether or not to build O'Shaughnessy Dam, would you have voted for or against it? Why? Include science ideas to support your decision.

_____

_____

_____

_____

_____

_____

_____

Part 4. Follow the directions in the question below (20 points)

13. Write one paragraph with at least ten sentences summarizing the ways individual communities use science ideas to protect the Earth's resources and environment. You can use multiple examples you learned in this unit.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

14. Pretend you are a forester using science ideas to plan a harvest that would result in the forest being able to continue to produce timber for hundreds of years and at the same time provide habitat for wildlife. Draw your ideal harvested forest, label the parts, and describe why each part is necessary. Also describe what data you would collect.

Drawing:

Description:

_____

_____

_____

_____

_____

Railtown 5th Grade Unit Plan — Unit Assessment Alternate
Applying Science Ideas to Earth's Environment

Brochure Instructions

Many environmental issues affect our communities. Some might affect thousands of people, and some might affect just our school. As we learned during our study of tree harvesting and dam building, decisions affecting resources and natural systems are based on a wide range of considerations and decision-making processes. Every issue can be viewed from different perspectives, including social, economic, political, and environmental.

Directions:

Choose an environmental issue in your community. You should be familiar with the issue or affected by it. It can be something in your neighborhood, school, or larger community. Research the issue and identify the science ideas that are related to the issue. Consider other perspectives. Take a stand on the issue. Create a brochure to be shared with classmates in small groups.

Your brochure should include at least the following key elements:

- a description of the environmental issue (20 points)
- your stance on the issue (10 points)
- evidence to support your stance, including science ideas (30 points)
- multiple perspectives on the issue (40 points)

During our next class session, be prepared to share your brochure, answer questions by supporting your claims with evidence, and ask other students about their brochures.

Use this space to write or draw your ideas.

Applying Science Ideas to Earth's Environment Brochure Sharing

Directions:

1. Listen carefully to your colleagues present their brochures.

2. In the spaces provided below, write one question for each of your colleagues. The questions should not be a "yes or no" question. Rather, they should lead to thoughtful discussions. Record your colleagues' responses.

Question 1 (20 points) Colleague's name: _____

Question asked: _____

_____

Response: _____

_____

Question 2 (20 points) Colleague's name: _____

Question asked: _____

_____

Response: _____

_____

Question 3 (20 points) Colleague's name: _____

Question asked: _____

_____

Response: _____

_____

Question 4 (20 points) Colleague's name: _____

Question asked: _____

_____

Response: _____

_____

Station 1: Balloons Matter

1. Can you see the air you're exhaling? _____

2. What is filling the balloon? Does it take up space?

_____

_____

_____

3. Can you see the air coming out of the balloon? What happened to the balloon after the air was let out?

_____

_____

_____

Station 2: Does Air Have Mass?

1. Inflated balloon mass: _____

2. Deflated balloon mass: _____

3. Do they have the same mass? Why or why not?

_____

_____

_____

Station 3: Where Did the Salt Go?

1. Mass of the salt in the plastic cup: _____

2. Mass of the water in the plastic cup: _____

3. What do you observe?

_____

_____

_____

4. Mass of the saltwater solution and two cups: _____

5. Is the mass of the saltwater solution the same or different from the original mass of the salt plus the original mass of the water? Why or why not?

_____

_____

_____

Station 4: Squishing in a Syringe

1. Describe your observations of the syringe with air.

_____

_____

_____

2. Describe your observations of the syringe with water.

_____

_____

_____

3. Did you feel a difference between the air and water? Why do you think this is happening?

_____

_____

_____

Station 5: Automated Balloon Filler

1. Describe what you see happening in the flask. What is filling the balloon? Where did that come from? Describe the appearance of the vinegar and baking soda.

_____

_____

_____

Station 6: Straw Paper Spitter

1. Describe your observations. What moved the paper? Describe the evidence you have to support your idea.

_____

_____

_____

Station 7: What Changed?

1. Mass of the plastic bag that contains 20 milliliters of water in the cup and one Alka Seltzer tablet:

_____

2. Describe what you see happening in the cup and the bag. What is filling the bag? Where did that come from? Describe the appearance of the water and Alka Seltzer tablet.

_____

_____

_____

3. Mass of the plastic bag with everything inside it after the reaction. _____

4. Are the two masses the same or different? Why do you think this is the case?

_____

_____

_____

Station 8: No Hands Car Race

1. What moved the car? Describe the evidence you have to support your idea

_____

_____

_____

Station 1: Balloons Matter

Instructions:

1. Exhale by blowing air in front of you. Can you see the air you're exhaling?

2. Blow up 1 balloon and then hold it closed. What is filling the balloon? Does it take up space?

3. Let the air out of the balloon. Can you see it? What happened to the balloon after the air was let out?

4. Complete your worksheet.

5. Reset the station.

Station 1: Balloons Matter *(using an air pump)*

Instructions:

1. Use the air pump to move air in front of you. Can you see the air being pumped out?

2. Use the air pump to blow up 1 balloon and then hold it closed. What is filling the balloon? Does it take up space?

3. Let the air out of the balloon. Can you see it? What happened to the balloon after the air was let out?

4. Complete your worksheet.

5. Reset the station.

Station 2: Does Air Have Mass?

Instructions:

1. Place the inflated balloon on the scale to find its mass. Write its mass on your worksheet.

2. Place the deflated balloon on the scale to find its mass. Write its mass on your worksheet.

3. Do they have the same mass? Why or why not?

4. Complete your worksheet.

5. Reset the station.

Station 8: No Hands Car Race

Instructions:

1. Place 1 toy car on the flat surface.

2. Make the toy car move using just your breath.

3. What moved the car? Describe the evidence you have to support your idea.

4. Complete your worksheet.

5. Reset the station.

Station 3: Where Did the Salt Go?

Instructions:

1. Measure 25 ml of salt and pour it into one of the plastic cups.

2. Find the mass of the salt in the plastic cup. Record it on your worksheet.

3. Measure 100 milliliters of water by pouring the water from the one-liter container into the 100 milliliter graduated cylinder. If you are slightly off, use the eye dropper to remove or add small amounts of water to the cylinder.

