SUSTAINABLE MOUNTAIN DEVELOPMENT

NORTH AMERICAN REPORT

Principal Researcher: Rebecca J. Wallace

Rebecca J. Wallace, Karinjo DeVore
Aspen International Mountain Foundation

Pamela Lifton-Zoline, John Lifton-Zoline
The Telluride Institute

A REPORT SUBMITTED FOR

RIO+20

January 2012

ACKNOWLEDGEMENTS

In late October 2011, the Aspen International Mountain Foundation and the Telluride Institute learned that no one was preparing a report on North America's mountains for the Rio+20 Summit. We knew then that we could not meet the November 2011 deadline to submit a comprehensive report, but we decided to try to pull together a sufficient amount of information that could serve as a placeholder for North America. Our goal was to produce a report by early January 2012.

As a result of posting a data call on the Mountain Forum Listserv and writing dozens of emails, we received numerous responses to our request for information, despite the extremely short deadline requested. We want to thank all of our contributors, without whom there would be no North American report. A special thanks goes to Dr. Baktybek Abdrisaev and his political science students at Utah Valley University who drafted the mountain range descriptions found in the Appendix to the report. Finally, we owe our deepest thanks and appreciation to Dr. Jane Pratt, whose advice and encouragement gave us the courage to undertake what, we thought, was an impossible task.

Contributors

Baktybek Abdrisaev, Ph.D.
Steve Berwick, Ph.D.
Robert Blair
William Bowman, Ph.D.
Gillian Bowser, Ph.D.
Mark Brown, Ph.D.
Ashley Cantrell
Joni Cooper
Hume Davenport
Carmen Ghanim
Maria Gunnoe
Toby Harper
Alison Hill
Stella Joy
Burt Lauderdale
John Leonard
Peter McBride
Lauren Mc Donell
Laurence A.G. Moss
Koren Nydick, Ph.D.
David Orr, Ph.D.
Scott Powell
Jane Pratt, Ph.D.
Mary Riddle
Regina Rochefort, Ph.D.
Auden Schendler
Christina Tague, Ph.D.
Utah Valley University
Western Mountain Initiative
John Weiner, Ph.D.

SUSTAINABLE MOUNTAIN DEVELOPMENT

NORTH AMERICAN REPORT

Principal Researcher:
Rebecca J. Wallace

Rebecca J. Wallace
Karinjo DeVore
Aspen International Mountain Foundation

Pamela Lifton-Zoline
John Lifton-Zoline
The Telluride Institute

A REPORT SUBMITTED FOR

RIO+20

January 2012

ASPEN INTERNATIONAL MOUNTAIN FOUNDATION
AIMF

TELLURIDE INSTITUTE

Formally organized in 2001 in the heart of the Rocky Mountains, the Aspen International Mountain Foundation (AIMF) evolved from a decade of working collaboratively with the United Nations' Environment Program, the City of Aspen, the Aspen Institute, Aspen Sister Cities, and other public and private organizations that produced a series of international conferences focusing on issues facing mountain communities. A Colorado nonprofit corporation, 501(c)3, AIMF is dedicated to promoting sustainable development in the world's mountain communities.

Telluride Institute was founded 28 years ago to create strong local environmental and cultural activities. Our programs demonstrate innovative and practical methods for building and sustaining healthy communities and environments. Rocky Mountain News called us "the World's highest altitude think tank", and others have called us a "think-and-do-tank" because of the practical, hands-on, results-oriented nature of our programs. We work both locally and globally to meet Wallace Stegner's challenge to Westerners to "build a society to match the scenery".

TABLE OF CONTENTS

ACKNOWLEDGEMENTS	ii
ACRONYMS	vi
INTRODUCTION	3
NORTH AMERICAN MOUNTAIN RANGES	5
Alaskan Range	5
Appalachian Mountains	5
Cascade Range	6
Laurentians	6
Coast Ranges	6
Rocky Mountains	7
Sierra Nevada Range	8
Sierra Madre Mountains	8
PHYSICAL ATTRIBUTES AND ISSUES	10
Water	10
Glaciers	13
Minerals	16
BIOLOGICAL/ECOSYSTEM ISSUES	17
Biodiversity	17
Climate Change	19
HUMAN/MOUNTAIN INTERACTIONS	23
Encroachment/Wildland-Urban Interface	23
Conservation/Protected Areas	26
Recreation/Ecotourism	29
Mountain Events and Culture	30
Mineral Extraction	31
Poverty/Wealth Discrepancies	39

SUSTAINABLE DEVELOPMENT—TAKING ACTION 41

Trans-boundary Cooperation/Collaboration 41
Climate Adaptation Strategies/Land Management 45
Education/Research 46
Renewable Energy Initiatives 49
Other Sustainable Practices 51

MEETING THE CHALLENGE 52

REFERENCES 53

FIGURES

Figure 1: Snowmass Mountain 2
Figure 2: North America's Mountains 4
Figure 3: Colorado River Delta 11
Figure 4: Recession of Grinnel Glacier 14
Figure 5: Recession of Exit Glacier 15
Figure 6: Water Quality Discharge Facilities in Kentucky with Water Quality Violations 17
Figure 6: Gas wells, southwest Virginia 33
Figure 7: Coal Trucks, Kent Mason TNC, West Virginia 35
Figure 8: Water Quality Discharge Facilities in Kentucky with Water Quality Violations 36
Figure 9: Connections Between Coal-Fired Power Plants and Mountaintop Removal Mines 38
Figure 10: Unemployment Rates and Poverty Rates in Appalachia 40
Figure 11: Coal Production and Mining Employment Over Time 40

APPENDICES A1

Appendix 1: Alaskan Range A3
Appendix 2: Appalachian Mountains A6
Appendix 3: Cascade Range A11
Appendix 4: Laurentians A14
Appendix 5: Coast Ranges A17
Appendix 6: Rocky Mountains A20
Appendix 7: Sierra Nevada Mountains A23
Appendix 8: Sierra Madre Mountains A27

ACRONYMS

ACC	Alpine Club of Canada
ACP	Appalachian Carbon Partnership
ARC	Appalachian Regional Commission
CBFA	Canadian Boreal Forest Agreement
CCE	Crown of the Continent Ecosystem
DOE	U.S. Department of Energy
EIS	Environmental Impact Statement
EKPC	East Kentucky Power Cooperative
EPA	U.S. Environmental Protection Agency
FONSI	Finding of No Significant Impact
GHG	Greenhouse gas
KFTC	Kentuckians for the Commonwealth
MACED	Mountain Association for Community Economic Development
MRS	Mountain Research Station
MSI	Mountain Studies Institute
MTR	Mountaintop removal
NCAP	North Cascadia Adaptation Partnership
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
NRDC	Natural Resources Defense Council
PEIS	Programmatic Environmental Impact Statement
RMCO	Rocky Mountain Climate Organization
SMCRA	Surface Mining Control and Reclamation Act
SMD	Sustainable mountain development
TECO	Tampa Energy Company
TMDL	Total Maximum Daily Load
UNESCO	United Nations' Educational, Scientific and Cultural Organization
USGS	U.S. Geological Survey
UVU	Utah Valley University
WCI	Western Climate Initiative
WMI	Western Mountain Initiative
Y2Y	Yellowstone to Yukon Conservation Initiative

SUSTAINABLE MOUNTAIN DEVELOPMENT

NORTH AMERICAN REPORT

Principal Researcher:
Rebecca J. Wallace

Rebecca J. Wallace
Karinjo DeVore
Aspen International Mountain Foundation

Pamela Lifton-Zoline
John Lifton-Zoline
The Telluride Institute

A REPORT SUBMITTED FOR

RIO+20

January 2012

Figure 1: Snowmass Mountain
Photo: Peter McBride

"Snowmass Mountain (14,092 feet) stands above the Roaring Fork River - a tributary of the Colorado R. Up to 90 % of the river's water comes from snowmelt. The Rockies recently are often coated with red dirt blown by wind from deserts throughout the Colorado River Basin, and sometimes, from as far away as China. Instead of reflecting the heat, the dirty snow absorbs it, evaporates, and melts prematurely. This recent phenomenon - caused by desert development on fragile soils and climate change - sends the source water downstream a month earlier, affecting irrigation and planting cycles throughout the basin while increasing reservoir evaporation."

Jonathan Waterman, Peter McBride, *The Colorado River--Flowing Through Conflict*, Westcliffe Publishers, 2011

INTRODUCTION

If we consider the Earth as a home that is comprised of many floors and rooms, 'The Roof of the World' would be all of the Earth's mountainous regions. If the roof becomes destabilized, the rest of the house is threatened. Like the rest of the world's mountainous regions, the mountains of North America are experiencing many changes that impact the health of these fragile ecosystems and the people who live there.

This report begins with brief descriptions of North America's major mountain ranges. Next, it explores some of the critical issues they face. The 11 themes discussed are:

water
glaciers
minerals
biodiversity
climate change
encroachment/wildland-urban interface
conservation/protected areas
recreation/ecotourism
mountain events
mineral extraction
poverty/wealth discrepancies

Finally, the report highlights institutional/organizational initiatives on sustainable mountain development that are taking place within North America.

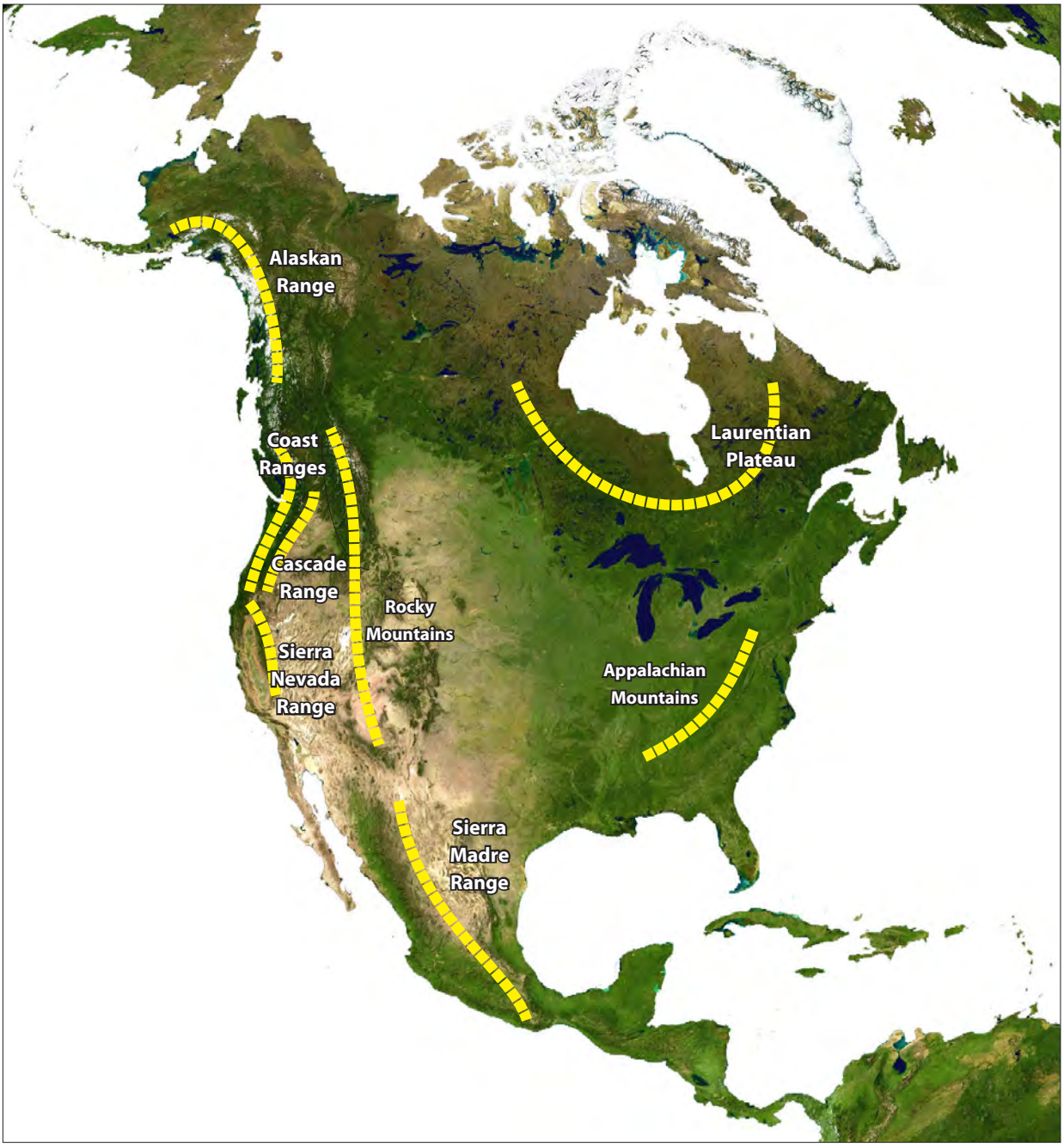

Figure 2: North America's Mountains

THE NORTH AMERICAN MOUNTAIN RANGES[1]

Mountains cover approximately 36 percent of North America's land mass. Wikipedia lists 284 mountain ranges within Canada, the United States, and Mexico, many of which are sub-ranges within larger ranges.[2] Among the more significant North American mountain ranges are the:

- Alaskan Range
- Appalachian Mountains
- Cascade Range
- Laurentians
- Coast Ranges
- Rocky Mountains
- Sierra Nevada Mountains
- Sierra Madre Mountains

ALASKAN MOUNTAINS

The Alaskan Mountains consist of three main mountain ranges that are northwestward continuations of the Rocky Mountains and the Pacific Mountain System. The Alaska Range to the southwest spans approximately 600 miles to where it merges with the Aleutian Range. The Aleutian Range includes the Aleutian archipelago and spans approximately 1,500 miles total. The Brooks Range is the region's northernmost range, located above the Arctic Circle, and spans approximately 620 miles (Encyclopædia Britannica Online).

The Alaskan Mountains are home to North America's highest peak, Denali (also known as Mount McKinley), which rises to approximately 20,320 ft (6,194m). Alaska is part of the "Pacific Ring of Fire" - the ring of volcanoes and associated mountains around the Pacific Ocean—and has more than 100 volcanoes and volcanic fields, many of them located in the Aleutian Islands. Earthquakes are fairly common, especially in the coastal areas (U.S. Geological Survey 1964).

The most notable glaciers and ice fields in the region are found within the Alaska and Aleutian Ranges. Many of the mountains in these ranges are heavily glaciated, with extensive ice caps covering most of the mountains. Malaspina is the largest glacier in the region with an area of approximately 1,500 miles^2. The Chugach and St. Elias ice fields are the most extensive highland and valley glaciers in North America (Encyclopædia Britannica Online).

APPALACHIAN MOUNTAINS

The Appalachian Mountains are the oldest mountain chain in North America. The Appalachian Mountain Range, as defined by the Appalachian Regional Commission (ARC), spans 205,000

1 Additional information on these ranges is included in the Appendices.
2 Different sources tend to describe the various mountain ranges in different ways, particularly with respect to the sub-ranges within larger mountain ranges.

miles^2, covering the entire state of West Virginia and sections of Alabama, Georgia, Kentucky, Maryland, Mississippi, New York, North Carolina, Ohio, Pennsylvania, South Carolina, Tennessee, and Virginia (Appalachian Regional Commission 2011). Although not recognized by the ARC, Appalachia also can be said to extend farther in all directions, including parts of Canada. The Appalachians consists of four geologically defined provinces: the Blue Ridge (southern Pennsylvania to northern Georgia), the Appalachian Plateaus (New York to north central Alabama), the Ridge and Valley (southeastern New York to Alabama), and the Piedmont (Virginia to northern Florida) (Byerly et al 2006). They have an average elevation of 3,000 ft; the highest peak, Mt. Mitchell in North Carolina, reaches 6,684 ft. The climate throughout the range is very diverse, in part due to its location on the polar front, which creates weather conditions such as "blizzards, ice storms, tornadoes, hurricanes, and extremes in temperature and precipitation (Constantz 2006)."

CASCADE RANGE

The Cascade Range (or Cascades) is a major mountain range in western North America, stretching 700 miles (1,130 km) from northern California through Oregon and Washington and into British Columbia, Canada. At its widest point, it is 80 miles (129 km) wide. Like the Alaskan Range, the Cascades are part of the "Pacific Ring of Fire". The tallest volcanoes of the Cascades are called the High Cascades and dominate their surroundings, often standing twice the height of the nearby mountains. They often have a visual height (height above nearby crestlines) of one mile (1.6 km) or more. The tallest peaks, such as the 14,411 ft (4,395 m) Mount Rainier (the highest peak in the range), dominate their surroundings for 50 to 100 miles (80 to 160 km). All of the known historic eruptions in the contiguous United States have occurred in Cascade volcanoes. The two most recent eruptions were Lassen Peak in 1914 to 1921 and a major eruption of Mount St. Helens in 1980. Minor eruptions of Mount St. Helens also have occurred since; most recently in 2006 (U.S. Geological Survey).

LAURENTIANS

The Laurentian Mountains are located in the province Quebec, Canada and are partially bounded by the Ottawa, St. Lawrence, and Saguenay Rivers. Principle sub-ranges in the Laurentian Upland are the Opeongo Hills, Misquah Hills, Huron Mountains, and the Porcupine Mountains. Although one of Quebec's official regions is called Laurentides, the mountain range runs through four other regions; Capitale-Nationale, Outaouais, Lanaudière, and Mauricie. The foothills of the Laurentians also extend into northeastern Ontario. The Laurentian Mountains are some of the oldest in the world, with rock dating over 540 million years old (Encyclopædia Britannica Online). Elevations in the Laurentians generally range from approximately 1,640 ft (500 m) to 3,280 ft (1,000 m), with Mont Raoul-Blanchard being its highest peak at 3,825 ft (1,166 m). Mont Tremblant, Mont Bleu, and Mont des Conscrits are the other highest peaks in the range.

COAST RANGES

The Coast Ranges in the United States consist of a series of ranges that run parallel to the Pacific Coast for more than 1,000 miles (1,600 km), from the Transverse Ranges of Southern California to the Olympic Ranges in west-central Washington State. The Northern Ranges consist of the

Olympic Range in Washington State, the Oregon Coast Range in Oregon, the Calapooya Range in Oregon, and the Klamath-Siskiyou Range in Oregon and northern California. The Southern Ranges consist of the Northern Coast Ranges in California, the Central California Coast Ranges in California, and the Transverse Ranges in California. The Coast Ranges have an average elevation of 3,300 ft (1,006 m) above sea level, but some peaks and ridges rise to more than 6,600 ft (2,000 m) (Encyclopædia Britannica Online).

The Pacific Coastal Plain is narrow, and in many cases the Coast Ranges plunge directly into the sea creating dramatic coastlines. The mountains of the Coast Ranges were formed by faulting and volcanism. The San Andreas Fault, a fracture in the Earth's crust, parallels the trend of the Coast Ranges from San Francisco Bay to the California/Mexico border, and earthquakes are common along that entire length. Precipitation is variable along the Coast Ranges. From northern California northward, the mountains are among the wettest in the world and support temperate rain forests. The southern reaches of the ranges are dry, with open forests rising from dry desert plains (Peakbagger.com 2012).

ROCKY MOUNTAINS

The Rocky Mountains (the Rockies) form the cordilleran backbone, a rugged and massive continuous mountain chain, of the great upland system that dominates western North America. They run more than 3,000 miles (4,800 km), from the Rio Grande in the State of New Mexico to the Liard River in British Columbia, Canada; covering more than 300,000 miles^2 (777,000 km^2). The Rockies are located between the Great Plains on the east (from which they rise abruptly for most of their length) and a series of broad basins and plateaus on the west, and span up to 300 miles (480 km) across. Notably, the Rocky Mountains form the Continental Divide, separating rivers draining into the Atlantic and Arctic Oceans from those draining into the Pacific Ocean.