4. Pour the 100 milliliters of water into an empty plastic cup.

5. Find the mass of the water in the plastic cup. Record it on your worksheet.

5. Mix the salt and water by slowly pouring the salt into the cup with 100 milliliters of water. Stack the empty cup under the cup with the saltwater solution.

6. Use the stirrer to slowly mix the solution. Describe what you observe.

7. Find the mass of the saltwater solution and two cups. Record it on your worksheet.

8. Is the mass of the saltwater solution the same or different from the original mass of the salt plus the original mass of the water? Why or why not?

9. Pour your saltwater solution into the one-liter container marked "waste saltwater solution," stack your cups and set them inside the plastic tub.

5. Complete your worksheet.

6. Reset the station.

Station 4: Squishing in a Syringe

Instructions:

1. Use a syringe to draw up 10 milliliters of air. Place the thumb of your other hand on the narrow opening. Attempt to push the plunger downward while keeping your thumb tightly on the opening. Describe your observations.

2. Use a syringe to draw up 10 milliliters of water. Place the thumb of your other hand on the narrow opening. Attempt to push the plunger downward while keeping your thumb tightly on the opening. Don't let any water leak out. Describe your observations.

3. Did you feel a difference between the air and water? Why do you think this is happening?

2. Return the water from the syringe to the one-liter container.

3. Complete your worksheet.

4. Reset the station.

Station 5: Automated Balloon Filler

Instructions:

1. Take 1 balloon.

2. Place the small plastic funnel in the opening of the balloon.

3. Measure 15 ml of baking soda.

4. Pour the baking soda into the balloon using the funnel.

5. Measure 20 milliliters of vinegar. If you need to remove or add a small amount of vinegar, use the eye dropper.

6. Pour the 20 milliliters of vinegar into the Erlenmeyer flask.

7. Place the opening of the balloon around the mouth of the Erlenmeyer flask. Make sure it is a snug fit. Do not let the baking soda spill into the flask while you are doing this.

8. Tilt the balloon upwards so the baking soda spills into the flask. Hold the mouth of the balloon tightly around the flask. Describe what you see happening in the flask. What is filling the balloon? Where did that come from? Describe the appearance of the vinegar and baking soda.

9. Place your used balloon on the tray. Pour any remaining liquid into the one-liter container on the tray.

10. Complete your worksheet.

11. Reset the station.

Station 6: Straw Paper Spitter

Instructions:

1. Take 1 straw per group member

2. Rip a small piece of scratch paper.

3. Crumple the piece of scratch paper.

4. Place the crumpled paper into one end of your straw.

5. Aim your straw at the trash can.

6. Place your mouth at the other end of the straw and blow the piece of paper into the trashcan. Describe your observations. What moved the paper? Describe the evidence you have to support your idea.

7. Complete your worksheet.

8. Reset the station.

Station 7: What Changed?

Instructions:

1. Take 1 quart-size sealable plastic bag.

2. Place 1 plastic cup and one tablet of Alka-Seltzer (not in the cup) into the bag.

3. Measure 20 milliliters of water into the graduated cylinder. If you need to remove or add a small amount of water, use the eye dropper.

4. Pour the 20 milliliters of water into the plastic cup that is inside the bag.

5. Seal the bag without spilling the water.

6. Find the mass of the plastic bag that contains 20 milliliters of water in the cup and one Alka-Seltzer tablet. Record it on your worksheet.

7. Keep the bag sealed. From outside the bag, move the Alka-Seltzer tablet so it falls into the cup. Keep the bag upright. Describe what you see happening in the cup and the bag. What is filling the bag? Where did that come from? Describe the appearance of the water and Alka-Seltzer tablet.

8. Find the mass of the plastic bag with everything inside it after the reaction. Record it on your worksheet.

9. Are the two masses the same or different? Why do you think this is the case?

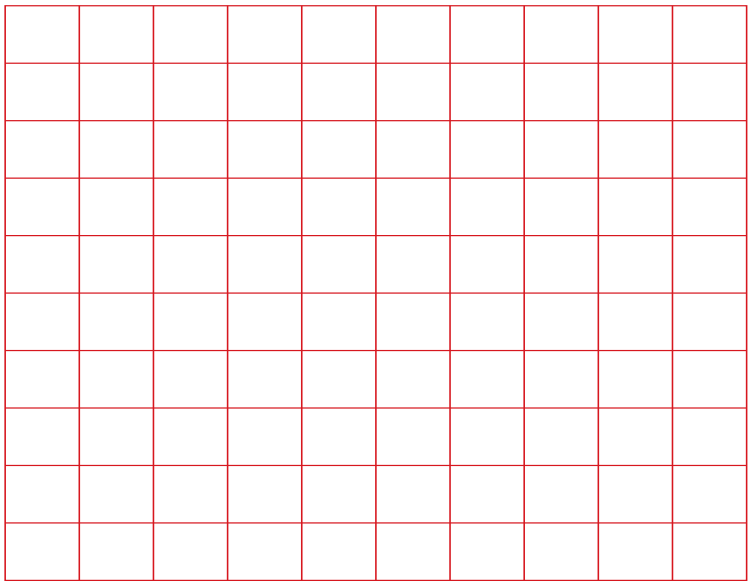
10. Place the bag with all its contents into the large tub.

11. Complete your worksheet.

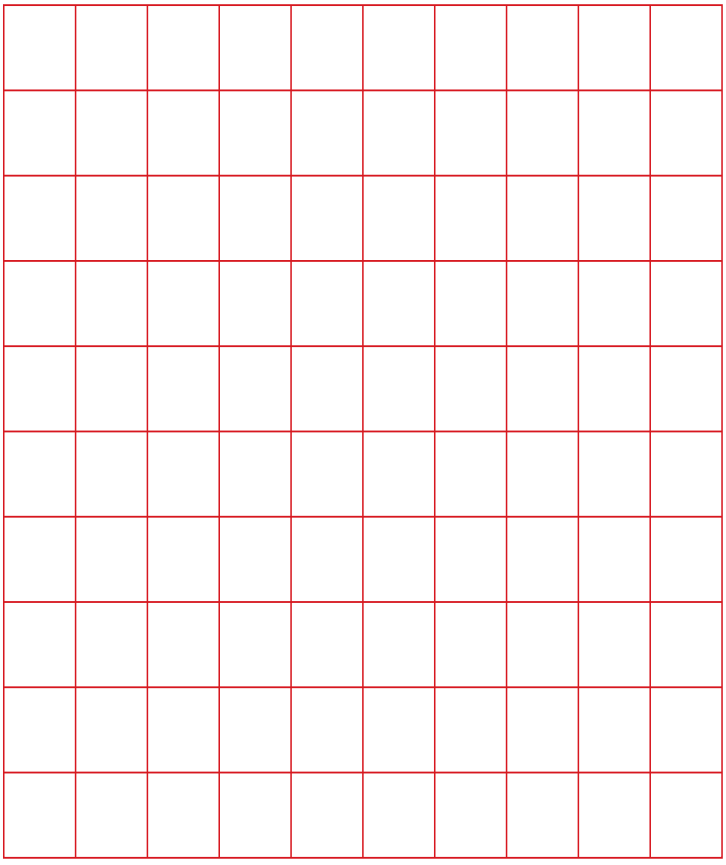
12. Reset the station.

Transparency grids for Lesson 4 — A Changing Landscape

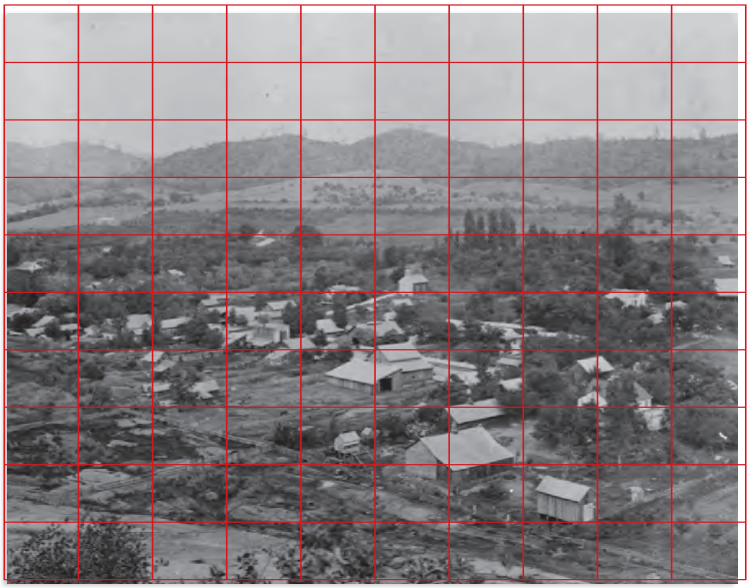
Use this grid for the Jamestown photos on page 19 of the Student Workbook.

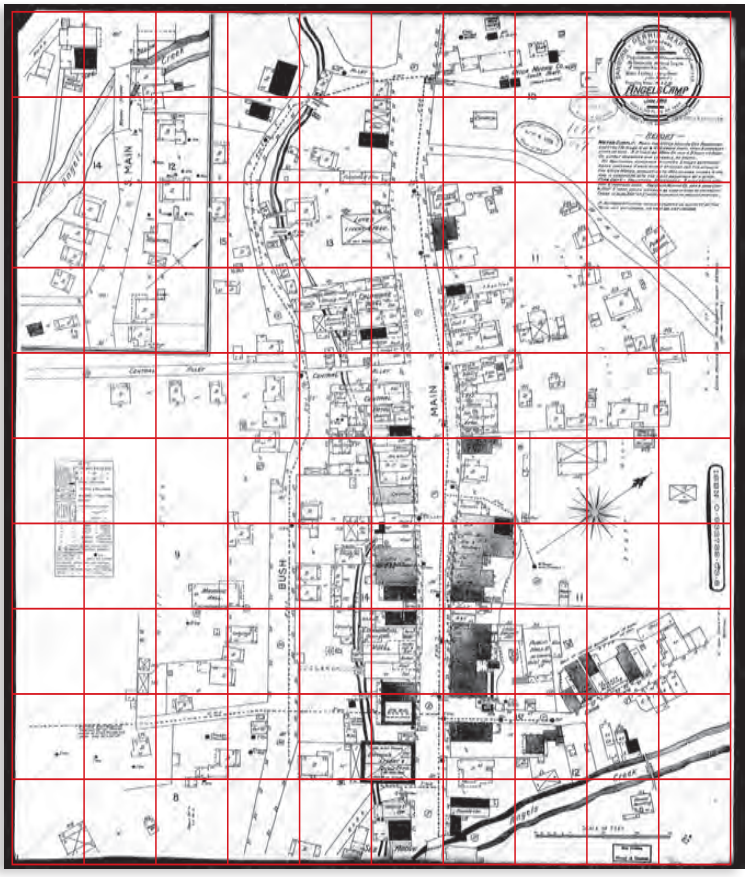


Use this grid for the Angels Camp maps on pages 20–21 of the Student Workbook..



Sample showing grid placement on the images / maps.





1. Resolution from the Graffort Women's Club of Portsmouth, New Hampshire:

http://www.archives.gov/legislative/features/hetch-hetchy/graffort.html

Edited text from letter:

Portsmouth, New Hampshire, February 4, 1910

Dear Honorable Jacob H. Gallinger, U.S. Senator:

The Graffort Women's Club of Portsmouth, New Hampshire, is opposed to the dam for the following reasons:

- The Hetch-Hetchy Valley is one of the grandest and most important features of the great Yosemite National Park belonging to the 90 millions of people that live in the United States;
- This valley is threatened with destruction by those seeking a water supply for San Francisco and the use of the park by the public would thereby be seriously restricted;
- The integrity of our whole National Park system is at risk if San Francisco is granted the right to build a dam in Hetch-Hetchy Valley, which is in a National Park;
- The need for great public playgrounds is becoming vastly greater instead of diminishing;
- Eminent engineers report that this proposed invasion of a national wonderland is wholly unnecessary and that San Francisco can get an abundance of pure water elsewhere.