The Rockies are divided into four sections:

- the Southern Rockies (primarily in the states of New Mexico, Colorado, and southern Wyoming). These are the highest section and boast many peaks above 14,000 ft (4,267 m), including Mt. Elbert and Mt. Massive (14,418 ft, 4,395 m), which are the highest points in the Rockies.

- the Middle Rockies, which are chiefly in the states of northeast Utah and western Wyoming

- the Northern Rockies, which are situated in the states of northeastern Washington, north and central Idaho, northwestern Wyoming, and western Montana

- the Rocky Mountain System of Canada. The Canadian Rockies are composed of two major sections; the high rugged peaks of the Canadian Rockies proper to the east, and the Columbia Mountains to the west.

There are over 35 ranges within the Rocky Mountains. Numerous national monuments, designated wilderness areas, and national parks are located in the Rockies, including Banff National Park in Canada and Yellowstone National Park (spanning Idaho, Montana, and Wyoming), which is the world's oldest national park (est. 1872).

SIERRA NEVADA RANGE

The Sierra Nevada Range in the United States runs along the western border of the State of Nevada and the eastern edge of the State of California. The range extends more than 400 miles (640 km) northward from the Mojave Desert to the Cascade Range of northern California, and approximately 70 miles (110 km) across east to west from California's Central Valley to the Basin and Range Province. The Sierra Nevada is basically a west tilting massive block of granite called a 'batholith', which was caused by major faulting (U.S. Geological Survey 2012).

The Sierra Nevada ("snow-capped mountain") is home to 2 national monuments, 20 wilderness areas, and 3 national parks, including Yosemite, Sequoia, and King's Canyon National Parks. The sequoia trees protected in the Sequoia National Park are the most massive trees in the world. The Sierra Nevada also hosts Lake Tahoe, the largest alpine lake in North America, at an altitude of 6,225 ft (1,897 m) and with a size of 191 miles^2 (490 m^2). There are 13 peaks in the range that exceed 14,000 ft including Mt. Whitney, the highest peak in the contiguous United States at 14,505 ft (4,421 m).

The Sierra Nevada snowpack is the major source of water and a significant source of electric power generation in California (Sierra Nevada Conservancy 2012). Eroding residue from the Sierra Nevada filled the Central Valley of California, creating extremely fertile agricultural land. A rain shadow cast by the monumental range greatly affects the climate and ecology to the east and is largely responsible for Nevada being the driest state in the United States (NOAA Earth Systems Research Laboratory).

SIERRA MADRE MOUNTAINS

The Sierra Madre, the chief mountain system of Mexico, consists of the Sierra Madre Occidental (to the west), the Sierra Madre Oriental (to the east), and the Sierra Madre del Sur (to the south). These ranges enclose the great Central Mexican Plateau, a volcanic belt, which itself is part of the system (Bruman et al 2012).

The Sierra Madre Oriental, beginning in the barren hills south of the Rio Grande, runs for 700 miles (1,130 km), roughly parallel to the coast of the Gulf of Mexico from 10 to 200 miles inland. It reaches an elevation of 18,700 ft (5,700 m) in Citlaltepetl, or Pico de Orizabo, a dormant but not extinct volcano. Orizabo is the third highest peak in North America, rising to 18,491 ft (5,636 m), and belongs to the volcanic belt Cordillera de Anahuac. This belt, which divides Mexico in half at about latitude 19 N and includes the peaks Popocatepetl (17,749 ft, 5410 m) and Iztaccihuatl (17,159 ft, 5230 m), joins the Sierra Madre Occidental.

The Sierra Madre Occidental, paralleling the Pacific coast for 1,000 miles (1,610 km), extends southeast from the State of Arizona in the United States. Its main escarpment is more abrupt

than that of the eastern cordillera. Elevations range from 5,000 ft (1,520 m) in the north to over 10,000 ft (3,048 m) in the south.

The Sierra Madre del Sur is a 'tumbled, broken mass of uptilted mountains that touch the Pacific coast but form into no clearly defined range.' It spreads over southern Mexico between the volcanic belt and the Isthmus of Tehantepec and forms the natural harbor of Acapulco (The Columbia Electronic Encyclopedia 2012).

Due to its extensive terrain, the Sierra Madre functions as 'climate corridors' where different kinds of climates interact; from warm-humid to warm or cold climates with snow; warm subtropical to temperate climates; and between arid and semi-arid to warm-humid areas (Secretary of Environmental and Natural Resources 2011).

PHYSICAL ATTRIBUTES AND ISSUES

WATER

When considering sustainable development and the survival of life on Earth, the health and balance of the global fresh water system is one of the most important issues that needs to be addressed. It is estimated that nearly half of the world's fresh water comes from mountains (Pratt and Shilling 2002). Mountains store fresh water in the form of ice and snow and in lakes, wetlands and reservoirs. As water is released, it provides critical flows to rivers and streams (Active R.E.M.E.D.Y.). Indeed, all of the major, and many of the world's minor rivers originate in mountains. The City of Los Angeles, California could not exist without the water that has its source in the Rocky Mountains (Pratt and Shilling 2002).

Watershed Management

Although water emanating from the mountains is critical to providing North America with needed supplies, there is the risk that climate change may impact those supplies due to the overwhelming evidence of rapid glacial melt (Haeberli 2005). Water shortages have now reached the point where cities such as Los Angeles, California, Las Vegas, Nevada, and Phoenix, Arizona have acquired all possible water-use rights in the Colorado River system all the way to the Colorado Rockies. In some cases, entire watersheds in mountains are being earmarked as water supplies for the mega-cities. The best example is New York City (Herring 1999), which acquired land in a major watershed in the Catskill Mountains in order to be able to regulate

New York City, USA: Watershed Agricultural Program

Failure to protect upland watersheds and forests of upland regions from run-off of dairy and other farms resulted in a serious threat to the water quality and quantity available to over 10 million downstream users in New York City. Residents were faced with the looming need for massive new investments in water treatment, estimated to cost over US $6 billion. A partnership between New York City and the upstate farmers of the Catskill Mountains to protect 1,900 miles^2 of watershed from further degradation while allowing for the growth of upstate communities was signed in January 1997.

New York City agreed to fund $35.2 million for farmers in the Catskills to purchase or build pollution abatement devices. Because success (and payment) depends on participation of at least 85 percent of the upland farmers, the program was designed to be voluntary, and to be run entirely by the farmers themselves. They meet as a decentralized, 21-member, democratically elected Watershed Agricultural Council to decide on priorities for allocation of the City funds. On average, a farm will receive $75,000 for improvements such as cement manure pipes, fencing to improve cattle feeding, and riverside tree planting. Equally important, the sustainability of farming systems in the upland watershed has been enhanced, and long-standing distrust between upstate farmers and the City of New York is being replaced by new bonds of trust and understanding, leading to more equitable political decision making in other areas (Pratt and Shilling 2002).

Source: The Mountain Institute, 1997

the land use and guarantee safe long-term supplies for the city. In addition, they entered into a partnership with all mountain stakeholders to ensure that best management practices are followed in those areas remaining under private holdings (Schreier 2005).

Storing water for those periods when supplies are insufficient is a necessity in most of the major mountain watersheds, but according to Gleick (2000), very few new reservoirs were built in North America from 1995 to 2000. New reservoir construction has become increasingly unpopular due to environmental concerns.

Figure 3: The Colorado River Delta: One of the American West's great rivers no longer reaches the sea
Photo: Peter McBride

The Effects of Dams

The Colorado River and its tributaries are the primary water providers for the western United States, including the states of Wyoming, Colorado, Utah, New Mexico, Arizona, Nevada, and California. A series of dams along these waterways is a primary mechanism used to regulate water for consumption and other uses and to generate hydropower. The April 2011 report, *National Parks of the Colorado River Basin: Water Management, Resource Threats, and Economics* examined how dam management strategies affected natural and cultural resources in five national parks—Dinosaur National Monument, Black Canyon of the Gunnison National Park, Canyonlands National Park, Glen Canyon National Recreation Area, and Grand Canyon national Park. Some of the key findings include:

- Dams in the Colorado River Basin have resulted in rivers with highly unnatural flow regimes, including reduced peak flows, enhanced baseflows, and the absence of consistent and predominant spring floods. These flow changes affect processes that shape landforms and plant communities in the national parks along the river,

wildlife, and fish survival, among other things. Though diminished, these effects are still visible hundreds of miles downstream of the dams.

• Dams fragment the Colorado River system and interfere with natural ecological processes such as fish migration and sediment transport in the national parks.

• Change in river temperatures and habitats caused by dams have contributed significantly to declines in native fish, leading to imperiled populations in or extirpations from the national parks.

• Dams affect prehistoric and historic cultural resources within the national parks by limiting the availability of sediment needed to replenish riverbanks containing archaeological resources. They also create conditions that allow previously remote sites to be more easily accessible to visitors who could inadvertently or deliberately harm them. In addition, changing water levels in reservoirs periodically inundate or expose cultural resources, leaving them open to damage from the elements or visitors.

"Fifty miles south of the U.S.-Mexico border, the Colorado River Delta and its once-rich estuary wetlands—reduced by 95% since the river was built out by dams—are now as parched as the surrounding Sonoran Desert. Only rare floods or cancelled farm orders allow the river to reach the Gulf of California (Sea of Cortez). Since the river was parceled out to the seven member-states north of the border, only a fraction of its former flow reaches the farms of northern Mexico. Once a refuge for deer, jaguars, and beaver, the delta below the agriculture still shelters 360 bird species. In hopes of restoration, conservationists are seeking to purchase and create a small sustained flow of water to the sea, supplemented by larger periodic flows."

Jonathan Waterman
The Colorado River-Flowing Through Conflict

• According to available data, changes to dam operations to reduce impacts on endangered fishes and other resources would have relatively minimal effects on hydropower revenues.

Among the report's recommendations are that:

• Dam operations should be modified such that dam releases more closely mimic the natural flows of the Colorado River and its major tributaries.

• Dam operators, resource managers, and stakeholders basin-wide must work together, instead of on a site-specific, dam-specific, or park-specific basis, to adopt a broad perspective, commit to informed and adaptive decisions, and cooperate with one another to successfully address concerns and meet various needs for resource protection, water delivery, flood control, and hydropower generation. Natural, cultural, and recreational resources all must be taken into account.

As other parts of the world are pushing forward to build more dams, these findings and recommendations can, perhaps, serve as warnings and guides.

Water Quality

Managing mountain watersheds and maintaining their health has become increasingly difficult due to pressures within mountain ecosystems, often caused by population growth, and even greater external pressures from lowland populations. "Harvesting mountain resources to sustain urban growth and lowland activities is becoming a major challenge facing mountains" (Schrier 2005). In addition, summer and winter mountain tourism, which is a water-demanding industry, puts even more pressure on mountain water resources.

The U.S. federal Clean Water Act requires each state to conduct water quality assessments to determine whether its streams, lakes, and estuaries are sufficiently "healthy" to meet their designated uses, i.e., drinking, shellfishing, or recreation. A water body that does not meet its designated use is defined as "impaired" and is added to a list of impaired waters, also known as the 303(d) List. For all water bodies on their 303(d) Lists, states are required to develop TMDLs,[3] the maximum amount of a specific pollutant the water body can accommodate and still serve its beneficial use. The TMDL process is just one component of watershed management. Effective watershed management is an ongoing process that must be flexible enough to adapt to the unique characteristics of different watersheds as well as changing circumstances within a single watershed. It results in reduction of contaminants within watersheds and improvement of water quality.

GLACIERS

Glaciers form the "water towers of Earth." In many regards, the changes witnessed in North America's mountain glaciers are completely natural and cyclical—nature's way of regulating herself. This year, parts of the Rocky Mountains could see some glaciers and snowfields increase as snow piles up in the high country over the unusually deep snow from last winter that did not melt. Scientists have measured new ice atop Montana's Glacier National Park and Colorado's Front Range mountains. There also is evidence of snowfield growth in the Bridger-Teton National Forest in northwest Wyoming.

However, over the last century, mountain glaciers worldwide have, on average, been seriously decreasing in length and volume. Glaciers worldwide have been retreating so rapidly that they may almost completely disappear within 50 years (Chadwick, 2007). On the sheltered slopes of the highest peaks of Glacier National Park in Montana, glaciers are diminishing rapidly. The National Park Service and the U.S. Geological Survey have mapped the area of each glacier for decades. Although scientists have measured increases in some of the glaciers in the park two or three times in the past seven or eight years, each one is more than offset by the losses in the negative years. Comparing photographs taken in the mid-19th century with contemporary images provides ample evidence that the glaciers in the park, such as Grinnell Glacier, have retreated notably. In 1887, Grinnell Glacier was described "as 1,000 ft high and several miles across" (Diettert 1992). About 90 percent of the ice is now gone.

3 Total Maximum Daily Load (TMDL is the calculation of the maximum amount of a pollutant that a water body can receive and still safely meet water quality standards (U.S. Environmental Protection Agency 2011).

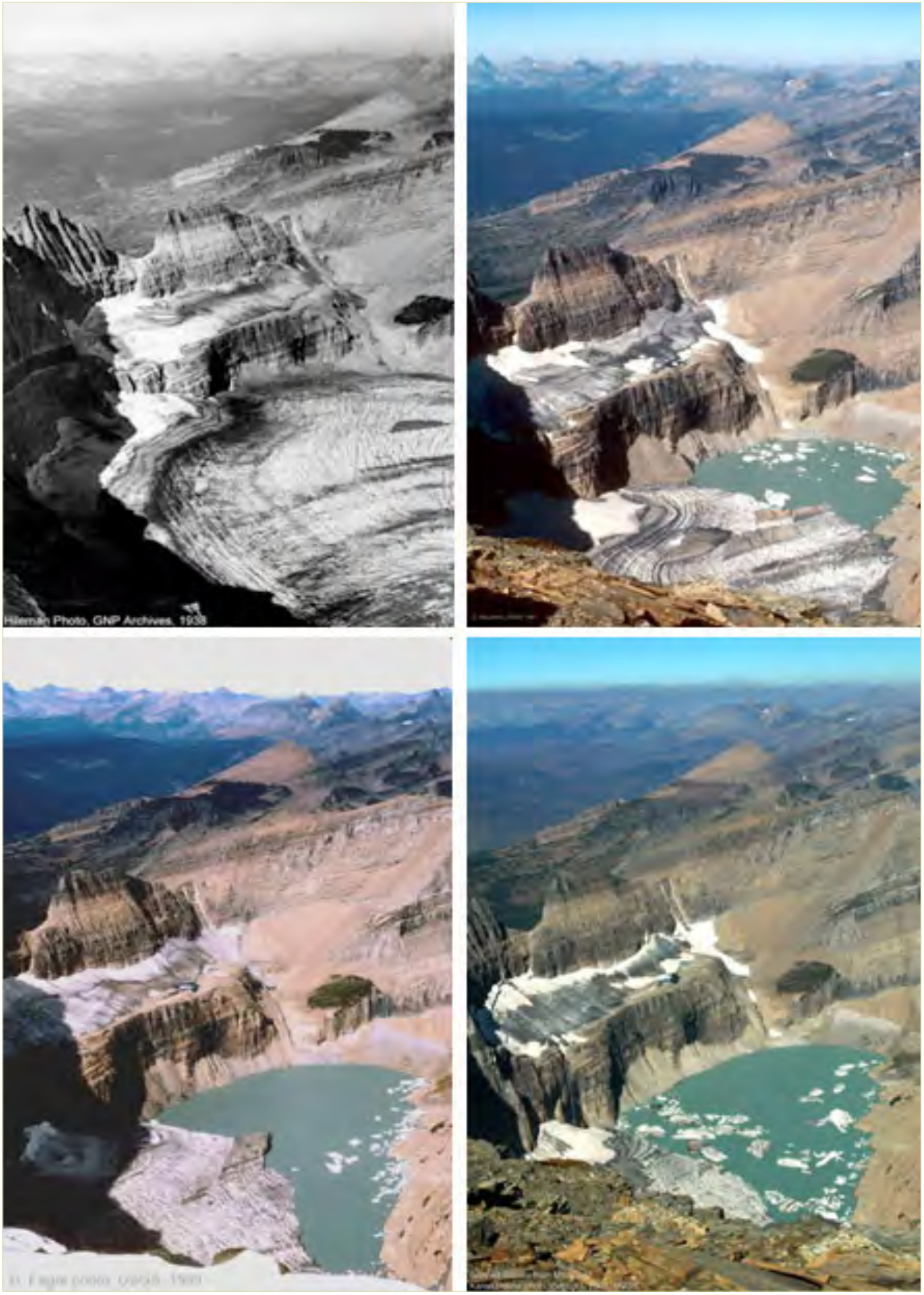

Figure 4: Recession of Grinnell Glacier
Grinnell Glacier from the summit of Mt. Gould, Glacier NP. Upper left (1938) – Oblique view of Grinnell Glacier shows decreased glacier area and reduced depth of the glacier along the cirque wall where, prior to 1938, the ice-surface elevation was high enough to connect with the upper band of ice. (T. J. Hileman, Glacier NP archives). Upper right (1981) (C. Key, U.S. Geological Survey [USGS]). Lower left (1998) (D. Fagre, USGS). Lower right (2006) (K. Holzer, USGS).

The larger glaciers in Glacier National Park are now approximately a third of their size from when they were first studied in 1850. Numerous smaller glaciers have disappeared completely. Only 27 percent of the 99 km^2 (38 $miles^2$) area of Glacier National Park covered by glaciers in 1850 remained covered by 1993. Researchers believe that by 2030, the vast majority of glacial ice in the park will be gone unless current climate patterns are somehow reversed. This is a common condition throughout all the mountain regions of North America and the rest of the world (Active R.E.M.E.D.Y.).

Figure 5: Recession of Exit Glacier
Once covering a larger area, visitors now walk a path to Exit Glacier showing how it has receded in the last 60 years at Kenai Fjords National Park. In the lower right corner of the image you can see where the glacier terminated in 1951. Photo by National Park Service.

Of concern to scientists studying the impacts of climate change on the alpine environment and glaciers of southern Alberta and British Columbia is that the rate of change is "quite startling" and "outside of the envelope of statistical random fluctuations." Glaciers are always advancing or retreating, but the current retreat in the Canadian Rockies has been labeled "unusual in the context of the last 3,000 years." Glaciers, such as the Saskatchewan and Dome glaciers, are melting out to the point where they are exposing old growth forest dating back 3,300 years (Ward 2011).

Glacier Trends and Response to Climate in Denali National Park and Preserve

Glaciers cover approximately one-sixth of Denali National Park and Preserve in Alaska. They are not only enjoyed by visitors for their scenic and recreational values, but also are an important driver of Denali's diverse ecosystems. Scientists from the National Park Service and University of Alaska–Fairbanks have been researching glacier dynamics and monitoring glacier trends for more than 20 years. Mass balance measurements on the Traleika and Kahiltna glaciers showed a cumulative net gain of mass from 1991 to 2003. Since 2003, however, data show that there has been a net loss of ice mass. Analysis of Denali's glacier extent reveals an 8 percent loss in area since 1950; however, whereas most glaciers lost area, a few surge-type glaciers gained area. Repeated photographs from historical images show examples of smaller glaciers decreasing in size and a surge-type glacier that has not changed as noticeably.