We are opposed to such a needless local use of a priceless national possession in which the entire citizenship is interested.

Very respectfully,

Anne Howard, Secretary

2. Petition from the Hypatia Women's Club of SF

http://www.archives.gov/legislative/features/hetch-hetchy/hypatia.html

Edited text from letter:

San Francisco, February 5, 1910

Dear Honorable Frank P. Flint, U.S. Senator:

The Hypatia Women's Club of San Francisco has voted to request that the permission granted by the Government to San Francisco to take water from Lake Eleanor and the Hetch-Hetchy Valley be not revoked, for the following reasons:

1st. San Francisco has no other available supply of pure water that is sufficient.

2nd. Under the permit Lake Eleanor is to be first developed.

3rd. The Yosemite Park is an immense tract, while the Hetch-Hetchy Valley, where a reservoir is proposed, is a very small space not over a mile wide and not more than three or four miles long. The Hetch-Hetchy Valley is often flooded for long periods during storms and high water. The dam would just make a permanent reservoir and beautify this small piece of land.

4th. Yosemite Park of which this valley is so minute a portion, is a vast domain of almost inaccessible mountains, lakes and streams at a very high altitude and largely a region of perpetual snow. It is not, or never will be visited by large numbers of people at any one time.

5th. This vast supply of pure water is running away to the ocean through the river which empties out to the sea, while San Francisco is suffering for a supply of pure water.

6th. The individual who adores every bush or tree, and who would sacrifice the rights and needs of a great city for pure water is irrational and unjust.

7th. The chief and open opponent to the dam has been the Spring Valley Water Company, which has a monopoly of the present undesirable and inadequate water supply of San Francisco. They are only worried about losing money.

Respectfully submitted by,

Edith Webster, Secretary Hypatia Women's Club

3. Protest against diversion of waters from lands requiring irrigation from Citizens of Merced and Stanislaus Counties

http://www.archives.gov/legislative/features/hetch-hetchy/merced.html

Edited text from letter:

Protest Against Diversion of Waters from Lands Requiring Irrigation

Livingston, California, May 30, 1913

We are opposed to the damming of water in the Hetch-Hetchy Valley for the following reasons:

- The city and county of San Francisco are asking for a special act from congress granting to them certain rights and titles to the Tuolumne River;
- The city and county of San Francisco have stated they will divert the Tuolumne River water to points outside of the San Joaquin Valley for use other than those of irrigation;
- Reports of United States army engineers show that the entire run-off supply of the watershed to the San Joaquin Valley is necessary for the Valley's agricultural and commercial development;
- Conserving all of the waters of the San Joaquin Valley watershed, coming from the Tuolumne River, is of paramount importance to the very life of every county and community within the San Joaquin Valley;
- It has been clearly shown and proved by competent engineers that San Francisco can secure an adequate supply of water for its own use from other sources;

Therefore, the 2,000 citizens of Merced and Stanislaus counties, in the San Joaquin Valley, protest strongly against the city and county of San Francisco diverting the Tuolumne River water. The senators and representatives of the state of California must come together to protect the agricultural and commercial interests of the San Joaquin Valley. The Tuolumne River water is needed to irrigate the crops growing in the lands of our valley.

E.S. Ellis, President of the Day

4. Petition from the American Scenic and Historic Preservation Society

http://www.archives.gov/legislative/features/hetch-hetchy/scenic.html

Edited text from letter:

June 25, 1913

Dear Honorable George E. Chamberlain, Chairman of the Public Lands Committee, U.S. Senate:

We respectfully and earnestly protest against the granting by Congress to the City of San Francisco of any portion of the Yosemite National Park.

This wonderful region, including the Hetch-Hetchy Valley, was set aside for the preservation of great natural monuments for the use of all the people. To give it away to San Francisco is a wrong to the rest of the nation. It would also be a return to the commercial treatment of public lands and would take away the importance of setting aside National Parks. We believe that with thoughtful consideration, not only California but the whole country would vote against the project.

The effort to show that the Hetch-Hetchy Valley is the only abundant source of good water for the city has failed. Official representatives of San Francisco confessed that the city could get a good supply of water anywhere along the Sierra if they paid for it. The project involves the destruction of one of the most beautiful valleys in the world and one of the very few camping places in Yosemite National Park. This destruction is unnecessary as a means of supplying the city with good drinking water.

Indeed, the object of the project is not so much water for drinking purposes, but for using water as power. Once Yosemite National Park is given over to this purpose, the rest of the country's national parks are in danger of the same thing happening. For this very reason, many years ago, Theodore Roosevelt opposed the commercial invasion of the Yellowstone Park. In this matter, Congress is responsible for caring for national parks.

Yours very truly,

George King, President

5. Petition from the Society for the Preservation of National Parks

http://www.archives.gov/legislative/features/hetch-hetchy/preservation.html

Edited text from letter:

San Francisco, June 27, 1913

Dear Honorable George Chamberlain, Senator:

The Yosemite National Park is not only the greatest and most wonderful national playground in California, but in many of its features it is without a rival in the whole world. It belongs to the American people and in world wide interest ranks with Yellowstone and the Grand Canyon. Yosemite National Park contains the head waters of two rivers – the Merced and the Tuolumne.

The Hetch Hetchy Valley is a wonderfully exact counterpart of the great Yosemite, not only in its cliffs and waterfalls and peaceful river, but in the gardens, groves, meadows and camp grounds of its flowery park-life floor. Damming this site would take away from 90 million people one of their most priceless possessions for the sake of saving San Francisco dollars.

San Francisco may be in immediate need of an increased supply of water. But engineers admit that the present supply can be more than doubled by adding nearby sources. That is the first and most economic plan of development before the city eventually goes to the Sierra for additional water.

Ever since the establishment of Yosemite National Park by Act of Congress, October 8th, 1890, constant battles have been going on between good and evil around its boundaries. On behalf of all of the people of the nation, we ask your aid in putting an end to these assaults on our great national parks.