Researchers on Kahiltna Glacier, Denali National Park, Alaska
Source: www.nature.nps.gov/ParkScience/popupAbstract.cfm?ArticleID=509

The San Juan Mountains have no exposed glacial ice or identified glaciers. However, the San Juan's support the largest concentration of rock glaciers in the United States. Gary White (1972) identified 658 rock glaciers all with interstitial ice, of which he estimated 37 likely to be ice cored. Collectively, these rock glaciers are thought to contain 0.5 to 0.75 km^3 of water storage in the San Juan's (Brenning, Grasser, and Friend 2007). Climate warming will likely reduce this storage over the next century. Current monitoring is unable to effectively track these trends. However, research shows that temperatures in the San Juan have increased 1°C over the past century (Rangwala and Miller 2010) (Robert Blair 2011).

> *"I almost didn't recognize the Saskatchewan Glacier when I walked in there a few years ago. Soon you won't have to walk on ice at all to reach Castleguard Meadows. It's just unbelievable. To someone who sees a glacier for the first time it seems massive and permanent, but they are melting back very, very fast if viewed year-to-year. My kids might not see glaciers in the Rockies when they are my age if the current trend keeps up."*
>
> **Will Gadd, Mountaineer**
>
> Source: The State of the Mountain Report

MINERALS

Mountains are a prime source of most minerals—precious and other metals, gems, construction materials (limestone, marble, etc.), and to a lesser extent coal. The tectonic movements that create mountains fold and force up minerals normally found deep below the Earth's surface. Because the minerals are closer to the surface and more easily accessible in mountains, it is to be expected that most mining would occur there. And in fact, a review of mine locations shows a high concentration in mountainous areas. In North America, mines are clustered in the Rocky Mountains and the Appalachians (Pratt and Shilling 2002). Alaska's mountains also support a significant mining industry for coal, gold, silver, and zinc. Coal from mining operations provides approximately 40 percent of the state's electricity. Mining companies in Alaska help sustain native culture by contributing monetarily (usually in the form of rent or other payments) to Alaska Native corporations (Alaska Miners Association, Ltd.).

Although an important economic driver in many mountain communities, mineral extraction has increasingly become controversial in the United States. (See page 32 for a discussion on mineral extraction.)

BIOLOGICAL/ECOSYSTEM ISSUES

BIODIVERSITY

Forest Ecosystems

Mountains are increasingly becoming an important preserve of forest ecosystems and biodiversity. The large number of small eco zones over short distances contributes to the variety of species and genetic diversity. However, the more harsh and fragile climate of mountains means that when one of these areas is disrupted, it takes longer to recover, if it can at all. Threats to mountain forests stem from more intense logging and from opening up areas to other uses. Building roads to mines or other locations creates access for logging and opportunities for invasive weeds, as well as conversion to homes and other uses, and increases the danger of damaging forest fires.

To the extent that human incursions impact the fragile mountain environments, there is a threat of loss of biodiversity, with unknowable long-term impacts. For example, about 10 years ago, much of the world's corn crop was threatened by disease. A wild variety of corn resistant to that disease was discovered in a mountain valley in Mexico. It provided the disease-resistant genetic material that was cross-bred into commercial corn seed, saving much of the world's corn crop. That valley was flooded a few years later when the dam downstream was completed, eliminating forever the natural habitat of that particular variety of corn (Pratt and Shilling 2002).

Pollinators

In their 1996 book, *The Forgotten Pollinators*, Buchmann and Nabhan estimated that animal pollinators are needed for the reproduction of 90 percent of flowering plants and one third of human food crops. Each of us depends on these industrious pollinators in a practical way to provide us with the wide range of foods we eat. In addition, pollinators are part of the intricate web that supports the biological diversity in natural ecosystems that helps sustain our quality of life. Abundant and healthy populations of pollinators can improve fruit set and quality, and increase fruit size. In farming situations, this increases production per acre. In the wild, biodiversity increases and wildlife food sources increase.

> "*Farming feeds the world, and we must remember that pollinators are a critical link in our food systems*."
>
> Paul Growald,
> Co-Founder, Pollinator Partnership

Alfalfa, melons, squash, and heirloom tomatoes are some of the crops raised in the Southern Rocky Mountain Steppe that rely on honey bees and native bees for pollination. Domestic honey bees pollinate approximately $10 billion worth of crops in the U.S. each year.

Unfortunately, the numbers of both native pollinators and domesticated bee populations are declining. They are threatened by habitat loss, disease, and the excessive and inappropriate use of pesticides. The loss of commercial bees to Colony Collapse Disorder has highlighted how severe the issues of proper hive management are to reduce stresses caused by disease, pesticide use, insufficient nutrition, and transportation practices. Currently, the pollination

services that the commercial beekeeping industry provides are receiving much needed research and conservation resources. The efforts to understand the threats to commercial bees should help us understand other pollinators and their roles in the environment as well (Pollinator Partnership).

The Pollinator Partnership and the North American Pollinator Protection Campaign have published a guide, *Selecting Plants for Pollinators*, to help farmers, land managers, and gardeners add plants to the landscape that provide food and shelter for pollinators throughout their active seasons and by adopting pollinator friendly landscape practices. It is an excellent example of how information technology and capacity are facilitating a shift towards real sustainability by mobilizing stakeholder participation, with implications for profound changes in policy and practice.

Wild Horses Versus Mineral Extraction

Disappointment Valley, about 60 miles from Telluride, Colorado, is one of the sites where the Bureau of Land Management is conducting round-ups of wild horses. Despite the 1971 passage of the Free Roaming Wild Horse and Burros Act, wild horses are being captured and left to languish in disease-infested facilities that cost taxpayers about $120,000 a day. They are then sold to slaughterhouses in Mexico, which sell the meat for human consumption. This systematic destruction of whole bands is happening across the American West.

The reason for the round-ups, according to Anaquad Kleinert, who has recently released a documentary on this subject—"Wild Horses & Renegades"—is that the land the horses roam also happens to be rich in desirable minerals. Thus, mining corporations are motivated to circumvent environmental impact investigations and regulations that prohibit extraction on protected habitats. Some of these companies have been strategizing for decades to work around the legislation that prohibits them from drilling. In the case of southern Colorado, the interest is in uranium, which would be processed at the controversial proposed Piñon Ridge Mill in Paradox Valley (www.denverfilm.org/filmcenter/detail.aspx?id=24250).

Squirrels in North America's Mountains

An estimated 280 species of squirrels live on the Earth; they can be found in virtually all of North America's mountains. Squirrels are divided into three main categories—Ground Squirrels, Flying Squirrels, and Tree Squirrels—each of which performs functions that are highly beneficial to the ecosystems they inhabit.

Ground Squirrels improve and maintain the natural quality and property of the soil by aerating it, which assists numerous biological processes; **Flying Squirrels** pollinate the fungi in forests that produces mushrooms; a source of food for many species; **Tree Squirrels**, the most important, bury the nuts that grow into trees.

The squirrel population is currently under threat from natural factors, such as predators, disease, and starvation; climate change factors, such as the increase in the number, intensity, and area impacted by forest fires, which destroy their habitat; and human factors, such as hunting and

trapping, and the destruction of their habitat by deforestation, forestry practices (clearcuts, thinning), and human encroachment and activities. Around the world, it is estimated that 85 percent of the squirrel species have already disappeared (Ghanim 2011).

CLIMATE CHANGE

More Rapid Warming in the West

2003 to 2007 5-Year Average Temperatures Compared to 20th Century Averages

Planet	+1.0°F
Western United States	+1.7°F
Colorado River Basin	+2.2°F
Arizona	+2.2°F
California	+1.1°F
Colorado	+1.9°F
Idaho	+1.8°F
Montana	+2.1°F
Nevada	+1.7°F
New Mexico	+1.3°F
Oregon	+1.4°F
Utah	+2.1°F
Washington	+1.4°F
Wyoming	+2.0°F

Saunders et al 2008

Although there is a segment of the population that disputes the existence of global warming, there is a significant body of research that confirms that the Earth's climate is changing—it is becoming….

Hotter and Drier

According to a report issued by the Rocky Mountain Climate Organization (RMCO) and the Natural Resources Defense Council (NRDC), nowhere is climate change more evident in the United States (outside of Alaska) than the West. The American West has heated up even more than the world as a whole. From 2003 to 2007, global temperatures averaged 1.0°F warmer than the 20th century average. For that same period, RMCO found that the in 11 western states, the average temperatures were 1.7°F warmer—70 percent more warming than the rest of the world as a whole. In addition to temperature increases, the West is getting drier. Decreases in snowpack, less snowfall, earlier snow melt, more winter rain events, increased peak winter flows, and reduced summer flows have been documented. RMCO reports that scientists have confirmed that most of the recent warming in the West has been caused by human emissions of heat-trapping gases (Saunders et al 2008).

This warming is disrupting ecosystems. An earlier section of this report discusses the impact of climate change on glaciers (see pages 13-16). Researchers also found that warmer temperatures are impacting forest ecosystems.

Impact on Forest Ecosystems

Scientists have found—with the exact numbers deduced only recently—that forests have been absorbing more than a quarter of the carbon dioxide that people are putting into the air by burning fossil fuels and other activities. It is an amount so large that trees are effectively absorbing the emissions from all the world's cars and trucks. Without that disposal service, the level of carbon dioxide in the atmosphere would be rising faster. But scientists are concerned that as our planet warms, trees themselves could become climate-change victims on a massive scale. If that were to happen, they would not only stop absorbing

> *"At the same time that we're recognizing the potential great value of trees and forests in helping us deal with the excess carbon we're generating, we're starting to lose forests."*
>
> Thomas W. Swetnam
> University of Arizona

carbon, they also might start to burn up or decay at such a rate that they would spew huge amounts of carbon dioxide back into the air—as is already happening in some regions. That, in turn could further speed our planet's warming (Gillis 2011).

There already is evidence that warmer temperatures are impacting the fire regimes. Warmer spring and summer temperatures (1.5°F) over a 17-year period after 1987 have lead to increases in the frequency and magnitude of fires throughout forests in the Mountain West, including:

- a 78-day increase in the length of the fire season
- a 4-fold increase in the number of fires
- a 5-fold increase in the time needed to put out the average wildfire
- 6.7 times as much area being burned

Warmer temperatures also have been linked to the proliferation of the mountain pine beetle in the West, which kill the host trees to reproduce. Pine beetle populations normally are held in check by extreme cold. But with warmer temperatures in western mountains, more beetles can survive the winter at higher latitudes and higher elevations and can complete their life cycle in just one year instead of two. Largely for these reasons, beetle outbreaks are now widespread across the West. Red-hued mountainsides have become a familiar sight in a half-dozen states, including Montana and Colorado, and have jumped the Rocky Mountains into Alberta and British Columbia in Canada. Fears are rising that the beetles could spread across the continent as temperatures rise in coming decades. Pine beetles have already killed virtually all the mature lodgepole pine forests in Colorado. Research by the U.S. Forest Service also has linked the rapid mortality of aspen trees in Colorado—called "sudden aspen decline"—to the hotter and drier conditions in the interior West. The death of these trees leaves vast stands that become the fuel for more frequent and intense forest fires.

The warming of the West also is impacting the natural timing of the seasons and wildlife. For example, lilacs and honeysuckle bushes are blooming earlier in the season and ptarmigans are hatching earlier. Other species are adapting to an altered climate by changing where they live. In Yosemite National Park, 14 of 50 animal species studied can no longer be found in the lower-elevation portion of the range they occupied early in the 20th century (Saunders et al 2008).

Western Mountain Initiative

The Western Mountain Initiative (WMI), a consortium of research groups in the western United States, focuses on understanding and predicting responses of mountain ecosystems to climatic variability and change—emphasizing sensitivities, thresholds, resistance, and resilience. Concentrating their research in five bioregions—Pacific Northwest, Sierra Nevada, and the Northern, Central, and Southern Rockies—WMI addresses four key questions:

1. How are climatic variability and change likely to affect disturbance regimes?
2. How are changing climate and disturbance regimes likely to affect the composition, structure, and productivity of vegetation?
3. How will climatic variability and change affect hydrologic processes in the mountainous West?

4. Which mountain resources and ecosystems are likely to be most sensitive to future climatic change, and what are possible management responses?

The research framework for WMI is premised on natural experiments in time (paleoecological and long-term studies), natural experiments in space (studies across regions and elevation gradients), and synthetic modeling. Results to date have documented how climatic variability and change affect long-term patterns of snow, glaciers, and water geochemistry; forest productivity, vigor, and demography; and long-term patterns of fire occurrence. Some significant physical and biological thresholds are already being reached (e.g., glacier recession, forest dieback), and empirical and simulation modeling indicates that major changes in hydrologic function and ecological disturbance will occur as climate continues to warm.

WMI's research has documented several trends, such as:

- There have been significant reductions in ice and snow since 1900: 66 percent in Montana, 40 percent in Colorado, 56 percent in California, 30 percent in Oregon; and 24-46 percent in various Washington locations.

- Monitoring in Rocky Mountain National Park since 1982 shows that there has been a period of below-average precipitation during 2000-2006 and a steady increase in summer and fall temperatures of 0.12˚C per year since 1991. A warming climate and higher daily temperature extremes during summer may negatively impact existing trout populations by increasing water temperatures beyond critical physiological thresholds (Selong et al 1997).

- Analysis of data from unmanaged old forest plots across the western United States reveal that background tree mortality rates have more than doubled in recent decades (van Mantgem et al 2009). For a number of reasons, regional warming appears to be a likely contributor to the widespread increases in tree mortality.

- Using historical fire-scar records from sites ranging from northern New Mexico to eastern Washington, WMI documented the overarching control of climate, particularly drought, on fire when examined at broad scales (Hessl et al 2004, Margolis et al, Kellogg et al 2008).

WMI is working with national parks and national forests to develop science-based management options for adapting to climatic change. The next phase of its research will target activities to help inform the land management agencies' decisions (Peterson et al At press).

Landscape Response to Climate Change and its Role in Infrastructure Protection and Management at Mount Rainier National Park

Tahoma Creek, showing an abundance of sediment, Mount Ranier National Park, Washington

Mount Rainier is a 4,392 m (14,410 ft) volcano that presents considerable risks from numerous natural hazards. While most of the spectacular hazards associated with volcanoes happen infrequently and are usually preceded by warning signs, flooding and debris flows occur more often and sometimes without warning. Devastating floods at Mount Rainier National Park, Washington, have increased in frequency in the last decade and have led to tens of millions of dollars' worth of damage to park infrastructure. Major rivers at Mount Rainier are fed by glaciers. As a consequence of regional climate warming, all of the 25 glaciers in the park are retreating and thinning. As the glaciers retreat, unconsolidated and unstable sediment is exposed and mobilized into rivers, which causes aggradation downstream. This filling in of rivers in with sediment is occurring at rates of up to 1.8 m (6 ft) per decade; whereas historically they were aggrading at 7–13 cm (3–5 inches) per decade. This tremendous increase in aggradation is leading to more frequent catastrophic shifts (avulsions) in the location of river channels, which tend to destroy park infrastructure and disturb riparian forest habitat

www.nature.nps.gov/ParkScience/popupAbstract.cfm?ArticleID=508

4 Sources include: Theobold, D. 2001. Land use dynamics beyond the urban fringes. Geog. Rev. 91:544-564. Soule', M. and B. Wilcox. 1980. Conservation Biology. Sinauer Assoc., Sunderland, MA. Harris, L. et al. 1996. The role of networks and corridors in enhancing the value of parks and equivalent area In Wright, R. (ed.) National Parks and Protected Areas. Blackwell Science, Cambridge:173-197. Clevenger, A. et al. 2002. Roads and Wildlife in the Canadian Rocky Mountain Parks. Final rept. For Parks Canada, Banff, Alta. Conover, M. et al. 1995. Review of human injuries, illnesses, and economic losses caused by wildlife in the U.S. In Transportation Research Board. 2002. National Coop Highway Res. Prog. Synthesis #305.

MOUNTAIN INTERACTIONS

The extent of the human impact on mountains is large and varied. Those impacts, both positive and negative, affect all mountain residents. However, the economic benefits that are derived from the utilization of mountain resources do not necessarily benefit all mountain residents.

ENCROACHMENT/WILDLAND-URBAN INTERFACE

Fast population growth in mountains and their valleys has been widely documented, especially for the United States. From 1960 to 1990, human settlement has doubled in the western mountains. For the last decade or more, Loudoun County, Virginia—located within the Blue Ridge Mountains—has been listed as the fastest, or among the fastest growing counties in the United States. This growth has had significant impacts on mountain environments. For example, Loudoun County contains the most threatened part of the famous Appalachian Trail.

Habitat Fragmentation and Impacts on Biodiversity

Human expansion into mountain environments is generally accompanied by new infrastructure such as reservoirs, roads, and fences. Such development has focused on valleys and foothills, which provide key winter habitat or movement corridors for seasonal migrations of native fauna. Roads and their traffic not only kill some 400 million vertebrates/year (including 1.5 million deer), they can be a complete barrier to essential seasonal movements. One effect of such fragmentation includes loss of fitness due to isolation and inbreeding. For example, mountain bighorn sheep evolved in the open tundra following glaciations, but have been increasingly isolated as forests they are reluctant to traverse spread. A population of bighorns in Montana had three bottlenecks to their movements, which lead to coefficients of inbreeding (~35 percent) seen only in domestic animals manipulated commercially. Without predators (wolves had been completely extirpated), the isolated Montana herd suffered from reduced fecundity, disease resistance, milk yield, size, and other results of inbreeding. It declined from over 200 to 3 in 10 years, i.e., functional extinction. Another impact of human development in mountain environments can be seen in elk herds. Elk will evacuate an area when it is within half a mile of a road, and there is a loss of elk when there are more than 3 linear miles of road/mile^2. When elk herds must use developed areas, they spend a greater amount of time alert rather than feeding, and suffer higher winter mortality.

If recently isolated habitats can be re-connected, the potential exists for their fauna to remain viable. Connectivity via natural or man-made corridors works. For example, 46 miles of highway in the Flathead Valley of Montana are now crossed by 42 crossing structures (underpasses and overpasses) for wildlife, particularly grizzly bear and elk. Similarly, the Banff corridor project has reduced road kills of large wildlife, particularly wolves and grizzly bear, by 90 percent while enabling seasonal movements (Berwick 2011).[4 opposite]

The Crown of the Continent Ecosystem

Glacier National Park lies at the center of an area known as the Crown of the Continent Ecosystem (CCE), which encompasses about 16,000 miles^2 of the Rocky Mountains. The CCE lies within the southern portions of the Canadian provinces of Alberta and British Columbia; the northern portions of the state of Montana in the United States; and across numerous tribal and

see opposite

aboriginal lands, municipal authorities, public land blocks, private properties, and working and protected landscapes. It is one of North America's most ecologically diverse and jurisdictionally fragmented ecosystems. It is internationally recognized for its biodiversity and landscape form that range from flat grasslands to high mountain peaks, from forests to rocks and glaciers, from formal and informal wilderness areas to densely populated human settlements. Wildlife and vegetation also is varied. A full complement of carnivores and ungulates are found in the region. This area contains some of the last areas available for large scale connectivity for wildlife and vegetation in the world.

The CCE faces continued pressure from all forms of human activity—urban and rural residential development; increased recreational use of all forms; increased demand for resource use and extraction; and increased infrastructure to support all of these. Oil and gas exploration and potential development east of Glacier National Park on the Blackfeet Reservation and continued growth and development in the Flathead Valley, south and west of the park are but a few examples (Riddle 2011).