Faithfully yours,

John Muir

6. Telegram from the Executive Board of the San Francisco District of the California Federation of Women's Clubs

http://www.archives.gov/legislative/features/hetch-hetchy/executive.html

Edited text from letter:

San Francisco, December 2, 1913

Dear Senate of the United States:

The Executive Board of the San Francisco District of the California Federation of Women's Clubs, representing a membership of 6,000 women voters of San Francisco and surrounding communities, is in support of the Raker Hetch-Hetchy Bill to dam the valley.

We women have been face to face with the water problem of San Francisco for many years and know it as no other women can. We have given careful thought to the problem. Many of our homes in San Francisco are without fire protection due to the lack of availability of sufficient water. Our families' health is in danger because we have to cook and clean with water from questionable sources.

We do not agree with those people who think Hetch Hetchy will be less picturesque than in its natural state when a beautiful lake covers the valley floor. This is a minor issue when considered against San Francisco's desperate need of water.

Mrs. Percy S. Shuman, President

7. Resolution by the Massachusetts State Federation of Women's Clubs

http://www.archives.gov/legislative/features/hetch-hetchy/massachusetts.html
Edited text from letter:

Boston, Massachusetts, November 1913

Dear Sir:

We are against the damming of the Hetch-Hetchy Valley for the following reasons:

- The Hetch-Hetchy Valley contains some of this country's most wonderful scenery and most stimulating resources for recreation;
- This valley belongs to all the people and is used and enjoyed by Americans from the East as well as the West;
- It is not, as has been stated, an inaccessible region of barren granite of no possible use to humanity except through the production of water and power. Instead, it is visited each summer by large parties of women as well as men who find health and inspiration as campers upon its fertile floor of matchless beauty;
- Better transportation facilities with hotels and permanent camps which might readily be supplied by the Federal Government would allow more people to benefit from this sublime recreation ground;
- The use of the Hetch-Hetchy Valley as a water supply for the city of San Francisco would destroy its use and enjoyment by all of us as a park and recreation ground;
- With growing population the areas for public playgrounds are diminishing while the need for them is increasing;
- Handing over part of a national park to a city would set a precedent for it happening again in the future;
- The dam project has been pronounced by eminent engineers as wholly unnecessary since San Francisco has other sources of abundant water supply, some even more available than Hetch-Hetchy.

Because of these reasons, we oppose this needless and irrevocable sacrifice by the whole nation of an invaluable possession and we petition the United States President and our Senators to defeat the bill.

Signed,

Mrs. George W. Perkins, President

8. Resolution from the Augusta, Hallowell, and Gardner Central Labor Union of Maine

http://www.archives.gov/legislative/features/hetch-hetchy/labor.html

Edited text from letter:

Maine, December 1913

Dear Sir:

We support the damming of the Hetch-Hetchy Valley for the following reasons:

- San Francisco has been, for 12 years, asking the Federal government for rights in the Sierras so they can provide their community with a pure and adequate supply of water;
- The Hetch-Hetchy region is the only source for San Francisco that has an uncontaminated water supply that will provide the immediate and future needs of its people;
- All that San Francisco asks of the Federal government is the right to construct a dam which will create a water reservoir and beautiful lake in the Hetch-Hetchy Valley;
- The natural beauties of the Hetch Hetchy region will be made more easily accessible to thousands of nature lovers due to the building of roads and trains which San Francisco will construct into this entire region;
- Human consumption is the highest use to which the Hetch Hetchy water can be put, in that it will safeguard the health and supply the present needs of a community of 800,000 people, and the future needs of many times that number.

For these reasons, the Augusta, Hallowell, & Gardner, Central Labor Union declares its firm conviction that human needs are more important than the sentimental objections of so-called "nature lovers" who profess to see, in San Francisco's project, a destruction of nature. Especially because the work of San Francisco in the high Sierras will, in reality, bring this wonderful region closer to the real lovers of nature, and will not impair the grandeur of the scenery.

F.B. Tohan, President

9. Petition from San Francisco Swedish Clubs

http://www.archives.gov/legislative/features/hetch-hetchy/swedish.html

Edited text from letter:

December 1913

Dear Honorable A.J. Gronna:

The organizations representing the Swedish residents of the City of San Francisco are in favor of obtaining water from the Hetch-Hetchy Valley. It is absolutely essential to the future welfare of the city that the bill be passed when it comes before the United States Senate.

Our need is imperative. No sound arguments have been presented against devoting this water supply to its highest possible use, which is to provide the people of a large city with a pure and adequate supply of water, and to insure the city against any possible recurrence of a water shortage which now threatens.

Hetch-Hetchy is the only adequate available water supply to which San Francisco can turn. Suggested alternative supplies are either inadequate or involve an expenditure of money which the city cannot at this time meet, due to the heavy financial burden the city is now bearing as a result of restoring public buildings and public works destroyed in the fire of 1906.

The construction of the proposed dam will not affect the beauty of the valley, but will rather enhance it by placing there a beautiful lake and building roads which will make accessible a region now visited only by a few hardy camping parties.

We earnestly request you to help us.

Signed,

The Worlds Fair Committee of the Swedish

The Swedish Singing Society

The United Swedish Singers of the Pacific Coast

The Swedish Society of San Francisco

The Swedish – American Patriotic League of California

Odin Lodge

10. San Francisco Examiner Petition to the Senate of the United States

http://www.archives.gov/legislative/features/hetch-hetchy/examiner.html

Edited text:

To the Senate of the United States:

We, the undersigned citizens of California, ask your favorable action on the bill giving San Francisco the right to use the water of the Hetch-Hetchy Valley.

The Tuolumne River in the Hetch-Hetchy Valley is the only available water supply not under private ownership. San Francisco owns three-fourths of the land in that valley because the city pays for it. We only require your favorable action on this bill to let us utilize our ownership of that land so that it will provide us with a water supply without which the future of San Francisco is endangered.

San Francisco's need of this water supply is urgent and imperative. Without it the city is beaten; its health menaced; its development blocked.