Impacts on Fire Management

As the number of homeowners in mountainous areas has increased, so too has opposition to controlled burning in the "red zones" of wildland-urban interface areas. As a result, debris accumulates, and when ignited during drought periods, leads to more devastating fires than if controlled burns had been allowed in prior years. In the summer of 2002, the United States experienced its largest wildfires in over 100 years, almost entirely in mountain regions (Pratt and Shilling 2002).

"Amenity Migration"

The quality-of-life available in mountain areas attracts both retirees and younger people because of their richness in natural and cultural amenities. "Amenity migrants" move, both part time and permanently, mainly for perceived superior environmental quality and cultural differentiation. High-amenity mountain areas have similarly experienced growth in tourism because of their greater availability of outdoor activities and distinctive cultural experiences (Moss and Glorioso 2011).

These new people and land uses have a significant impact on natural systems and landscapes. The historic economy dependent on resource extraction such as forestry, mining, livestock, and wildlife harvest has been replaced by an amenity economy that says jobs bring people, and communities must make themselves attractive to business to enlarge the tax base. The mountain towns of Aspen and Durango in Colorado are examples of the new "boom" and amenity economy. More than 85 percent of the historic winter range of elk in the Roaring Fork Valley above Aspen is now

International Amenity Migration Centre (IAMC)

The IAMC focuses on sustainability opportunities and issues associated with human migration for environmental and cultural amenities, especially in mountain ecological zones. It undertakes research and formulation of policy and strategy for better understanding and management of the socio-cultural, environmental, and political-economic impacts and implications of this growing societal phenomenon. The IAMC has relevant experience in mountain areas of Argentina, Canada, Czech Republic, Indonesia, Philippines, Thailand, Laos and USA (Moss and Glorioso 2011).

occupied by homes and condos on the warm south slopes looking across to the ski mountain. The remnant elk herd now survives by foraging on the north slopes of the valley by forging trails in deep snow on the face of the ski hill, which they keep open by repeated use, cropping the forage of oak and serviceberry down to fibrous branches of meager nutritive value. This herd is demographically underdeveloped, with bulls representing fewer than 10 percent of the herd—most dying of malnutrition in winter after the demands of fall rutting in their struggle to persist in unfavorable habitat near traditional areas formerly key to winter survival. A similar challenge exists in nearby Durango where 2,392 subdivision permits have been issued. While careful planning could mitigate metastasizing development and county "Comprehensive Plans" are generally required, the resulting zoning and regulations are not often observed by developers (Berwick 2011).

However, in a growing number of communities of British Columbia and Alberta, from the Pacific Coast Mountains through the Columbia Range to the Rocky Mountains, amenity migration is being recognized as an important change agent and is being considered in their planning and decision making (e.g., Smithers, Golden, Keremeos, Princeton, Vernon, Fernie, Canmore, High River). From the critical regional perspective, perhaps the most notable and advanced consideration is the Similkameen Sustainability Strategy for 2011-2020, a 10-year plan for the Similkameen Valley, a bioregion of some 9,000 inhabitants located in the mountains of south-central British Columbia (www.rdos.bc.ca/ssp).

The residents of the Similkameen Valley came together in 2009-2010 and developed a socio-cultural, economic, and environmental sustainability strategy for their mountain bioregion. In summary the strategy requires the Valley to:

- maintain and rehabilitate the bioregion's key attributes (beauty; high quality natural environment and resources; and rural, small town lifestyle) while building on existing sustainability values and practices, and adding greater knowledge and innovation
- increase residents' participation in local affairs to strengthen and solidify the Valley socially, culturally, and economically, relying heavily on volunteers working through informal and formal organizations
- attract and keep especially environmentally responsible and economically active in-migrants
- develop housing with a range of type and cost, especially appropriate to the needs and means of the young and old
- harness the power of a region, wherein the Valley's communities take advantage of the social, political, and economic strengths that come from their collaboration

The strategy was unanimously approved at a Valley-wide public meeting in April 2010, adopted by the regional district that includes Similkameen, and is now being used to guide water and watershed management, rural electoral area land use plans, a regional biodiversity strategy, and municipal decision making. While still at an early stage of implementation, and treating the specifics of this bioregion, the strategy shows a promising way through the complexities, harmonies, and discordances of mountain ecological management for environmental, socio-cultural, and economic sustainability. Moreover, the Valley's residents demonstrated the ability

to integrate into their understanding and action likely global and regional climate and energy change, and related security of clean water and food, along with political-economic shifts (Moss and Glorioso 2011).

CONSERVATION/PROTECTED AREAS

Conservation in the United States takes place in two ways: through land stewardship and private efforts (including those of non-governmental organizations), and through public efforts. Careful land stewardship is a deeply held value among traditional land-owners, and is an increasing movement among younger people who are able to participate in a 'return to the land' movement because economic recession has made land more affordable. In addition, Land Trusts and Conservation Trusts, whereby private individuals and nonprofit organizations collaborate to protect environmentally important private lands in perpetuity, are an important feature of conservation efforts. Begun in North America and now extending around the world, these conservation 'easements' have protected hundreds of thousands of acres from development. Finally, actions such as the creation of national parks, state parks, recreation areas, and preserves, and the development of conservation plans help preserve mountain ecosystems and contribute to their sustainability.

Protecting Canada's Boreal Forest

At 1.4 billion acres, Canada's Boreal Forest accounts for one-quarter of the intact, original forest remaining on Earth. On May 18, 2010, the Forest Products Association of Canada (representing 21 timber companies) and 9 leading North American environmental nonprofit organizations signed the Canadian Boreal Forest Agreement (CBFA), a monumental opportunity to protect 178 million acres of Boreal Forest—an area twice the size of Germany—under various layers of protection into perpetuity. Under the agreement, the 21 timber companies will halt road building, logging, and other forestry operations on over 70 million acres of prime woodland caribou habitat for three years. During that time, the partners will work with government, First Nations, and local communities to develop and implement conservation plans for protected areas, wildlife management, and ecosystem-based management that will direct how the forests are managed and logged.

By the end of the first year, CBFA produced several achievements in Quebec, Ontario, and the rest of Canada including: an evaluation of the woodland caribou recovery plan in Quebec; the identification of critical habitat for caribou in Ontario; recommendations to the Ontario government on how to protect and recover caribou; the creation of an Independent Science Advisory Team; and the development of draft ecosystem-based management principles and practices for ensuring world-leading sustainable forest practices in the Boreal Forest.[5]

U.S. National Park System

Preservation is about deciding what's important, figuring out how to protect it, and passing along an appreciation for what was saved to the next generation. Preservation is hands on. At the federal level, the U.S. National Park Service is the steward to 394 areas or "units," including 58 national parks. Many national parks are located within mountain environments. The purpose

5 www.nature.org/ourinitiatives/regions/northamerica/canada/explore/boreal-forest-agreement.xml

of the National Park Service is "...to promote and regulate the use of the...national parks...which purpose is 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" (National Park Service Organic Act, 16 U.S.C.1.).

In many areas, National Park System units represent the last vestiges of once vast undisturbed ecosystems. The National Park Service archeologists, architects, curators, historians, and other cultural resource professionals work in America's national parks to preserve, protect, and share the history of this land and its people. Beyond the parks, the National Park Service is part of a national preservation partnership working with American Indian tribes, states, local governments, nonprofit organizations, historic property owners, and others who believe in the importance of the nation's shared heritage—and its preservation.[6]

Preserving Biodiversity in the U.S. National Parks

Biological diversity (or biodiversity) includes all the living organisms on Earth, and within the parks are plants and animals that have disappeared in other parts of the world due to development, habitat fragmentation, climate change, invasive species, and other threats. National parks and other protected places are samples of the world's natural variety, often the last bastion of the Earth's wild wealth. They are vital to the Earth's future well-being.

The values of biodiversity in parks are legion: the value of nature for its own sake, a source of wonder and enjoyment; the value of learning about the workings of nature in places largely free of human influence, for comparison with landscapes dominated by humans; the survival value of multitudes of wild species that flourish as natural systems helping regulate climate, air quality, and cycles of carbon, nitrogen, oxygen, mineral elements, and water—all fundamental to life on Earth. There also is economic value in these same plants and animals. They are potential sources of food, medicine, and industrial products. Parks protect the species and their communities that underlie these values—serving if necessary as reservoirs of seed stock for restoring species lost elsewhere.

To preserve biodiversity in parks for future generations, it is first necessary to discover the breadth of life forms that exist. In the past decade, numerous parks have teamed up with professional scientists, university students, school groups, volunteers, and park partners for the purpose of biodiversity discovery. These efforts have identified species new to science, located species that have not been seen in parks in hundreds of years, and documented species that are able to survive in extreme conditions. The National Park Service also is working to preserve biodiversity more broadly by restoring ecosystems, controlling invasive species, practicing integrated pest management, and through other conservation measures.[7]

Biosphere Reserves

North America is home to 91 United Nations' Educational, Scientific and Cultural Organization (UNESCO) biosphere reserves; about one-third are located in mountain environments. Biosphere reserves serve as "living laboratories" for testing and demonstrating integrated management of

6 www.nature.nps.gov/protectingrestoring/
7 www.nature.nps.gov/biology/biodiversity/

land, water, and biodiversity. The three complementary and mutually reinforcing functions of the biosphere reserves include:

- a conservation function—to contribute to the conservation of landscapes, ecosystems, species, and genetic variation
- a development function—to foster economic and human development, which is socio-culturally and ecologically sustainable
- a logistic function—to provide support for research, monitoring, education, and information exchange related to local, national, and global issues of conservation and development (www.unesco.org/mab/doc/faq/brs.pdf).

Wilderness Designations in the United States

"Wilderness is the land that was wild land beyond the frontier...land that shaped the growth of our nation and the character of its people. Wilderness is the land that is rare, wild places where one can retreat from civilization, reconnect with the Earth, and find healing, meaning and significance".[8]

The Wilderness Workshop

Since 1967, the Wilderness Workshop has been the conservation watchdog of the White River National Forest and other nearby federal public lands in the State of Colorado. Through a mix of advocacy, scientific study, and education, WW works to keep the backcountry more or less "as is" and, where possible, to restore fragmented wildlife habitat. Among its many accomplishments is the establishment of the Hunter-Fryingpan, Collegiate Peaks, and Raggeds Wilderness Areas.

www.wildernessworkshop.org/our-worktml?page=186

In 1964, the leaders of the United States formally acknowledged the immediate and lasting benefits of wild places to the human spirit and fabric of the nation. That year, in a nearly unanimous vote, Congress enacted landmark legislation that permanently protected some of the most natural and undisturbed places in America. Passage of the Wilderness Act made the United States the first country in the world to define and designate wilderness areas through law. Today, the Act continues to be the guiding piece of legislation for all wilderness areas.

It takes an act of Congress to designate an area as wilderness. However, Congress must take the opinions of all American citizens into consideration when debating whether or not to designate an area as wilderness. This process can take years, even decades as there often are dissenting views between those who favor wilderness designations and those who favor more development.

Many areas within the mountains of North America have been designated as wilderness areas. For example, the San Juan Mountains, which are located primarily within the State of Colorado and encompass approximately 18,000 kilometers^2, are more than 80 percent federal lands (U.S. Forest Service and the Bureau of Land Management). Within the San Juan's, there are 7 wilderness areas that cover 4,000 kilometers^2. In addition, recently, large tracks (approximately 25 percent) have been designated as roadless areas (Robert Blair 2011).

8 www.wilderness.net/index.cfm?fuse=NWPS&sec=whatIsWilderness

In November 2011, the current Administration called for 18 new wilderness and conservation area declarations in 9 western states, including the expansion of land protections in the McKenna Peak Wilderness Study Area of the San Juan Mountains.

RECREATION/ECOTOURISM

The economies of many mountain communities throughout North America depend on tourism and the recreational opportunities that the mountains offer for their economic survival. On November 7, 2011, the United States enacted the Ski Area Recreational Opportunity Enhancement Act of 2011, which permits year-long recreation opportunities on U.S. Forest Service ski areas. The year-long recreation season is estimated to annually sustain up to 600 extra jobs and is expected to bring in an additional $40 million to local communities in direct spending. The new legislation amends the National Forest Ski Area Permit Act of 1986, which allowed only Nordic and alpine skiing. Under the new legislation, other snow sports may be permitted on National Forest System lands, as well as year-round activities. Potential permitted activities may include zip line, mountain bike terrain parks and trails, Frisbee gold courses, and rope courses.

"The Kahiltna Glacier, located on Mt. McKinley in Denali National Park, provides access each season for over 1,000 climbers attempting to summit the highest mountain in North America. The National Park Service must intensively manage human activity on Mt. McKinley due to the potential negative impacts heavy human use may have on the glacial environment. Currently, we estimate that 110 metric tons of human waste have been left on Mt. McKinley by climbers since 1970. The short- and long-term environmental health impacts of crevassing human waste in a glacial environment are poorly understood. Impacts on human health and water quality are the predominant concerns. Using field observations and lab experiments, we investigated the microbiological fate of human feces deposited in a variety of subarctic glacial microclimates. The survival of fecal microorganisms in this variety of glacial environments is greater than expected, and our results suggest that the coliform bacteria in waste deposited on the Kahiltna Glacier may survive decades of burial".

Goodwin, 2011

Even without the increased access the new law will provide, mountain areas are facing increased pressure as recreation groups demand their piece of the woods. For example, in the White River National Forest that surrounds Aspen, Colorado, there were 144 outfitters and guides operating in the forest in 2010. Skiers and snowboarders use public lands at 11 ski areas throughout the forest. Hikers and backpackers have 2,500 miles of trails at their disposal, and there are 751,900 acres of wilderness where motorized and mechanized uses are prohibited. Mountain bikers are always looking for new opportunities, occasionally building bandit trails and then trying to legalize them later. Dirt bikers and other off-road-vehicle enthusiasts clamor for more terrain where they can operate machines capable of covering more than 100 miles on a good day. Snowmobilers, rock climbers, big-peak baggers, paragliders, anglers, trail runners, backcountry skiers, picnickers, sightseers, nature lovers—everyone wants to spend time in the forest.

The Forest Service is adapting to this recreation explosion. The White River National Forest uses various management tools to ease the human impact:

- It now performs a capacity analysis on every proposed permit from outfitters and guides to determine if there is a need for additional permits.
- The Travel Management Plan issued during the summer of 2010 closed 692 miles of bandit trails, constructed or used illegally, and decommissioned another 519 miles of routes.
- Other rules, such as requiring camps to be a certain distance away from high-country lakes, have been in place for decades to prevent people from "loving our special places to death" (Condon 2011).

MOUNTAIN EVENTS AND CULTURE

The mountains have inspired a way of life for many of those who live, work, and play in their midst that celebrates the mountains and all they have to offer. Mountain events, such as the Telluride Mountainfilm Festival and the Banff Mountain Film and Book Festival, provide unique opportunities for people to share common experiences, values, and goals through their creativity.

Telluride Mountainfilm Festival

Mountainfilm was inaugurated in Telluride, Colorado in 1979 with the screening of a dozen films, all about mountains: mountain sports, mountain cultures, mountain issues. During the days, the audiences took to the mountains themselves, climbing the 13,000- and 14-000-foot peaks with skis on their backs; kayaking the San Miguel River, swollen with snowmelt; and engaging in spirited dialogue about the importance of wild places, adventure, art, and action. Mountains soon became as much a metaphorical theme as a literal one and, as the festival expanded in size and recognition, its programming readily stretched to the leading edges of critical contemporary mountain issues.

Mountainfilm's Memorial Day weekend festival attendance of approximately 3,500 people represents an attractive potential economic impact for the retail, restaurant, and lodging sectors of Telluride and Mountain Village at a time of year when tourism traffic is, otherwise, negligible. Around 60 percent of the annual festival attendees are from outside the Telluride region and stay for a minimum of three nights. This translates to approximately 6,300 room nights for lodging companies.

In 1999, Mountainfilm significantly grew the scope of its operation with the introduction of Mountainfilm on Tour. Today, the Mountainfilm festival occupies dozens of venues in Telluride and Mountain Village and fills the two towns with inspiring thinkers and doers. In line with its mission to educate and inspire audiences, Mountainfilm aims at heightening awareness of critical environmental, cultural, and social issues, and paying tribute to leading causes and names in exploration and adventure. By attracting pioneering world experts every year from a broad range of interests and disciplines, Mountainfilm provides a unique community benefit. (www.mountainfilm.org/about-mountainfilm).

Banff Mountain Film and Book Festival

The Banff Centre's Mountain Film and Book Festival, started in 1976, is one of the world's pre-eminent mountain festivals. A tight-knit group of climbers and outdoor folk looked for an annual event to entertain them during the shoulder season between climbing and skiing. As the story goes, several late night meetings and a few beers later, The Banff Festival of Mountaineering Films was born. What began as a one-day festival of climbing films, has now blossomed into a nine-day event in Banff and a year-round film tour that encompasses over 500 screenings, in 35 countries, on all continents (yes, they go to Antarctica!).

Since its inception, the Festival has accepted more than 5,000 films on climbing, mountaineering, outdoor adventure, mountain culture, and environmental films. Filmmakers enter the competition with the hope that their films might win an award and be chosen for the World Tour enjoyed by an audience of more than 250,000 annually. The Banff Mountain Film Festival's high adrenaline sibling, Radical Reels, also enjoys a widespread, younger audience of more than 30,000. Similarly, the Banff Mountain Book Competition is now in its 18th year, with more than 1,730 volumes gracing mountain library shelves.

Today, the world's best mountain films, books, photographs, and speakers take the spotlight for nine days each fall in Banff (late October – early November). Theatres and venues are packed with locals, international visitors, and world-renowned authors, filmmakers, conservationists, adventurers, and explorers from around the world (Cooper 2011).

Alpine Club of Canada

Vision: Preserving, practicing and promoting Canadian mountain culture and self-propelled alpine pursuits.
Mission: The Alpine Club of Canada fosters alpine experiences, knowledge and culture; promotes responsible access; and supports excellence in alpine leadership and skills.

The Alpine Club of Canada (ACC) is Canada's national mountain organization. Based in Canmore, Alberta, the ACC has been a focal point for Canadian mountaineers since 1906. With regional club sections across Canada, membership in the Union Internationale des Associations d'Alpinisme, year-round mountain adventures, and an extensive system of alpine and backcountry huts throughout the Canadian Rockies, the ACC has grown from its early inception into a full-fledged mountain organization with a strong foundation of volunteer, professional, and corporate support (www.alpineclubofcanada.ca/whoweare/index.html).

MINERAL EXTRACTION

Mining is the extraction of valuable minerals or other geological materials from the earth, from an ore body, vein, or coal seam. In the broader sense, mining also comprises the extraction of any non-renewable resource, e.g., petroleum, natural gas, or even water.

Mining is an important economic driver in North America's mountains.

- It provides an estimated 5,500 jobs in Alaska, and the coal that is extracted provides 40 percent of the state's electricity.

- The Rockies are a hub for coveted natural resources including, but not limited to, gold, silver, natural gas, coal, and oil. "Recent studies estimated that the region contains nearly 2 billion barrels of proven oil reserves, 186 billion cubic feet of proven natural gas reserves, and enough coal to supply the country for the next 120 years...No other region of the United States is equally endowed" (Smith 2008).

- According to the U.S. Energy Information Administration, although there were almost 1,400 coal mining operations in 26 states in 2007, over two-thirds of all coal mines, and over half of the estimated 80,600 mine employees, were located in just three states within the Appalachian Mountains—Kentucky, Pennsylvania, and West Virginia. In many rural areas, mining operations are the main employer. About 79 percent of mining establishments employ fewer than 20 workers (www.bls.gov/oco/cg/cgs004.htm).

> *"Safeguarding the public from the poisoning of the land, air, and water supplies is one of the most fundamental exercises of government's police power. Yet the containment of hazardous wastes and contaminated site cleanup activities can have dramatic often draconian effects on private property rights."*
>
> Meltz et al. ,1999
>
> *"What's missing from this concept is that there is so little consideration of a public property right to environmental quality."*
>
> Wallerstein 1974, 1980, 1989 (Weiner 2011)

Mining tends to be highly localized compared to forestry, but its impacts often are more profound—both more widespread, and more enduring. In addition to direct impacts, mining poses other threats to mountain environments. The roads required to bring equipment to mines and to extract ores disrupt large areas, contribute to erosion, and open new areas for access. Mine operations also can cause significant impacts over larger environmental areas. Most extraction processes use toxic chemicals (e.g., cyanide, arsenic) that create poisonous run-off. Tailing ponds try to contain the toxins, but have been notorious in their frequent failures over time causing serious downstream damage to land, water, and people (Pratt and Shilling 2002).

> Citizens in Battlement Mesa, Colorado have started to take their own air samples out of concern for air pollution caused by natural gas extraction, claiming that state air quality monitoring is not sufficient. Although there are some questions about the validity of their tests, citizens have report the presence of toxic chemicals in the air at 3 to 3,000 times the safe levels allowed by the Environmental Protection Agency, including carcinogens such as benzene.
>
> National Public Radio Broadcast
> Morning Edition 12/27/11

Natural Gas

High-volume hydraulic fracturing, or "fracking," is the process of injecting millions of gallons of water, chemicals, and sand into shale rock formations at high pressures to break open the rock and release the natural gas. This process is making it possible to extract natural gas from rock

Figure 6: Gas wells, southwest Virginia Photo: SouthWings

formations deep underground. The oil and gas industry's position is that fracking poses no risks to groundwater. However, others disagree and believe that more research is needed before exposing the public to the effects of fracking. Some of their concerns include:

- There have been more than 1,000 documented cases of water contamination near fracking sites around the country.

- Fracking produces hazardous wastewater, which can contain radioactive substances as well as toxic chemicals, making disposal difficult and dangerous.

- Fracking requires millions of gallons of water, which can deplete local water supplies (www.foodandwaterwatch.org/water/fracking/).

There also are concerns about the methane emissions from these operations. Currently, scientists have a very limited understanding of how much methane, a potent greenhouse gas, is being emitted from shale gas drilling across the United States. However, some estimates are that the methane emissions from fracking are at least 30 percent more than and perhaps more than twice as great as those from conventional gas extraction methods (Howarth et al 2011).

Struggle Over Uranium Mining, Milling, and Disposal in the American West

The Sheep Mountain Alliance, an advocacy group based in Telluride, Colorado, won a small victory in a large ongoing war of values and strategies, which accompanies most energy development and most mining in the modern American West. On October 18, 2011, SMA and its conservation partners won a sweeping legal victory when a federal judge ordered a halt to the Department of Energy's (DOE's) Uranium Leasing Program. The court issued an injunction

to suspend all drilling, mining, exploration, and existing and future uranium leasing over a 42-mile[2] area on the Western Slope.

The lawsuit was originally filed to stop the DOE's implementation of a 10-year leasing program that was authorized without conducting a full environmental analysis of the impacts to the environment, water and air quality, wildlife and Western Slope communities. DOE had refused to conduct a full Environmental Impact Statement (EIS) and instead issued a Finding of No Significant Impact (FONSI) in 2007. The plaintiffs in the suit were concerned that the renewal of uranium mining from Gateway to Dove Creek would threaten to deplete the San Miguel and Dolores Rivers, spread toxic and radioactive contamination, and have widespread impacts on the environment, air quality, wildlife, local communities, and recreational opportunities.

In August, as the final court ruling was still pending, DOE announced that it would conduct a Programmatic EIS and held a series of public meetings in the Uravan Mineral Belt. SMA and its conservation partners, along with many other individuals, submitted extensive comments during the scoping process in early September. The new PEIS provides an important opportunity for the public to take a role in determining the future of the region. The PEIS process will last several years and will have a major impact on the Western Slope, the DOE lease tract areas, and adjacent public lands.[9]

Surface coal mining in Kentucky has turned nearly 600,000 acres of one of the most bio-diverse forests on our planet into ecologically barren wastelands. That's an area 2/3 the size of the Grand Canyon. One out of every seven acres in the eastern Kentucky coalfields has been impacted by strip-mining.

Source: Appalachian Voices and NRDC report, "Reclamation Fail," May 2010

In recent years, numerous peer reviewed studies have confirmed that large scale surface mining in eastern Kentucky and Central Appalachia causes widespread and permanent harm to human health as well as to forest, soil and aquatic ecosystems. According to a 2010 study published in the journal ***Science***, "*The extensive tracts of deciduous forests destroyed by mountaintop mining and valley fills support some of the highest biodiversity in North America…. Burial of headwater streams by valley fills causes permanent loss of ecosystems that play critical roles in ecological processes…and downstream food webs.*" The study goes on to say, "*Elevated levels of airborne, hazardous dust have been documented around surface mining operations. Adult hospitalizations for chronic pulmonary disorders and hypertension are elevated as a function of county level coal production, as are rates of mortality; lung cancer; and chronic heart, lung, and kidney disease*."

Mountaintop Mining in Appalachia

Mountaintop removal (MTR) is a relatively new type of coal mining that began in Appalachia in the 1970s as an extension of conventional strip mining techniques. Primarily, mountaintop removal is occurring in West Virginia, Kentucky, Virginia, and Tennessee. Coal companies in Appalachia are increasingly using this method because it allows for almost complete recovery of coal seams while reducing the number of workers required to a fraction of what conventional methods require.

The U.S. Environmental Protection Agency defines MTR as follows:

9 www.biologicaldiversity.org/news/press_releases/2011/uranium-mining-10-19-2011.html

"Mountaintop removal/valley fill is a mining practice where the tops of mountains are removed, exposing the seams of coal. Mountaintop removal can involve removing 500 feet or more of the summit to get at buried seams of coal. The earth from the mountaintop is then dumped in the neighboring valleys." "…some valley fills may contain as much as 500 million tons of blasted mountains and run for as long as 6 miles" (Orr 2007).

Figure 7: Coal Trucks, Kent Mason TNC, West Virginia Photo: SouthWings

The 1977 Surface Mining Control and Reclamation Act (SMCRA) regulates surface coal mining operations in the United States and established the Office of Surface Mining Reclamation and Enforcement to establish "a nationwide program to protect society from the adverse effects of surface coal mining, yet striking a balance between environmental protection and the nation's need for coal as an essential source of energy". SMCRA established performance standards for surface coal mining operations. These standards provide "cradle to grave" coverage throughout the life-cycle of a surface coal mining operation—from the earliest aspects of exploration and planning of an operation, throughout all of the "active" mining operations, and concluding with reclamation of the project. All mining operations also must obtain permits and comply with regulations under the Clean Water Act, which are designed to avoid degradation of streams and other waters from impacts associated with mining activities (National Mining Association 2009). Despite the laws and regulations in place, however, MTR mining has become extremely controversial. On the one hand, the mining industry points to the positive economic impact MTR has on the region and the regulation and monitoring that takes place to ensure that areas affected by the process are properly reclaimed. Opponents to MTR point to the threats to the environment and human health that they believe are not being adequately regulated.

Environmental Impacts

According to the Nature Conservancy, the mountain region including southwest Virginia, southern West Virginia, eastern Kentucky and northeastern Tennessee contains some of the highest levels of biological diversity in the United States. This region also is at the headwaters of the drinking water supplies of many U.S. cities. A multi-agency Environmental Impact Statement issued in 2003[10] provided some useful information on the extent and impacts of mountaintop removal. Some of the impacts and concerns expressed in the final report include:

- More than 7 percent of Appalachian forests have been cut down and more than 1,200 miles of streams across the region have been buried or polluted between 1985 and 2001.
- Over 1,000 miles of streams have been permitted to be buried in valley fills. (For scale, this is a greater distance than the length of the entire Ohio River).
- Mountaintop removal mining, if it continues unabated, will cause a projected loss of more than 1.4 million acres by the end of the decade—an area the size of Delaware—with a concomitant severe impact on fish, wildlife, and bird species, not to mention a devastating effect on many neighboring communities.
- 800+ miles^2 of mountains are estimated to be already destroyed. (This is equal to a one-quarter mile wide swath of destruction from New York to San Francisco.[11]) (ilovemountains.org/)

The widespread and long-term destruction of water resources caused by MRT is of particular concern. The orange dots on Figure 8 show facilities with one or more water quality violations. The actual problems are likely much more severe.[12] In recent sworn testimony, the Kentucky Division of Water admitted that in many cases they don't even know the exact number or location of all discharge points on a given mine site.

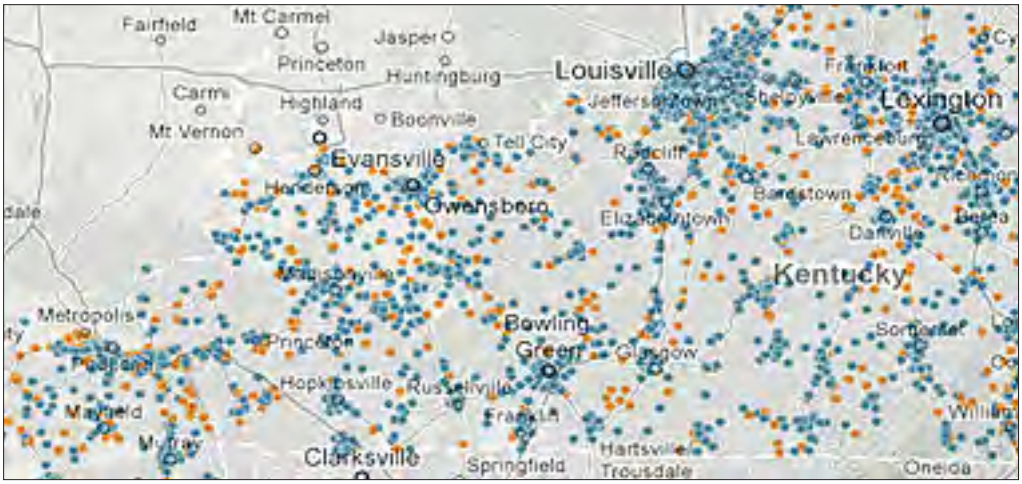

Figure 8: Water Quality Discharge Facilities in Kentucky with Water Quality Violations

10 There was considerable controversy surrounding this study. With the change in the Administration in 2000, the focus of the study changed from "developing agency policies … to minimize, to the maximum extent practicable the adverse environmental effects" of mountaintop removal to "centralizing and streamlining coal mine permitting." In addition, the permit maps used to report valley fill underestimated it in 6 West Virginia coal counties by 40 percent.

11 According to some, this figure is significantly underestimated.

12 This map was created and published by the New York Times using state data.

As Figure 8 shows, rural eastern Kentucky is carpeted with water pollution, in large part from coal mining facilities. Several hundred thousand people live in the affected counties. This area also serves as the headwaters for rivers, such as the Cumberland River, Big Sandy River, and Kentucky River, which provide drinking water to more than a million Kentuckians downstream.

The Kentucky Division of Water admits that 2,500 miles of Kentucky's headwater streams have been buried or significantly damaged by valley fills, and the total grows daily. According to the last Biennial Report to Congress on water quality from the Kentucky Division of Water, only 12 percent of the Big Sandy River can fully support aquatic life. And the headwaters of the Kentucky, Cumberland, and Licking Rivers also continue to deteriorate (Abbott 2011).

Impact on Families and Communities

Even government agencies that regulate mountaintop removal agree that the effects on nearby homes and communities can be "devastating." In their Mid-Atlantic Regional Assessment, the Environmental Protection Agency states:

> *"Every day some 3 million pounds of explosives are used in the 11 counties south of Charleston (WV)."*
>
> Dr. David W. Orr
> "The Carbon Connection"

"The impact of mountaintop removal on nearby communities is devastating. Dynamite blasts needed to splinter rock strata are so strong they crack the foundations and walls of houses. Mining dries up an average of 100 wells a year and contaminates water in others. In many coalfield communities, the purity and availability of drinking water are keen concerns" (ilovemountains.org/resources#mtrcommunities).

In addition to the frequent loss or pollution of drinking water, families living near mountaintop removal sites contend with:

Blasting Families and communities near mountaintop removal sites are forced to contend with continual blasting from mining operations that can take place up to 300 feet from their homes and operate 24 hours a day. The impact of blasting not only makes life all but unlivable in nearby homes, it also frequently cracks wells and foundations. Blasting also can send boulders flying hundreds of yards into roads and homes.

Flooding Coalfield residents have long complained about drastic increases in flooding following mountaintop removal operations. The coal industry maintains such floods are "Acts of God." However, researchers at the University of Kentucky recently concluded: "there is a clear risk of increased flooding (greater runoff production and less surface flow detention) following [mountaintop removal and valley fill] operations."

> *"In McRoberts, KY, the problem is flooding. In 1998, Tampa Energy Company (TECO) started blasting along the ridgetops above McRoberts….Then TECO sheared off all the vegetation at the head of Chopping Block Hollow and replaced it with the compacted rubble of a valley fill. In the region prone to flash floods, nothing was left to hold back the rain; this once-forested watershed had been turned into an enormous funnel. In 2002, three so-called hundred-year floods happened in 10 days."*
>
> Eric Reece

Sludge Dams Sludge dams represent the greatest threat to nearby communities of any of the impacts of coal mining. Impoundments are notoriously leaky, contaminating drinking water supplies in many communities, and also are known to fail completely. In 2000, a sludge dam breach in Martin County, Kentucky sent more than 300 million gallons of toxic coal sludge into tributaries of the Big Sandy, causing what the EPA called, "The biggest environmental disaster ever east of the Mississippi." (ilovemountains.org/)

The Role of Coal in America's Energy Future

According to the EPA, mountaintop removal accounted for less than 5 percent of U.S. coal production as of 2001. According to a report from the U.S. Geologic Survey (USGS) in 2000, the Appalachian coal basin will not continue providing coal for much longer. The report states:

"Sufficient high-quality, thick, bituminous resources remain in [Appalachian Basin] coal beds and coal zones to last for the next one to two decades at current production."

The report goes on to say that the major Appalachian coal beds:

"already have peaked in production and the remaining coal is deeper (>1,000 ft), thinner (<3.5 ft), and (or) contains environmentally less desirable medium-to-high ash yields and sulfur contents."

In short, MTR is destroying one of America's national treasures for a small fraction of the nation's energy supply that will last for only a few decades.

Breaking the Connection to Mountaintop Removal

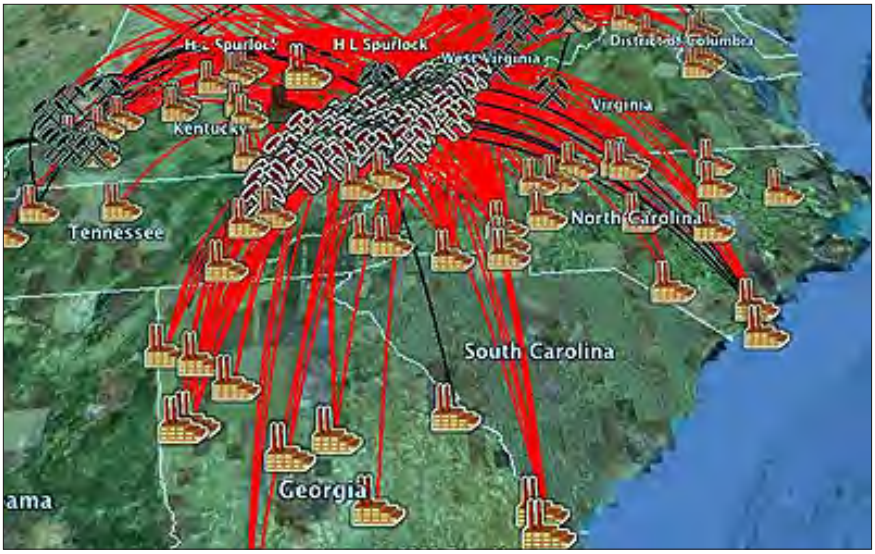

Figure 9: Connections Between Coal-Fired Power Plants and Mountaintop Removal Mines

Figure 9 shows some of the connections between coal-fired power plants and the mountaintop removal mines that supply them with coal. In most states where mountaintop removal coal is used to generate electricity, the actual mining is not taking place. The connection between flipping on a light switch and the blasting of one of the world's oldest mountains is not one many consumers make. In 2009, citizens and legislators in several states took steps to try to change that. In unprecedented moves, the top two consumers of mountaintop removal coal (Georgia

and North Carolina) introduced bills banning the use of mountaintop removal mined coal in their states. But they are not the only ones. Other states taking action include:

- Georgia
- Maine
- Missouri
- Pennsylvania
- Tennessee
- West Virginia
- Kentucky
- Maryland
- North Carolina
- South Carolina
- Washington DC

ilovemountains.org/

On April 27, 2009, Secretary of the Interior Ken Salazar asked the U.S. District Court in Washington D.C. to vacate the "stream buffer zone" rule passed in the waning days of the Bush Administration, which allowed coal mine operators more leeway to dump rock, dirt, and debris from mountaintop removal into streams, asserting that the rule failed to adequately protect water quality and stream habitat on which coal communities rely. In 2011, the Subcommittee on Energy and Mineral Resources held hearings on the proposed rule changes over concerns that vacating the rule will threaten the jobs of thousands of coalminers and tens of thousands of jobs associated with the industry.

www.southernenvironment.org/newsroom/press_releases/04_27_09_stream_buffer_zone_rule1

POVERTY/WEALTH DISCREPANCIES

Many mountain areas around the world are disproportionately poor, including the Appalachians in the United States. For over 100 years, people have mined the coal that lies under the ancient Appalachians. Coal mining has been the only livelihood for many families. The coal industry promised prosperity to the area. Even today, the industry points to the 14,000 direct and 60,000 indirect jobs created by MTR, and that the average mining wage is more than $66,000/year, excluding overtime, which is 57 percent higher than the average for industrial jobs. A 2004 study conducted by the Center for Business and Economic Research found that "the impact on state and local tax revenues will be precipitous if MRT is eliminated." The study's authors conclude that placing serious restrictions on MTR would result in a loss equaling almost nine percent

West Virginia, USA: Resource Extraction and External Investment

Extractive industries, such as mining, provide employment opportunities within the State of West Virginia, but the advance of technology has eliminated many jobs previously performed by human labor. A major mountaintop removal coal mine employs only 70-90 workers in total, many from out of state. As of 1998, West Virginia ranked 50th in the nation in terms of median household income and 3rd in terms of the percent of population below the poverty line, with a rate of 17.8 percent as compared to the national average of 12.7 percent.

Source: US Census Bureau
www.census.gov/statab/www/states/wv.txt
and Lewis, 1998

of West Virginia's tax revenue, which would impact a variety of state services, including K-12 education (National Mining Association 2009).