The Government of the United States has completed the Panama Canal (which connects the Atlantic and the Pacific Oceans by cutting across Central America). One of the principal benefits of the Canal was the development of the western edge of the United States, of which San Francisco is the main city. San Francisco cannot benefit from the Panama Canal if a sufficient water supply is withheld from the city. The water supply is capable of sustaining the health and life of the community.

We ask for simple justice. You have already granted to Seattle, Portland, and Los Angeles the use of federal reserved lands that gave those cities the water supplies they needed.

The need of no city ever has been so great as the need of San Francisco in this emergency. We ask your favorable vote on this bill, which will give San Francisco the only available water supply adequate for its present and future needs.

Signed,

Citizens of California

11. 1913 Testimony before the House Committee on Public Lands

Herbert Parsons (former Congressman)

http://www.sfmuseum.org/hetch/hetchy11.html

Edited text:

I appear in opposition to the bill. I appear as a nature lover. I was a member of the Sixtieth Congress and of the Public Lands Committee of the House of Representatives of that Congress. The matter of Hetch Hetchy as a reservoir for San Francisco, being taken up, was exhaustively considered. I took the position then that if San Francisco absolutely needed Hetch Hetchy Valley as a reservoir, San Francisco should have it, but the burden of proof was on San Francisco to show that she could not get another source of supply.

One argument made then before that committee was that instead of the reservoir spoiling Hetch Hetchy it would make it still more beautiful. I made up my mind that at the first opportunity I would go there to see for myself.

The beauty of the Hetch Hetchy is the floor of the valley. The valley gives you a park-like effect. There is a considerable variety of trees. The beauty of the valley consists in the meadows and trees, combined with the rocks and the river meandering through.

You do not need a lake in the Hetch Hetchy Valley in order to induce people to go there. The valley of Yosemite Park is filled with lakes. There are lakes everywhere.

You do not need a reservoir in Hetch Hetchy in order to have a rock-bound lake. The impressive part of Hetch Hetchy is that, after you have traveled through the park, through what you might call its waste portions and its rock-bound lakes, you come down to this gem of a valley, with its meadows, ferns, and trees, and the river meandering through. Its the beauty of the floor of the valley which will be absolutely destroyed by the reservoir.

You get better perspectives of the rocks and the trees and the floor of the valley and the river in the Hetch Hetchy than you do in the Yosemite itself. It has a charm which the Yosemite has not.

There is another feature which was recalled to my mind when I read over the diary I kept on that trip, and that is that in the Hetch Hetchy there are more nature sounds than there are in any other part of the park which I visited. Nature sounds-the fish and deer and particularly the birds. I suppose that is natural in view of the features of the valley and its being a place where birds would naturally come.

Now, one argument in opposition. It comes down to a question whether this valley, having been taken by the people of the United States because of its remarkable scenery and having been preserved in that way, is to be given to San Francisco for a reservoir when San Francisco does not absolutely need it. As I understand from Col. Biddle's testimony before the House committee, San Francisco can get a water supply elsewhere, but it is cheaper to get it in Hetch Hetchy. San Francisco would have to spend $20,000,000 more for a water source elsewhere. But now if San Francisco gets it, it will not cost the city so much, because the people of the United States have preserved it for the people of the United States.

It does not seem to me, with all due respect to San Francisco, that it is a fair proposition to all the people of the United States that they should give up to San Francisco what they have preserved for scenic purposes, when if it had not been preserved for scenic purposes it probably would have cost San Francisco just as much as any other source.

I know the objection is made that very few people go into the valley. Well, that is true of all reservations (national parks). We find that after a while people come in greater numbers, and there is no question that in time the numbers who go to Hetch Hetchy Valley will enormously multiply.

Lesson 6 — Role Playing Narratives

12. 1913 Testimony before the House Committee on Public Lands

Gifford Pinchot, the first Chief Forester of the United States

http://historymatters.gmu.edu/d/5721

So we come now face to face with the perfectly clean question of what is the best use to which this water that flows out of the Sierras can be put. As we all know, there is no use of water that is higher than the domestic use. Then, if there is, as the engineers tell us, no other source of supply that is anything like so reasonably available as this one; if this is the best, and, within reasonable limits of cost, the only means of supplying San Francisco with water, we come straight to the question of whether the advantage of leaving this valley in a state of nature is greater than the advantage of using it for the benefit of the city of San Francisco.

Now, the fundamental principle of the whole conservation policy is that of use, to take every part of the land and its resources and put it to that use in which it will best serve the most people, and I think there can be no question at all but that in this case we have an instance in which all weighty considerations demand the passage of the bill. There are, of course, a very large number of incidental changes that will arise after the passage of the bill. The construction of roads, trails, and telephone systems which will follow the passage of this bill will be a very important help in the park and forest reserves. The national forest telephone system and the roads and trails to which this bill will lead will form an important additional help in fighting fire in the forest reserves. As has already been set forth by the two Secretaries, the presence of these additional means of communication will mean that the national forest and the national park will be visited by very large numbers of people who cannot visit them now. I think that the men who assert that it is better to leave a piece of natural scenery in its natural condition have rather the better of the argument, and I believe if we had nothing else to consider than the delight of the few men and women who would yearly go into the Hetch Hetchy Valley, then it should be left in its natural condition. But the considerations on the other side of the question to my mind are simply overwhelming, and so much so that I have never been able to see that there was any reasonable argument against the use of this water supply by the city of San Francisco.

13. 1913 Testimony before the House Committee on Public Lands

James Phelan, former San Francisco Mayor

http://historymatters.gmu.edu/d/5721

Edited text:

The needs of San Francisco are pressing and urgent. San Francisco is expanding with tremendous rapidity due to the development of the interior of California and to the prospect of the early opening of the Panama Canal (connecting the Atlantic and Pacific Oceans through Central America).

A large number of our population has been lost to Oakland, Alameda, and Berkeley, because we have never had adequate facilities either of transportation or of water supply to meet what would otherwise be a demand for residences on the peninsula. So San Francisco asks the Federal Government for assistance in this matter by grant and not by money. It has obligated itself to pay $70,000,000 for a water supply.