Despite industry claims, however, the coal-bearing counties of Appalachia are some of the poorest in the nation, despite the fact that some of the greatest wealth is being extracted from them. Counties with the highest percentage of mining jobs tend to have high levels of poverty and unemployment. Thirty-six of the 100 poorest counties in the United States measured by median household income are in West Virginia, eastern Kentucky, southwest Virginia, east Tennessee, and southeast Ohio. The poverty rate ranges as high as 45 percent in these counties, with the greatest poverty found in the region's more rural communities and in counties with higher coal production. Recent studies from both Kentucky and West Virginia also document that taxpayers in those states lose hundreds of millions of tax dollars each year because the states spend more in coal subsidies than they receive in coal revenues (Abbott 2011 and ilovemountains.org/).[13]

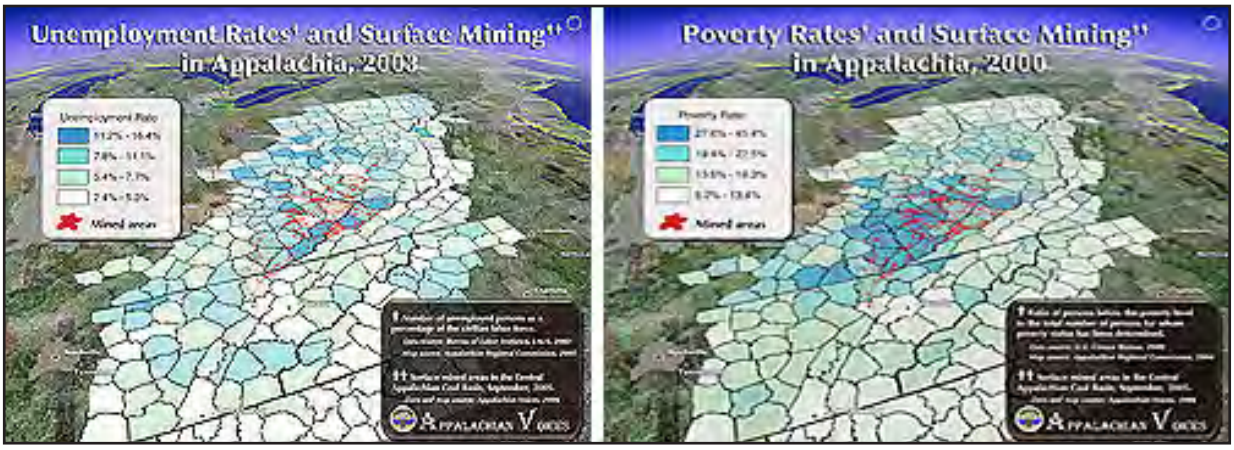

Figure 10: Unemployment Rates and Poverty Rates in Appalachia

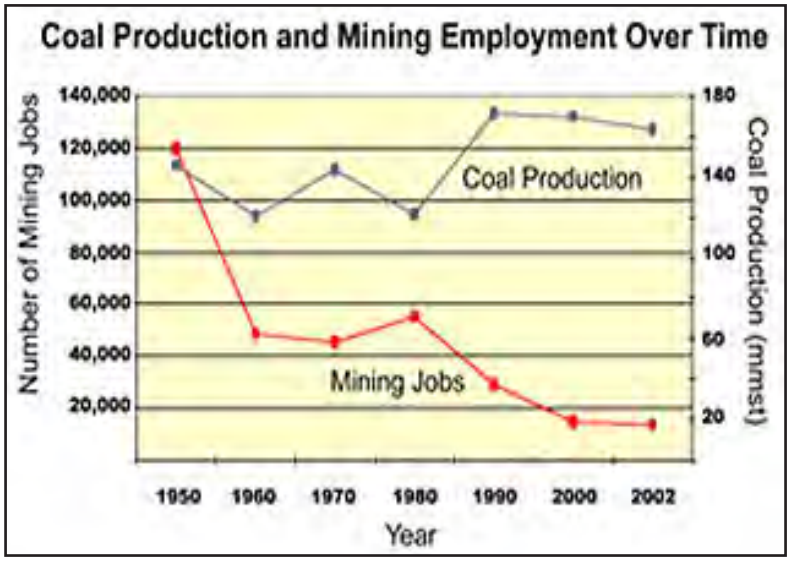

Figure 11: Unemployment Rates and Poverty Rates in Appalachia

Mountaintop removal is a mining technique designed to take the labor force out of the mining operation. According to the Bureau of Labor Statistics, in the early 1950's there were between 125,000 and 145,000 miners employed in West Virginia; in 2004 there were just over 16,000. During that time, coal production increased (ilovemountains.org/).

13 The impact report can be found at www.maced.org/coal/

SUSTAINABLE DEVELOPMENT—TAKING ACTION

Across North America, numerous activities have been launched to promote sustainable mountain development and to address the issues that impact it. The following are but a handful of such examples.

TRANS-BOUNDARY COOPERATION/COLLABORATION

In the last 20 years, North American has seen an increase in cross jurisdictional/multi-discipline/multi-professional/very large landscape/very deep ecosystem analysis and planning initiated by nonprofits, academia, and governments. These trans-boundary initiatives are exciting and important, even crucial, because they attempt to deal with stress, change, and opportunity at the scale at which events are happening.

Scientific and Managerial Collaboration—The Southern Sierra Conservation Cooperative
Accelerated climate change is projected to interact with existing agents of change and pose unprecedented challenges for the protection of native species and ecosystem services. Responding to this challenge calls for extraordinary levels of collaboration across the landscape and partnerships among scientific researchers and resource managers. The Strategic Framework for Science in Support of Management in the Southern Sierra Nevada Ecoregion was collaboratively developed by federal agencies to face the challenge head on. The framework will be carried out by the Southern Sierra Conservation Cooperative, a collaborative group of government agencies and nonprofit organizations in the Southern Sierra Nevada Ecoregion. The framework contains four goals: (1) understanding where and why changes occur, (2) anticipating possible futures, (3) developing tools required to take effective action, and (4) providing easy access to and delivery of information to target audiences (Nydick et al 2001).

Regional Partnerships
The Western Climate Initiative (WCI) began in February 2007 when the Governors of Arizona, California, New Mexico, Oregon, and Washington signed an agreement directing their respective states to develop a regional target for reducing greenhouse gas emissions; participate in a multi-state registry to track and manage greenhouse gas emissions in the region; and develop a market-based program to reach the target.

The WCI built on existing greenhouse gas reduction efforts in the individual states as well as two existing regional efforts. In 2003, California, Oregon and Washington created the West Coast Global Warming Initiative, and in 2006, Arizona and New Mexico launched the Southwest Climate Change Initiative.

During 2007 and 2008, the Premiers of British Columbia, Manitoba, Ontario, and Quebec, and the Governors of Montana and Utah joined the original five states in committing to tackle climate change at a regional level. All 11 jurisdictions collaborated in the development of the Design for the WCI Regional Program, which was released in July 2010.

In November, 2011, the Western Climate Initiative formed the Western Climate Initiative, Inc.

(WCI, Inc.), a nonprofit corporation that will provide administrative and technical services to support the implementation of state and provincial greenhouse gas emissions trading programs.

British Columbia, California, Ontario, Quebec, and Manitoba are continuing to work together through the Western Climate Initiative to develop and harmonize their emissions trading program policies. They also are continuing to work with western, mid-western, and northeast states on a range of other climate and clean energy strategies through the North America 2050 Initiative, a forum for states, provinces, and stakeholders to identify leadership opportunities in climate and clean energy policy (www.westernclimateinitiative.org/history).

North Cascadia Adaptation Partnership

North Cascades National Park, Mount Rainier National Park, Mount Baker-Snoqualmie National Forest, and the Okanagan-Wenatchee National Forest are working together to develop science-based climate adaptation strategies and tactics. This science-management partnership, the North Cascadia Adaptation Partnership (NCAP), focuses on approximately 6 million acres straddling the Cascade Mountains in Washington (www.northcascadia.org). The NCAP process includes four steps: education, vulnerability assessment, adaptation planning, and implementation. Management strategies will be developed for four resource-based issues: fish and fish habitats; access; wildlife and wildlife habitats; and vegetation and disturbance. Adaptation strategies will vary across the landscape reflecting agency missions and diverse environmental and climatic conditions. Access will be the most challenging topic as they are attempting to address social and natural perspectives associated with maintenance of roads, trails, and infrastructure; recreational opportunities, and traditional use of resources (Rochefort et al 2011).

The Southern Rockies Wildlands Network Vision

National parks, wilderness areas, and wildlife refuges have accomplished a great deal for nature. But over time, protected areas have been surrounded by roads and degraded landscapes. They have become too isolated to sustain viable populations of large animals, let alone many ecological and evolutionary processes. To overcome this, a very large landscape (continental) approach is needed to heal the areas that have been wounded. This logic led to the Southern Rockies Wildlands Network Vision—a science-based plan that provides an ambitious but practical approach to protecting networks of land in the Southern Rockies to maintain and restore native biological diversity in this spectacular region.

The culmination of this report was a joint effort between the Southern Rockies Ecosystem Project, the Denver Zoo, and the Wildlands Project. It emphasizes large core wild areas, functional connectivity across the landscape, and the vital role of keystone species (especially large carnivores) and processes. The Vision is both a prescription for the ecoregion itself, and an important piece of a larger picture to create contiguous wildlands, called MegaLinkages, across North America. Under the guidance of the Wildland Project, other regional conservation plans are striving to create a north to south MegaLinkage through the Rocky Mountain chain (Miller et al 2003).

Yellowstone to Yukon Conservation Imitative

The Yellowstone to Yukon Conservation Initiative (Y2Y) is a joint Canada-U.S. not-for-profit

organization that seeks to preserve and maintain the wildlife, native plants, wilderness, and natural processes of the mountainous region from Yellowstone National Park to the Yukon Territory. Y2Y was officially established in 1997 by conservationists and scientists who believed that lasting conservation requires an overall understanding of the landscape, and the setting of regional conservation priorities. Adopting a new paradigm that fits with this thinking, they developed an organization that integrated scientifically sound research, stewardship, and strategic partnerships.

At its heart, Y2Y is about people working together. The Y2Y organization serves an important role to catalyze and facilitate local conservation action by a myriad of partners. Its network includes local grassroots and community groups; government agencies; funders (both institutional and individual); Native American and First Nations communities and organizations; scientists and researchers; businesses; and others whose work contributes directly or indirectly to advancing the Yellowstone to Yukon vision.

As a catalyst, Y2Y commissions scientific research and synthesizes the work of others to better envision the region's overall condition and conservation needs. Using the large-scale needs of grizzly bears, birds, and fish, Y2Y establishes conservation priorities for the entire region and identifies critical areas with the greatest conservation need. By facilitating the exchange of ideas and research, as well as attracting international attention and funding to the region, Y2Y has been able to grow the capacity of other groups to achieve more than they could otherwise. Y2Y fosters collaborations that coordinate the work of its partners around agreed-upon conservation strategies that bring greater efficiency and effectiveness to regional efforts (www.y2y.net/home.aspx).

The Cabinet-Purcell Mountain Corridor Conservation Project is one example of Y2Y initiatives. The Corridor is one of only two remaining areas in the Y2Y region where grizzly bears and other wildlife species (including mountain caribou, cougar, lynx, and fisher) can move back and forth between Canada and the United States. This priority area represents over 18 percent of the Y2Y region, ranging from Missoula, Montana to Golden, British Columbia; covers 43,750 mi^2 (70,000 km^2); and comprises 4 mountain ranges—the Purcell, Cabinet, Selkirk, and Bitterroot Mountains. The project partners are working to address many of the threats facing the Corridor, such as increasing development, transportation routes, poorly managed recreational activities, human-wildlife conflicts, and inadequate resource management planning. A steering committee meets twice annually to prioritize implementation of on-the-ground projects identified by working groups (www.y2y.net/data/1/rec_docs/639_Purcell_Project_Profile_08.pdf).

Skagit Environmental Endowment Commission

The Upper Skagit watershed includes approximately 1,000 $miles^2$ of forested land upstream of Ross Dam on the Skagit River in Washington State. About 40 percent of the land is in British Columbia, Canada. The Skagit Environmental Endowment Commission (SEEC) is an international not-for-profit entity created in 1984 via treaty between the United States and Canada. It operates through terms of an Agreement between British Columbia and the City of Seattle relating to an earlier proposal by Seattle City Light to expand its hydroelectric power project on the Skagit River.

The Agreement established the Skagit Environmental Endowment Fund through contributions by both Seattle and British Columbia. The fund, now valued at about $9,000,000, has been managed to keep pace with inflation while providing a flow of resources (currently about $500,000 per year) to accomplish projects in both British Columbia and Washington State. Key purposes of the fund are to "conserve and protect wilderness and wildlife habitat" and "enhance recreational opportunities" throughout the watershed upstream of Ross Dam.

A Commission was created to administer the fund through the 80-year life of the Agreement. SEEC is composed of eight volunteer Commissioners, four appointed by the British Columbia Premier and four by the Seattle Mayor. Alternate Commissioners, in equal number, also are appointed, and all serve four-year terms. The Commission meets several times a year to administer the Fund by reviewing project proposals, monitoring contracts, and addressing environmental issues in the Upper Skagit Watershed. The Commission's budget must be approved by the Province of British Columbia and Seattle City Council.

The Commission does not manage any land itself. Rather, it cooperates with government agencies in both the U.S. and Canada that are responsible for this land. Most is publicly owned and administered by the park agencies in the respective countries.

SEEC operates in collaboration with several partners, including the British Columbia Ministry of Forests, Lands, and Natural Resource Operations, the U.S. National Park Service, the North Cascades Institute, the Hope Mountain Centre for Outdoor Learning, and the Student Conservation Association. Together, the Commission and its partners have developed a 5-year workplan that sets its priorities (Powell 2011).

Utah Valley University/Central Asian Collaboration

In 1999, Utah Valley University (UVU) in Orem, Utah established ties with Kyrgyzstan and other Central Asian nations based on similarities and challenges in the size of their territory, population, and the natural conditions of mountain life between the two regions. The initial focus of their collaboration—educational exchanges—was expanded to the promotion of the sustainable mountain development (SMD) agenda when UVU joined the United Nations' Mountain Partnership in 2006. The evolution of this collaboration was a natural extension of UVU's focus on "community engaged learning" both locally and globally; existing ties with Central Asia; and a network of close relationships with individuals and organizations prominent in planning the first Global Mountain Summit in Kyrgyzstan in 2002, which culminated in the UN International Year of the Mountains. These relationships were then extended to organizations in Montana, Colorado, and Wyoming in an effort to develop a regional approach for North American mountain communities to join the global SMD agenda. Those efforts culminated in the "Women of the Mountains International Conference" held in March 2007 in Orem, Utah and the "Women of the Mountains Second International Conference" held in March 2011, also in Orem.

The 2007 conference served as the first regional event in the United States that supported the entire SMD agenda and recognized gender issues as one of the major priorities of both the UN's Millennium Development Goals and SMD agendas. The final document of the Conference, "The

Orem Declaration of Mountain Women," defined a strategy for global mountain communities to promote jointly the cause of mountain women, and promoted further integration of the communities from the Rockies with the activities of the Mountain Partnership and the Mountain Forum. The second conference served to strengthen the regional approach for advancing the SMD and gender agendas by expanding the network of North American Mountain Partnership members and involving youth from Utah high-schools and UVU students in the conference activities (Abdrisaev 2011).

Restoring the Appalachian Trail

The Appalachian Trail is a marked hiking trail in the Appalachian Mountains in the eastern United States, extending between Springer Mountain in Georgia and Mount Katahdin in Maine. It is approximately 2,181 miles (3,510 km) long. The majority of the trail is in wilderness, however, some portions traverse towns and roads. As noted earlier, population growth and development are threatening portions of the Trail. To address this degradation to the Trail and the surrounding mountainside, collaborative efforts are now underway. The Friends of the Blue Ridge Mountains, National Wildlife Federation, Appalachian Trail Conservancy, and others have initiated a major effort to create a conservation corridor along the model of Y2Y.

CLIMATE ADAPTATION STRATEGIES/LAND MANAGEMENT

Fuels, Fire, and Restoration Ecology in Isolated Ranges of the Mogollon and Colorado Plateau

For 100 years, fire management in western American forests dictated the complete control of wildfires. The U.S. Forest Service's motto, "Out by 10," aptly described this approach.[14] But this aggressive suppression policy led to massive and unnatural fuel accumulations over 80 million acres of western montane forest, which has contributed to recent, uncontrollable stand replacement fires. These are "unnatural fires," burning much hotter than natural fires (50°C to 1500°C); volatilizing key elements such as nitrogen (at 200°F) and phosphorus/potassium (774°F); and searing the soil and its organisms much deeper than the 1-inch experienced under pre-settlement fires.

In 1887, forests at the Grand Canyon were open parklands of 100 trees/ac, but are now stocked at 1,000 to 3,700 trees/ac. Restoration of pre-1887 conditions was attempted in ponderosa pine forests at the Grand Canyon by testing retention of old growth, thinning of small trees, litter raking, and prescribed burning ($748/ac); minimal thinning of ladder fuels near old growth to reduce crown fires and prescribed burning ($566/ac); and burn only ($44/ac). There also was a control group. The original conditions were restored on the full treatment, which also restored the highest biodiversity from microbes to elk, deer, and turkey.

Forest management can lead to the restoration of natural forests that require fire return intervals of 5 to 40 years, a process heretofore promoted by indigenous residents before widespread

14 The Forest Service no longer manages by this motto. Various fire mitigation strategies, including prescribed fire, have been adopted in order to restore forest landscapes to more natural and healthier conditions. But the use of fire to restore landscapes remains somewhat controversial because of incidents where prescribed burns have gotten out of control and caused significant damage and/or threats to people and property. One notable example was the prescribed burn that escaped on the Bandelier National Monument in 2000, which threatened the City of Los Alamos, New Mexico and the Los Alamos National Laboratory.

European settlement. However, this represents a commitment and investment. A 20-person crew can treat an average 20 acres/day at a cost of $5,000/crew/day. If 25 percent of the overstocked 80 million acres is non-wilderness priority treatment (near structures, endangered species, steep slopes in important watersheds, etc.), a 4-year treatment cycle would cost about $1 billion/yr for four years of montane forest restoration in the United States. Once restored, natural ecosystems can be maintained with inexpensive natural or prescribed fire (Berwick 2011).[15] However, "[w]ith growing economic problems and a Congress skeptical of both climate science and new spending, changes for…funding appear remote" (Gillis 2011).

Regional Fire Planning

The Alternative Fire Management Futures Initiative is the first test of the Strategic Framework for Science in Support of Management in the Southern Sierra Nevada Ecosystem (see discussion above). The goal of this project is to develop critical information, processes, and tools to evaluate and create realistic and flexible fire management objectives based on plausible future environmental conditions in the Southern Sierra Nevada Ecoregion. This project is a collaboration among resource managers, fire managers, and scientists and uses a landscape approach. The partners combine existing tools (scenario planning, climate change vulnerability assessment, a climate change adaptation "toolbox, and structured decision making) to provide both qualitative strategic and spatially explicit operational management decision support. Results from this project will provide inputs to a National Park Service (NPS) resource stewardship strategy and NPS and U.S. Forest Service fire management plans (Nydick et al 2011).

Sustainable Forest Management

The Appalachian Carbon Partnership (ACP), a project of the Mountain Association for Community Economic Development (MACED), is a powerful new model for promoting the practice of sustainable forest management on private, non-industrial forestland. This program is the first in Central Appalachia to compensate forest landowners for the carbon sequestered by their sustainably managed forests, linking the global issue of climate change directly to local sustainable development in Central Appalachia. Currently, more than 45 landowners have enrolled 25,376 acres of forest land in this program. Seventy-five percent of those acres are in counties that qualify as "economically distressed." So far, participants in this program have received about $100,000 for the sale of carbon offsets (Abbott 2011).

EDUCATION/RESEARCH

Education and research initiatives focused on issues related to sustainable mountain development abound. A few of these efforts are highlighted below.

The Rocky Mountain Sustainability and Science Network

In March 2010, Gillian Bowser and Mark Brown of Colorado State University were awarded a grant from the National Science Foundation to develop the Rocky Mountain Sustainability and Science Network (RMSSN). The overarching goal of the network is to use the Rocky Mountain environment as a platform to help develop the next generation of global-minded leaders who are prepared to address future issues related to climate change and environmental sustainability. These youth leaders also would be representative of the cultural and ethnic diversity of the United States. That goal is grounded in four sub-goals for which the network has recruited

15 Sources: Fulé, P., et al. 2002. Comparing Ecological Restoration Alternatives: Grand Canyon, Arizona. Forest Ecol. and Mgmt. 170:19-41

partners (including over 20 academic institutions and federal agencies) with specific expertise related to global leadership, collaborative partnerships, science, and education. The hallmark of the RMSSN is a summer academy situated in the Rocky Mountains that uses the changing phenology of mountain ecosystems as a vehicle to train the students in climate change, shifting phenology, and climate policy. This academy ultimately leads to a Certificate in Global Leadership and Environmental Sustainability that students receive upon entering their own ecological observations in a national database. All graduates of this program have been successful in obtaining summer internships related to sustainability; obtained permanent employment with agencies that preserve and protect environmental and cultural resources; and/or have obtained entry into graduate degree programs related to sustainability and/or environmental science (Bowser and Brown 2011).

The Mountain Studies Institute

The Mountain Studies Institute (MSI), located in Silverton, Colorado, was formed in 2002 as a nonprofit with a mission to use research, education, and information to facilitate informed decisions by stakeholders by utilizing the San Juan Mountains as a "living laboratory." MSI has had an impact by supporting research on measuring mercury contamination in streams, lakes, vegetation, fish, and birds. It is active with biochar use in mine lands reclamation, studies with dust events, fen restoration, and is part of the international GLORIA monitoring network.

There is a lack of long-term monitoring in general, and MSI is working to correct this in the future by supporting citizen science and further academic research. In addition, MSI is engaged in expanding science education through select publications, such as "My water comes from the San Juan Mountains," which is designed for 2nd to 5th grade classes and has been adopted by schools in five Colorado counties. Another 2011 publication where MSI is a co-publisher is "The Eastern San Juan Mountains: their geology, ecology and human history." The royalties for this book go to an undergraduate research fund for senior theses at Fort Lewis College being conducted in the San Juan's (Robert Blair 2011).

The Headwaters Project

Western State College in Gunnison, Colorado sits centrally in what could be called "the Headwaters Region of the Southwest," a mountain-and-valley region in the Rocky Mountains with geographic, climatic, and cultural diversity. Western's "Headwaters Project" is part of the college's effort to serve the mountain valleys of this region as a resource and rallying-point, as the region's communities attempt to both retain unique cultural identities and still thrive in a globalizing and homogenizing world. The Project reaches out into the region interactively through the annual Headwaters Conference every autumn. The 22nd conference held in September 2011, "Small Steps, Big Stories: Climate Solutions in the Headwaters," brought together the "big stories" of climate solutions in the Headwaters that illustrate the vital balance between easy and effective, symbolic and concrete, feasible and imaginable (www.western.edu/academics/headwaters/headwaters-conference).

Mountain Research Station

Located at 2,900 m (9,500 ft) in the Front Range of the Colorado Rockies, the Mountain Research Station (MRS) is an interdisciplinary facility of the Institute of Arctic and Alpine Research,

University of Colorado that provides research and educational opportunities for scientists, students, and the general public. MRS' mission is to facilitate research and education to better understand the unique patterns and processes of biotic and physical systems in mountains, and how environmental changes may influence these patterns and processes.

Research at the MRS is primarily performed by investigators not formally associated with the MRS, with the exception of the Climate Program, established in 1952. The goal of the Climate Program is to provide long-term climate data from the montane, subalpine, and alpine zones of the Colorado Front Range. Four main meteorological stations have been maintained continuously since the inception of the program. The Climate Program interacts extensively with federal agencies, including the National Oceanic and Atmospheric Administration, the National Center for Atmospheric Research, and the Federal Aviation Agency, to provide data and field assistance for collecting trace gas samples. Other facilitated research efforts include the National Science Foundation-sponsored Niwot Ridge Long-Term Ecological Research program, long-term geomorphological and hydrological studies, research on the effects of N deposition on alpine ecosystems, and plant physiological ecology research (www.colorado.edu/mrs/stationinfo.html).

Rocky Mountain Research Station

The Rocky Mountain Research Station is one of five regional units that comprise the U.S. Forest Service Research and Development organization—the most extensive natural resources research organization in the world. The Station maintains 14 research locations throughout a 12 state territory, including the Rocky Mountains (www.fs.fed.us/rmrs/about/). Among its many research activities are:

- Air Water and Aquatic Environment—The research focuses on defining the components of healthy watersheds and riparian ecosystems, and developing decision-making tools and monitoring methods for these ecosystems. It relates historical and current landscape disturbances (drought, insects, and fire) with channel processes that affect aquatic habitats for species of conservation interest or concern. Their discoveries support assessments of watershed vulnerability to increased wildfire and climate change.

- Forest and Woodland Ecosystems: Bark Beetles—Researchers are looking at how bark beetles affect ecosystems and ways to connect bark beetle activity with landscape patterns so they can better understand the beetle's ecological role. They also are looking at the complicated interactions between bark beetles and forest fires—how fires injure trees and change the volatile emissions of conifers, and how bark beetles change the forest environment by influencing forest structure and transforming fuels. They also are looking at the factors that influence wildfire risk following beetle outbreaks, including weather and climatic patterns; forest type and tree cover type; site characteristics; changes in forest structure; time since mortality; and past management history.

- Managing Mixed-Severity Lodgepole Pine—Lodgepole pine is one of the most widely distributed conifers in North America. Throughout much of its range, the fire regime is mixed severity rather than stand replacement, resulting in patchy and often multi-aged

lodgepole pine heterogeneity. To determine the most appropriate treatment to create multi-aged lodgepole pine stands, scientists implemented a combination of thinning and prescribed burning treatments on the Tenderfoot Creek Experimental Forest in Montana. They measured changes in fuel loading, tree density, and tree mortality due to fire, finding that even-distribution thinning alone, or combined with prescribed fire, results in extremely low over-story density. Based on this research, the investigators produced a guide to help managers determine potential effects of harvesting and prescribed burning in lodgepole pine to create multi-aged stands (Hill 2011).

RENEWABLE ENERGY INITIATIVES

Glacier National Park

Glacier National Park actively pursues sustainable energy projects.

- It completed a LEED certified building (Gold) that serves as the Transit Center for the Park's visitor transportation system.
- A micro-hydro development was installed at the Goat Haunt developed area, at the head of Waterton Lake.
- Efforts are being undertaken to operate Logan Pass Visitor Center using solar energy, and many of the park's backcountry radio repeaters operate by solar energy.
- The heating and cooling system in the park's headquarters building was recently changed from electric to a ground source heat system.
- The park continues to look at wind, solar and micro-hydro for other developed area locations (Riddle 2011).

Regional Efforts in Kentucky

Kentuckians for the Commonwealth (KFTC), the Mountain Association for Community Economic Development, and several other regional organizations are working closely with a network of rural electric cooperatives to significantly increase those utilities' investments in energy efficiency and renewable energy solutions.

KFTC refers to this campaign as "Renew East Kentucky" because it has great potential to drive job creation and generate energy savings for consumers throughout the region who get their electric power from the East Kentucky Power Cooperative (EKPC). EKPC provides power to a network of 16 distribution cooperatives that together serve 500,000 customers in 89 Kentucky counties, including many distressed Appalachian counties.

"Renew East Kentucky" began with a successful campaign to stop EKPC from building two new coal-burning power plants. As part of that campaign, KFTC contracted with researchers at the Ochs Center to produce a report demonstrating that investments in energy efficiency and renewables could generate 9,000 new jobs while saving or generating an equivalent amount of energy at a lower overall cost compared to building the new plant. When the campaign to stop the power plants was over, work began immediately on the next phase, which was to win greater investment in those positive solutions.

During settlement talks, KFTC pushed for and won the formation of a Clean Energy Collaborative. That board, which is comprised of representatives from EKPC and its 16 distribution co-ops, the state Attorney General's office, affordable housing providers, MACED, KFTC, the Sierra Club, and other public interest groups, is now working to identify and recommend cost-effective ways the co-ops can save or generate an increasing share of electricity from energy efficiency programs and renewables.

One of the most promising of these strategies is an innovative program for financing residential energy efficiency upgrades that has been developed by MACED over the past two years in partnership with four distribution co-ops that serve Appalachian counties. Under this program, a utility customer can request an energy audit and receive the upfront funds necessary to make recommended efficiency upgrades. That cost is then paid back over time on the customer's utility bill. The financing is structured so that the customer pockets some of the projected monthly energy savings and uses the rest to pay for the upgrades. The benefits of this approach are numerous. Customers are eligible for the program as long as there are cost-effective efficiency upgrades that can be identified. Participation does not depend on the customers' financial status or credit history. The loan stays with the customer's utility meter, and does not follow the individual if they move. Thus it is a program that can be used effectively for rental property or owner-occupied homes (Abbott 2011).

Bag It

Created in Telluride, Colorado, this documentary, which was created by individuals from the small mountain town of Telluride, Colorado, has been garnering awards at film festivals across the United States. What started as a documentary about plastic bags evolved into a wholesale investigation into plastics and their effect on waterways, oceans, and even our bodies, and launched an environmental movement of sorts. A Bag It curriculum and educational DVD have been developed. Geared toward students in grades 4 through 12, they enable students to delve deeper into the issues and inspire them to act by exploring the effects of their everyday behavior on the environment, their health, and their well-being.

Efforts are underway to help 20 U.S. towns become Bag It Towns. Bag It Towns are municipalities that systematically reduce the collective consumption of single-use disposable bags. To become a Bag It Town, a municipality must meet one of the following criteria:

- voluntarily ban plastic and paper single-use disposable bags at grocery stores or town-wide
- pass an ordinance applying a minimum fee of 5 cents per single-use disposable bags at all grocery stores or town-wide
- pass an ordinance banning plastic bags completely and apply a minimum fee of 5 cents on all single-use paper bags at all grocery stores or town-wide
- pass an ordinance banning all disposable bags at grocery stores or town-wide (www.bagitmovie.com/index.html)

Aspen Hydropower—Castle Creek Energy Center

As part of its efforts to reduce greenhouse gas emissions (see the discussion below on the 'Canary

Initiative'), the City of Aspen, Colorado, is pursuing hydropower. Currently, the City's utilities are already 75 percent renewable; the hydro plant would increase that to 83 percent. The Castle Creek Energy Center will be able to produce at least 6.2 million kWh/year of renewable energy through hydroelectric power. This will reduce Aspen's carbon footprint by 5,200 tons of CO_2/year. This is equivalent to taking 908 cars off of Aspen's roads every year (City of Aspen 2011).

OTHER SUSTAINABLE PRACTICES

To protect their environments, mountain communities have undertaken numerous actions that promote sustainable mountain development. The City of Aspen and the Aspen Skiing Company have been leaders in this area.

In March 2005, the City of Aspen, adopted a plan to aggressively address global warming by reducing greenhouse (GHG) emissions. At the same time, other cities from around the country also recognized the need to address GHG emissions locally due to the absence of federal action. Out of these local efforts, the U.S. Mayors Climate Protection Agreement was created. Since then, signatory cities and other U.S. cities concerned about global warming have been pioneers; working as individual entities and collaborators to address this shared and immensely challenging issue through policy education, business partnerships, and leadership. Aspen was one of the first to take the lead by creating a comprehensive plan to address global warming—the Canary Initiative.

The Aspen City Council created the Aspen Global Warming Alliance to guide the City in implementing its new 'Canary Initiative.' The Alliance, which includes the Aspen Institute, the Aspen Global Change Institute, the Community Office for Resource Efficiency, the Aspen Skiing Company, the Rocky Mountain Institute, Holy Cross Energy, New Century Transportation Foundation, the Rocky Mountain Climate Organization, Aspen Center for Environmental Studies, Climate Mitigation Services, and climate scientist and author Susan Joy Hassol, works with the City to implement its global warming goals.

The Canary Initiative is so named because Aspen (which is economically dependent on winter snow for recreation and summer snow pack for water supply) sees itself as a canary in the coal mine for climate change. The Initiative called for: a GHG emissions inventory, an assessment of impacts due to climate change, an action plan, and education and advocacy on regional, state, and national levels.

The consensus was that the City needed to set a very aggressive GHG reduction goal. The resulting community reduction goals are to reduce GHG emissions 30 percent (below 2004 levels) by 2020 and 80 percent (below 2004 levels) by 2050. To accomplish these goals, the City established objectives and identified actions to meet those objectives in the areas of policy, research, and education; buildings; energy efficiency; transportation: air and ground; electricity; landfill: waste reduction and recycling; and localizations: carbon offsets and the food and beverage industry (City of Aspen 2007).

In the private sector, the Aspen Skiing Company (ASC):

- developed the ski industry's first climate policy and committed to reducing carbon dioxide emissions by 10 percent by 2012 from 2000 levels and 25 percent by 2020.
- built the largest solar photovoltaic system in the ski industry and has installed over 175 kW of solar energy
- became the first ski resort in the United States to be certified to the ISO 14001 standard
- established the first ski resort-supported Environment Foundation. More than $1.7 million has been given to local environmental causes.
- built one of the first 11 LEED-certified buildings (Bronze), then built structures certified to Silver, Gold, and Platinum, with another Gold structure under construction. All but one of those buildings replaced existing structures so they did not add to building stocks.
- launched the first climate change education campaign in the ski industry and partnered with www.protectourwinters.org to mobilize and engage the $66 billion winter sports community on climate change
- was the only ski resort to file an Amicus Brief on the landmark Supreme Court case, Mass v. the Environmental Protection Agency, which created defacto climate policy in the United States
- built a 115 kW small hydroelectric plant at Snowmass, Colorado that is a model for using snowmaking systems for generating clean power
- sent staff and its chief executive officer to Washington, DC, a half dozen times in the last decade to lobby Congress and the White House for action on climate change
- published widely on sustainability, including a book about implementation, *Getting Green Done*
- is on the verge of closing a deal to generate an equivalent amount of power to that which ASC uses in a carbon negative way, through a project whose carbon emissions reductions will far exceed ASC's carbon footprint (Schendler 2011)

MEETING THE CHALLENGE

The challenges to sustainable mountain development are many and the actions needed to meet those challenge must be addressed at many levels. Perhaps most critical are the impacts of climate change and the disproportionate threat it poses to mountain communities. Local and regional actions have made some inroads to promote sustainability. But some people would argue that those actions actually represent failures because voluntary, individual actions fail to address the climate problem at scale. To address the threats that climate change poses requires actions at the federal level. But climate legislation in the United States has been stalled for several years, and concerns (real or imagined) from some corners about the impact of such legislation on jobs and economic growth continue to produce inaction.

REFERENCES

"A Tapestry of Time and Terrain." USGS. 2 January 2012 nationalatlas.gov/tapestry/features/23srnevada.html

Abbott, Lisa, *Kentuckians for the Commonwealth Issue Paper*. 2011.

Abdrisaev, Baktybek, *Contribution to Sustainable Mountain Development (SMD) Agenda,* by Utah Valley University. 2011.

"About Mountain Film." Mountain Film in Telluride. 14 December 2011 www.mountainfilm.org/about-mountainfilm

"About RMRS." USDA Forest Service Rocky Mountain Research Station. 29 December 2011 www.fs.fed.us/rmrs/about/

"About the Club." Alpine Club of Canada. 4 January 2012 www.alpineclubofcanada.ca/whoweare/index.html

Active R.E.M.E.D.Y. *The Critical Role of Mountain Regions and Their Indigenous Forests for Long-Term Sustainability Upon Earth*. 2011.

"Alaska Earthquake 1964." United State Geological Survey. 30 November 2011 libraryphoto.cr.usgs.gov/cgi-bin/search.cgi?search_mode=exact;selection=AlaskaEarthquake 1964|Alaska Earthquake|1964

Alaska Miners Association, Ltd. *The Economic Benefits of Alaska's Mining Industry.* Brochure, Alaska Miners Association, Anchorage: Alaska Miners Association, Ltd, 2011, 1-3.

"The Appalachian Region." Appalachian Regional Commission. 16 November 2011 www.arc.gov/appalachian_region/TheAppalachianRegion.asp

Bag It: Is your life too plastic? 1 January 2012 www.bagitmovie.com/index.html

Beason, Scott R. et al. "Landscape response to climate change and its role in infrastructure protection and management at Mount Rainier National Park." National Park Service. 12 December 2011 www.nature.nps.gov/ParkScience/popupAbstract.cfm?ArticleID=508

Berwick, Steve. "Fragmentation of Habitats of Populations, Corridors, and Biodiversity Retention in Montane America." 2011.

Berwick, Steve. "Land Use: Its Regulation and Impacts in the Montane West." 2011.

Bower, Donald E. *The Magnificent Rockies: Crest of a Continent. American West*, 1973.

Bruman, Henry J. and George C. Engerrand. "Sierra Madre." Encyclopædia Britannica 2 January 2012 www.britannica.com/Ebchecked/topic/543406/Sierra-Madre

Burrow, Rob et al. "Glacier trends and response to climate in Denali National Park and Preserve" National Park Service. 12 December 2011 www.nature.nps.gov/ParkScience/popupAbstract.cfm?ArticleID=509

Byerly, W. Don & John J. Renton. *Encyclopedia of Appalachia*, 1st ed., s.v. "Blue Ridge Province." Knoxville : University of Tennessee Press, 2006.

"Cabinet-Purcell Mountain Corridor Conservation Project." Yellowstone to Yukon. 1 January 2012 www.y2y.net/data/1/rec_docs/639_Purcell_Project_Profile_08.pdf

"Career Guide to Industries; 2010-2011 Edition - Mining." Bureau of Labor Statistics. 1 January 2012 www.bls.gov/oco/cg/cgs004.htm

Center for Biological Diversity. 1 January 2012 www.biologicaldiversity.org/news/press_releases/2011/uranium-mining-10-19-2011.html

City of Aspen. *City of Aspen Canary Initiative Climate Action Plan*. 2007.

City of Aspen. *City of Aspen Primer Castle Creek Energy Center*. 2011.

"Coast Ranges." Encyclopædia Britannica. 15 December2011 www.britannica.com/EBchecked/topic/123106/Coast-Ranges

Condon, Scott. "Loving the Land to Death?" The Aspen Times (December 2011).

Constantz, George. *Encyclopedia of Appalachia*, 1st ed., s.v. "Climate." Knoxville : University of Tennessee Press, 2006.

Cooper, Joni. Email to Rebecca Wallace. 12/16/11.

"FAQ—Biosphere Reserve?" 30 December 2011 www.unesco.org/mab/doc/faq/brs.pdf

"Fracking." Food & Water Watch. 30 December 2011 www.foodandwaterwatch.org/water/fracking/

Ghanim, Carmen, "Squirrels in North America's Mountains." November 2011.

Gillis, Justin. "With Deaths of Forests, a Loss of Key Climate Protectors." New York Times (October 2011).

Goodwin, Katelyn E., "Survival Rate of Fecal Coliforms in a Glacial Environment: Implications for Human Waste Management on Mount McKinley, Alaska." April 2011.

Gruver, Mead "Old Snow Adds to Glacier Volume." The Aspen Times (1 November 2011).