We have pride in the beauties of California, in the valleys, in the big trees, in the rivers, and in the high mountains. Even for a water supply we would not injure the great resources which have made our State the playground of the world. By constructing a dam at this very narrow gorge in the Hetch Hetchy Valley, about 700 feet across, we create, not a reservoir, but a lake, because Mr. Freeman, who has studied a similar case, has shown that by planting trees or vines over the dam, the appearance of a dam is entirely lost; so, coming upon it, it will look like an emerald gem in the mountains; and one of the few things in which California is deficient, especially in the Sierras, is lakes, and in this way we will contribute to the scenic grandeur and beauty of California.

To provide for the 800,000 people of San Francisco Bay is a matter of much greater importance than encouraging the few who, in solitary loneliness, will sit on the peak of the Sierras enjoying nature. There is no comparison between the highest use of the water—the domestic supply—and the mere scenic value of the mountains. When you decide that affirmatively, as you must, and then, on top of that, that we are not detracting from the scenic value of the mountains, but enhancing it, I think there is nothing left to be said.

14. 1913 Testimony before the House Committee on Public Lands

Letter from Robert Underwood Johnson presented during Testimony

http://historymatters.gmu.edu/d/5721

Edited text:

What is at stake is not merely the destruction of a single valley, but the fundamental principle of conservation. Let it be established that these great parks and forests are to be held at the whim or advantage of local interests and sooner or later they must all be given up. One has only to look about to see the rampant materialism of the day. It can only be overcome by a constant regard for ideas and for the good of the whole country now and hereafter.

The opponents of the Hetch Hetchy scheme maintain that their position is not harmful to the true interests of San Francisco. They say if there were no other source of good and abundant water for the city they would willingly sacrifice the valley to the lives and the health of its citizens. The records of the hearing before the Senate Committee on Public Lands two or three years ago show that two official representatives of the city (one, ex-Mayor Phelan) confessed that the city could get water anywhere along the Sierra if the city would pay for it. This is the crux of the whole matter. The assault upon the integrity of the park has this purpose—to get something for nothing. Mr. Freeman, the engineer employed by the city, has also stated that it is physically possible to get water anywhere along the Sierra. It has not been demonstrated that Hetch Hetchy is the only available source, but only that it might be the cheapest. On this point we hold that while we are willing to die for the lives or the health of the citizens of San Francisco, we are not willing to die for their pockets.

The opponents of the bill invite your careful attention to the fact that whereas at first the scheme was put forward as one appealing to humane instincts—to provide a great city with potable water—it is now clearly seen to be aiming at quite another purpose—the production of power for use and for sale. This is commercialism pure and simple.

I have not yet spoken of the great recreative, curative, and hygienic uses of the park. It contains three considerable camping spots—the Yosemite Valley, now greatly crowded every summer; the Tuolumne Meadows, and the Hetch Hetchy. The second is much more difficult of access than the third, and both would be withdrawn from public use by the operation of the proposed bill, for it would be idle to take the valley for a reservoir without giving to the city full control of the watershed, since a single case of typhoid infection would endanger the health of the city. The population of the San Joaquin Valley, in the hot and dusty summer, increasingly frequent the park as campers. These would be deprived of the use of these wonderful scenes.

I have only time for one other point. In 1890, when I appealed to Senator George Hearst to support the bill creating the Yosemite National Park, a project which, as is well known, was first proposed by me to Mr. Muir in 1889, and was jointly urged by us upon Congress, that practical Senator assented with alacrity, and in effect said, “The chief use of that region is for water for irrigation purposes and for its scenery.”

I have the honor to remain, respectfully yours,

Robert Underwood Johnson

15. Water and power for San Francisco from Hetch-Hetchy Valley in Yosemite National Park.

Martin Samuel Vilas, Published in 1915

http://memory.loc.gov/cgi-bin/ampage?collId=amrvg&fileName=vg24//amrvgvg24.db&recNum=17&itemLink=r%3Fammem%2Fconsrvbib%3A%40FIELD.%28NUMBER%28vg24%29%29&linkText=0 and

http://memory.loc.gov/cgi-bin/ampage?collId=amrvg&fileName=vg24//amrvgvg24.db&recNum=18&itemLink=r%3Fammem%2Fconsrvbib%3A%40FIELD.%28NUMBER%28vg24%29%29&linkText=0 and

http://memory.loc.gov/cgi-bin/ampage?collId=amrvg&fileName=vg24//amrvgvg24.db&recNum=24&itemLink=r%3Fammem%2Fconsrvbib%3A%40FIELD.%28NUMBER%28vg24%29%29&linkText=0 and

http://memory.loc.gov/cgi-bin/ampage?collId=amrvg&fileName=vg24//amrvgvg24.db&recNum=25&itemLink=r%3Fammem%2Fconsrvbib%3A%40FIELD.%28NUMBER%28vg24%29%29&linkText=0

Edited text:

City Engineer M. M. O'Shaugnessy of San Francisco testified before the House Committee on the Public Lands in Washington, June, 1913 that this city now needs 75,000,000 gallons of water per day and that about one-third of the city is without water and obliged to haul it in barrels and wagons.

The present plans of the city provide for its water needs as far ahead as the year 2000.

The Bay section is the largest urban section in California and is doing more business than any other. Its growth is rapid. San Francisco is coming into control of all her municipal utilities. The four great cities on the Bay are one in interest. This water power will be of tremendous commercial advantage to these cities. To desire to obtain this water power, is not sordid commercialism or base greed on the part of this section. It is an endeavor to make use of the beneficial forces of nature. It is evidence of a high state of advanced civilization. It is a manifestation of enlightened government. It is fitting and highly proper. It is a cause for praise to this city.

That the lake in Hetch-Hetchy will not add to the attractiveness of the beautiful valley is undetermined. Opinions are divided. The lake and its accessories will be the means of bringing thousands to a spot that before was secluded, isolated, and to many, inaccessible.

San Francisco may obtain this water, as good as any in the world, and sufficient for her thousands to come for the next 100 years. She may thereby obtain such water power as during the same time will cause all the wheels of industry on her great Bay to whirl and to whirr. Yet the Yosemite National Park in the entire and Hetch-Hetchy in particular will remain, visited by more than ever before, a thing of beauty and a joy unto the ages yet to be.


3

Appendix: Projectables

Louise and William's Forest

Illustration by Julia Rigby

Tree	Height (feet)	DBH (inches)
A	250'	168"
B	220'	144"
C	180'	60"
D	200'	120"
E	250'	84"
F	32'	15"
G	64'	30"
H	48'	20"

Directions: You need to know the diameter, in inches, at breast height (DBH) and the height, in feet, of the tree. Use these to calculate the number of board feet that can be harvested from Trees A, F, G, and H from this forest. For some trees you will use your calculator and the formula below. This formula assumes the tree's shape is neiloid. But it doesn't account for the thickness of the bark, or how much waste there will be in cutting.
You will be able to use the Scribner Decimal C chart (on page 16) for some of the trees. It assumes one-quarter inch saw cut (called kerf), one-inch thick boards, and that the tree is a cylinder shape. You will also notice you need to add a "0" to the number from the chart to get the board-foot measurement.

Calculation Process for Each Tree: $V = (¼)\ \pi \times r^2 \times h$ (volume for a neiloid)

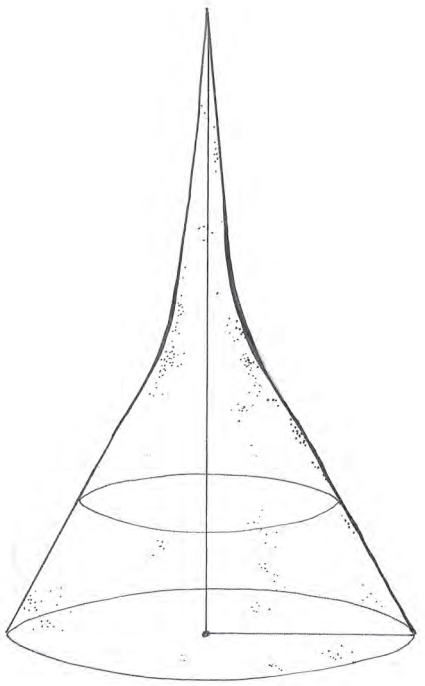
1. Divide DBH by 2 to get the **radius** (r).
2. **Convert** the radius from inches to feet so all the units of measurement are the same. You can do this by multiplying by a fraction equal to 1, or by using proportions and cross-multiplying *(see examples of both methods on the next page)*.
3. Find the **area** of the tree in feet: $\pi \times r^2$ (use $\pi = 3.14$)
4. Find the **volume** of the tree in cubic feet: Area (ft.) × height (ft.)
5. **Divide** the answer from Step #4 **by 4** to account for tapering (narrowing) of the tree at the top.

This completes the calculation of the volume for a neiloid.

Now we need to **convert volume in cubic feet to board feet.**

6. **Multiply** the answer from Step #5 (tapered volume in cubic feet) **by 12** because there are **12 board feet in one cubic foot.** *(This does not account for the cutting process. In reality there might be five to eight board feet in one cubic foot due to the saw width and waste.)*
7. **Add** all the board feet measurements from each tree to determine **the total board feet** that can be harvested from this forest.

Example Calculation
Tree DBH = 40 inches
Tree Height = 100 feet


a neiloid shape

Step #1: Divide DBH by 2 to get the radius (r).
40 inches ÷ 2 = 20 inches

Step #2: Convert 20 inches to feet using one of these two alternatives:

Alternative #1: Multiplying by 1, example:

$$20 \text{ inches} \times \frac{1 \text{ foot}}{12 \text{ inches}} =$$

$$\frac{20 \text{ feet}}{12} = 1.67 \text{ feet} = \textbf{radius} \text{ in feet}$$

Alternative #2: Using Proportions and Cross-Multiplying, example:

$$\frac{20 \text{ inches}}{\text{r foot}} = \frac{12 \text{ inches}}{1 \text{ foot}}$$

Cross multiply: $20 \times 1 = 12 \times r \qquad 20 = 12r$

Isolate the r by dividing both sides by 12
$20 \div 12 = r = 1.67$ feet = **radius** in feet

Step #3: Find the **area** of the tree in feet: $\pi \times r^2$ (use π=3.14 and r = radius in feet)
$3.14 \times 1.67 \text{ feet} \times 1.67 \text{ feet} = 8.76 \text{ feet squared} = 8.76 \text{ feet}^2 =$ **area**

Step #4: Find the **volume** of the tree in cubic feet: area (feet^2) × height (feet)
$8.76 \text{ feet}^2 \times 100 \text{ feet} = 876 \text{ feet cubed} = 876 \text{ feet}^3$

Step #5: Divide the answer from Step #4 by 4 to account for tapering (narrowing) of the tree at the top.
$876 \text{ feet}^3 \div 4 = 219 \text{ feet}^3$

Step #6: Multiply the answer from Step #5 (tapered volume in cubic feet) by 12 because there are 12 board feet in one cubic foot. This is a conversion:

$$\frac{1 \text{ feet}^3 \text{ (V)}}{12 \text{ board ft.}} = \frac{219 \text{ feet}^3}{? \text{ board ft.}}$$

Cross multiply

$219 \text{ feet}^3 \times 12 = 2628$ board feet

Answer:

According to this formula, there are 2,628 board feet in a tree with DBH = 40 inches and a height of 100 feet.

Calculation Space:

Tree volume table based on Scribner Decimal C rule.*

Diameter 4½ feet above ground (inches)	16 foot log	32 foot log	48 foot log	64 foot log
	Volume in board feet			
10	3	4		
11	4	6		
12	5	8	10	
13	6	9	12	
14	7	11	15	
15	8	14	18	
16		16	21	25
17		18	25	29
18		21	26	33
19		24	32	38
20		27	26	41
21		30	41	49
22		34	46	55
23		37	51	61
24		41	46	66
25		45	62	74
26			68	81
27			74	89
28			80	96
29			86	104
30			93	112

*The figures shown in this table must be multiplied by 10 to obtain board foot values.