Hill, Alison. Email to Rebecca Wallace. December 2, 2011.

"History." Western Climate Initiative. 18 December 2011 www.westernclimateinitiative.org/history

"How Wilderness Becomes Wilderness." Wilderness.net. 26 December 2011 www.wilderness.net/index.cfm?fuse=nwps&sec=designation

"How WW Works," Wilderness Workshop. 4 January 2012 www.wildernessworkshop.org/our-work.html?page=186

Howarth, Robert W., Santoro, Renee, and Ingraffen, Anthony, "Methane and the Greenhouse Gas Footprint of Natural Gas from Shale Formulation," Climate Change (Volume 106, Number 4) (April 2011). www.springerlink.com/content/e384226wr4160653/

"Impaired Waters and Total Maximum Daily Loads." U.S. Environmental Protection Agency. 31 December 2011 water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/

Koren Nydick. and Charisse Sydoriak, "Alternative Futures for Fire Management Under a Changing Climate," *Park Science* (Spring 2011): 1.

Landforms." Worldatlas. 3 January 2012 www.worldatlas.com/webimage/countrys/nalnd3.htm

"Laurentian Mountains." Encyclopædia Britannica Online, 16 November 2011 www.britannica.com/EBchecked/topic/332432/Laurentian-Mountains

"Learn More About Mountaintop Removal Coal Mining." ILoveMountains.org. 15 December 2011 ilovemountains.org/

Matt Gouras, "Administration Urges New Wilderness Protections" Aspen Daily News

Miller, Brian et al. *Southern Rockies Wildland Network Vision: A Science-Based Approach to Rebuilding the Southern Rockies*. (2003). 1.

Miller, Maynard M. and R.A.M. Schmidt. "Alaskan Mountains." Encyclopædia Britannica Online. 16 Nov. 2011. www.britannica.com/EBchecked/topic/12347/Alaskan-mountains

Moss, Laurence A.G., and Romella S. Glorioso. *Mountain Amenity Migration & Experience of Western Canada*. (2011)

"Mount St. Helens, Washington: Eruption 2004 to Current." United States Geological Survey. 17 December 2011 vulcan.wr.usgs.gov/Volcanoes/MSH/Eruption04/framework.html

"Mountain Research Station Information." University of Colorado at Boulder Mountain Research Station. 30 December 2011 www.colorado.edu/mrs/stationinfo.html

National Mining Association, *Mountaintop Mining Fact Book*, March 2009.

National Parks Conservation Association, *National Parks of the Colorado River Basin: Water Management, Resource Threats, and Economics*, April 2011. www.npca.org/about-us/center-for-park-research/colorado_river_basin/Colorado_River-Summary.pdf

NOAA Earth Systems Research Laboratory. "Climatology by state based on climate division data: 1971-2001."

Orr, David W., "The Carbon Connection." *Conservation Biology* (2007).

"Pacific Ranges." Peakbagger.com. 2 January 2012 www.peakbagger.com/range.aspx?rid=12

Peterson, David L. et al. (In press). "Response of Western Mountain Ecosystems to Climatic Variability and Change: A Collaborative Research Approach." Taylor and Francis Publishing, New York, NY.

Pollinator Partnership and the North American Pollinator Protection Campaign, *Selecting Plants for Pollinators*. www.pollinator.org/PDFs/EasternBroadleaf.Oceanic.rx18.pdf

Powell, Scott, *Skagit Environmental Endowment Commission Historical Summary and Current Priorities*. 2011

Pratt, Jane K. and John D. Shilling, *High Time for Mountains A Program for Sustaining Mountain Resources and Livelihoods* (June 30, 2002).

"Preserving Biodiversity." National Park Service. 13 December 2011 www.nature.nps.gov/biology/biodiversity/

"Protecting and Restoring." National Park Service Explore Nature. 12 December 2011 www.nature.nps.gov/protectingrestoring/

Reece, Erik. "Mountaintop-removal mining is devastating Appalachia, but residents are fighting back." *Orion Magazine* (February 2006).

Riddle, Mary. *Response to Information Request for North American Mountain Alert for Rio+20*. 2011.

Rochefort, Regina M., and Palmer (Chip) Jenkins. *The North Cascadia Adaptation Partnership Summary for the Rio+20 Earth Summit*. 2011.

"Rocky Mountains." Yahoo!Education. 3 January 2012 education.yahoo.com/reference/encyclopedia/entry/RockyMts

Saunders, Stephen et al. "Hotter and Drier: The West's Changing Climate" (March 2008).

Schendler, Auden. Email to Rebecca Wallace. November 25, 2011.

Schrier, Hans, "Challenges in Mountain Watershed Management," in *Global Change and Mountain Regions*, edited by Huber et al. (The Netherlands: Springer, 2005).

Secretary of Environmental and Natural Resources. *Climate Change Strategy for Protected Areas*, 2010. (Mexico, DF: National Commission of Protected Areas). 2011. (Spanish document translation)

"Sierra Madre." The Columbia Electronic Encyclopedia, 2000-2007. Pearson Education. 2 January 2012 www.factmonster.com/ce6/world/AO845168.html

"Small Steps, Big Stories: Climate Solutions in the Headwaters." State College of Western

Colorado. 1 January 2012 www.western.edu/academics/headwaters/headwaters-conference

Smith, Duane A. 'Rocky Mountain Heartland: Colorado, Montana, and Wyoming in the Twentieth Century.' Chapter 10, Into a New Millennium pgs. 257 (2008).

Southern Environmental Law Center. 16 December 2011 www.southernenvironment.org/newsroom/press_releases/04_27_09_stream_buffer_zone_rule1

Southwings. Aerial Photos of Mountaintop Removal Mining in Appalachia.

"Striking an Accord for People and Nature." The Nature Conservancy. 19 December 2011 www.nature.org/ourinitiatives/regions/northamerica/canada/explore/boreal-forest-agreement.xml

Tague, Christina and Aubrey L. Dugger. "Ecohydrology and Climate Change in the Mountains of the Western USA—A Review of Research and Opportunities." *Geography Compass* (2010).

Ward, Meghan J. *The State of the Mountains Report: the Impacts of Climate Change on the Alpine Environments and Glaciers of Southern Alberta and British Columbia* (March 2011).

"Water-Most of California's Water Comes from the Sierra Nevada." CA.gov Sierra Nevada Conservancy. 2 January 2012 <http://www.sierranevada.ca.gov/docs/Water09.pdf>

Waterman, Jonathan, and Peter McBride. *The Colorado River, Flowing Through Conflict*, Westcliffe Publishers, 2011.

"The Watershed of the San Miguel: Head in the Clouds, Feet in the Desert", You Tube. 31 December 2011 www.youtube.com/watch?v=Kg-7hWGV0JM

"What is Wilderness?" Wilderness.net. 26 December 2011 www.wilderness.net/index.cfm?fuse=NWPS&sec=whatIsWilderness

"Who We Are." The Appalachian Carbon Partnership. 5 January 2012 www.appalachiancarbonpartnership.org/who-we-are

Wiener, John. *Note on Property Rights in the U.S. and Mountains*. 2011.

"Wild Horses & Renegades."Denver Film Center. 17 December 2011 www.denverfilm.org/filmcenter/detail.aspx?id=24250

APPENDICES

Many thanks to the students of Utah Valley University who rallied when time was very short, and contributed the following descriptions of mountain ranges.

ALASKAN MOUNTAIN RANGE

By: Victoria Gibson and Jordan Giles

The Alaska Mountain Range consists of three main mountain groups. The Alaska Range to the southwest spans approximately 600 miles to where it merges with the Aleutian Range. The Aleutian Range includes the Aleutian archipelago and altogether, spans approximately 1,500 miles total. The Brooks Range is the region's northernmost range, located above the Arctic Circle, and spans approximately 620 miles.[1]

PHYSICAL CHARACTERISTICS

The Alaskan Range is home to North America's highest peak, Denali (also known as Mount McKinley), which rises to approximately 20,320 feet. Alaska is part of the "Pacific Ring of Fire" and has more than 100 volcanoes and volcanic fields, many of them in the Aleutian Islands. Earthquakes are fairly common especially in the coastal areas.[2]

The soils of the Alaskan Mountain Range consist mostly of silt, clay, or ash over bedrock due to active volcano activity; areas near water may have rich peat soil. The nature of the soil significantly raises erosion potential and the occurrence of permafrost. The main sources of fresh water in the Mountains are the Yukon and Kuskokwim Rivers. Boreal forests are dominant in the Cook Inlet Sub-region of the Aleutian Range.[3]

The most notable glaciers and ice fields in the region are found within the Alaska and Aleutian ranges. Much of the mountains in these ranges are heavily glaciated, with extensive ice caps covering most of the mountains. Malaspina is the largest glacier in the region with an area of approximately 1,500 miles^2. The Chugach and St. Elias ice fields are the most extensive highland and valley glaciers in North America. The largest glaciers in the Brooks Range are only about 5 miles long, due in part because of limited snowfall.[4]

BIOLOGICAL/ECOSYSTEM CHARACTERISTICS

There are 570,640 miles^2 of territory in Alaska,[5] mostly forest. National parks, such as Denali National Park and Glacier Bay National Park, provide revenue to conserve the area's natural prestige as well as provide education regarding the different geological and ecological systems found within. Urbanization has not been a major issue in Alaska because of its vast size, but there are small examples of urbanization when it comes to mining and mining exploration.

1 Maynard M. Miller, R.A.M. Schmidt. Alaskan Mountains. Encyclopædia Britannica Online. Nov 16, 2011. www.britannica.com/EBchecked/topic/12347/Alaskan-mountains (accessed Nov 16, 2011).

2 United State Geological Survey Alaska Earthquake 1964. libraryphoto.cr.usgs.gov/cgi-bin/search.cgi?search_mode=exact;selection=Alaska Earthquake 1964|Alaska Earthquake|1964.

3 Institute of Social and Economic Research. Soils. Institute of Social and Economic Research, University of Alaska Anchorage. 2004. www.alaskool.org/resources/regional/sc_reg_pro/soils_subregions.html (accessed Nov 14, 2011).

4 Maynard, Britannica Online.

5 U.S. Census Bureau. 2010 Alaska Census results. quickfacts.census.gov/qfd/states/02000.html

Biodiversity has increased with the establishment of nature preserves upon breeding grounds of different whale and seal species.

Variety in vegetation and wildlife is limited due to the extreme climate. Flora and fauna consists mainly of alpine and/or moist tundra, tall brushes, and grass at higher elevations[6] with spruces at lower elevations. Alaska supports a wide variety of fauna consisting of bears, moose, Sitka Deer, and other small mammals.

HUMAN/MOUNTAIN INTERACTIONS

The Alaska Range has a poverty rate of 11.7 percent, which is lower than the national average of 14.3 percent.[7] The reason for the difference comes from higher paying petroleum and mining-related jobs as well as the Permanent Dividend Fund, which in 2008 paid each resident of Alaska $2,080.[8]

Due to the harsh mountain climate, the majority of communities lie in the valleys between or near the base of mountains and only in the southern ranges. The northern-most part of the region is almost uninhabited, with most of these communities existing on the pacific coastline.

Alaska's mountains support a significant mining industry for coal, gold, silver, and zinc. Mining provides an estimated 5,500 jobs to Alaska. Coal from mining operations provides approximately 40 percent of the state's electricity. Mining companies in Alaska help sustain native culture by contributing monetarily (usually in the form of rent or other payments) to Alaska Native corporations.[9]

Alaska has more than 20 completed hydropower projects that produce as much as 21 percent of Alaska's electricity. Producing 126 MW annually, Alaska's largest project is the Bradley Lake plant. King Cove, a small Aleutian community, receives 100 percent of its electricity from the 800 kW Delta Creek hydropower project.[10] Legislation is currently pending to open the oil and natural gas fields and allow oil drilling in the Arctic National Wildlife Refuge.[11]

ADDENDUM

Much of the controversy over drilling in the Arctic National Wildlife Refuge (ANWR) depends on oil reserve estimates. Polls show that the majority of Alaskans are in favor of exploring reserves in the region while the rest of Americans seem almost equally divided on the issue. Only about

---

6 Institute of Social and Economic Research. Soils. Institute of Social and Economic Research, University of Alaska Anchorage. 2004. www.alaskool.org/resources/regional/sc_reg_pro/soils_subregions.html (accessed Nov 14, 2011).

7 U.S. Census Bureau. 2010 Alaska Census results. quickfacts.census.gov/qfd/states/02000.html

8 Juneau Empire. 2010 PFD $1281. juneauempire.com/stories/092210/sta_710735266.shtml

9 Alaska Miners Association, Ltd. The Economic Benefits of Alaska's Mining Industry. Brochure, Alaska Miners Association, Anchorage: Alaska Miners Association, Ltd, 2011, 1-3.

10 Renewable Energy Alaska Project. Projects in Alaska: Hydroelectric. 2011. alaskarenewableenergy.org/alaskas-resources/projects-in-alaska/ (accessed Nov 16, 2011).

11 Arctic Power. Arctic National Wildlife Refuge: The Issue. Frontier Communications. 2011. www.anwr.org/ANWR-Basics/Arctic-National-Wildlife-Refuge-the-issue.php (accessed Nov 16, 2011).

8 percent of the ANWR area is legally available for development (often referred to as the 1002 area, approximately 2,340 miles^2 of land), which includes the Prudoe Bay area where oil drilling has already been established.[12] Current assessments estimate 4.3 billion barrels of oil in the region, though there is the possibility of recovering as much as 11.8 billion barrels. In the same area, there is an estimated 34 trillion ft^3 of natural gas.[13]

Those who support drilling in the 1002 area favor the economic boost to local (mostly native) communities. Exploration and drilling would be a long-term investment. If legislation was approved immediately, it would be some 15 years before oil production was ready to begin. Such an initiative is estimated to result in at least 250,000 jobs, with more generous estimates going as high as 735,000.[14] Those opposed to exploration or drilling in the 1002 area are concerned for the environmental impact of such initiatives for so little oil. Where U.S. consumption is so high and oil imports already at more than 60 percent, many believe ANWR would not yield benefits substantial enough to justify the environmental damage.[15]

Reports differ greatly on how drilling in ANWR would affect national oil prices, dependency, and sustainability.

12 Arctic Power. 2011.

13 U.S. Department of the Interior. Arctic National Wildlife Refuge, 1002 Area, Petroleum Assessment, 1998, Including Economic Analysis. USGS.gov. 2011. pubs.usgs.gov/fs/fs-0028-01/fs-0028-01.htm (accessed Dec 2, 2011).

14 Arctic Power. 2011.

15 Defenders of Wildlife. Arctic National Wildlife Refuge. www.defenders.org/programs_and_policy/habitat_conservation/federal_lands/national_wildlife_refuges/threats/arctic/index.php (accessed Dec 4, 2011)

APPENDIX B

APPALACHIAN MOUNTAIN RANGE

By: Kate Woolfe, Alexis Sagen, and Sean Edwards

The Appalachian Mountains are the oldest mountain chain in North America.[1] The Appalachian Mountain Range, as defined by the Appalachian Regional Commission (ARC), spans 205,000 miles[2], covering the entire state of West Virginia and sections of Alabama, Georgia, Kentucky, Maryland, Mississippi, New York, North Carolina, Ohio, Pennsylvania, South Carolina, Tennessee, and Virginia.[2] Although not recognized by the ARC, Appalachia also can be said to extend farther in all directions, including parts of Canada. Appalachia consists of four geologically defined provinces: the Blue Ridge (southern Pennsylvania to northern Georgia), the Appalachian Plateaus (New York to north central Alabama), the Ridge and Valley (southeastern New York to Alabama), and the Piedmont (Virginia to northern Florida).[3] The Appalachian Range has an average elevation of 3,000 feet; the highest peak (Mt. Mitchell in North Carolina) reaches 6,684 feet.[4] The Appalachian climate is very diverse, in part due to its location on the polar front, which creates weather conditions such as "blizzards, ice storms, tornadoes, hurricanes, and extremes in temperature and precipitation."[5]

PHYSICAL CHARACTERISTICS

"Since their formation, the Appalachians have undergone extensive erosion, [creating] a geologically complex range of mountains [which consist of] metamorphosed sediments and volcanic rock layers."[6] The Appalachian soils are classified as inceptisols, ultisols, and alfisols,[7] and many are infertile due to high levels of acidity and toxicity due to aluminum and manganese.[8] Iron deposits exist throughout all of Appalachia in bog and mineral form, and many mining settlements sprang up around ironworks.[9]

Due to the steepness of the Appalachian landscape and "the destruction of the mountains' protective forest cover by agriculture, mining, logging, and fire," there are increased chances

1 Barritt, Karla, and George Padmore. The Appalachian Mountains, "ncsu.edu." Accessed November 30, 2011. www.ncsu.edu/midlink/appalachian.mt./app.Mt.facts.html.

2 Appalachian Regional Commission, "The Appalachian Region." Accessed November 16, 2011. www.arc.gov/appalachian_region/TheAppalachianRegion.asp.

3 Byerly, W. Don & John J. Renton. Encyclopedia of Appalachia, 1st ed., s.v. "Blue Rigde Province." Knoxville : University of Tennessee Press, 2006.

4 Peakware World Mountain Encyclopedia, "Appalachian Mountains.." Accessed November 15, 2011. www.peakware.com/areas.html?a=308.

5 Constantz, George. Encyclopedia of Appalachia, 1st ed., s.v. "Climate." Knoxville : University of Tennessee Press, 2006.

6 Klappenbach, Laura. About.com, "Appalachian Mountains." Accessed December 1, 2011. animals.about.com/od/environmenthabitat/p/appalachian.htm.

7 Constantz, George. Encyclopedia of Appalachia, 1st ed., s.v. "Climate." Knoxville : University of Tennessee Press, 2006.

8 Ritchey, K. Dale, M. Zaifnejad, Ralph B. Clark, V.C Baligar, and D.C. Martens. 1999 International Ash Utilization Symposium, Center for Applied Energy Research, "Many Appalachian soils are infertile and acidic, and plant growth is limited by Al and Mn toxicity. ." Accessed November 19, 2011. ddr.nal.usda.gov/bitstream/10113/44388/1/IND44419366.pdf.

9 Phipps, Sheila R. Encyclopedia of Appalachia, 1st ed., s.v. "Iron Settlements." Knoxville : University of Tennessee Press, 2006.

of landslides, earth failures, flooding, and water contamination.[10] Much of the area has been sculpted by glacial erosion, though no current glaciers exist.

Fresh water is found in the Ohio River, and many streams drain to the Gulf of Mexico directly or through the Mississippi-Ohio River system or directly into the Great Lakes or Atlantic Ocean. Because it existed before the Appalachian Mountains as the main headwaters of the Teays River, the New River was able to erode the mountains as they grew and has kept its original course reaching from the Blue Ridge Mountains in North Carolina to where it empties into the Gulf of Mexico near New Orleans.

BIOLOGICAL/ECOSYSTEM CHARACTERISTICS

"The Appalachian region is the cradle of biodiversity for North America." There are over 4,000 species of flowering plants in the Great Smokey Mountains National Park alone. The region has 150 tree species. The Appalachians are home to 75 mammalian species, including foxes, coyotes, mountain lions, and endangered black bears. There is a remarkably high number of fish species. The region also has upwards of 149 species of birds, including 34 "rare or declining" species.[11]

The Appalachians have 8.1 million acres of commercial forest land. Of this, the U.S. Forest Service protects 6.2 million acres. State, county, or other governmental bodies own another 4.78 million acres; and forest industries own 13.8 million acres.[12] National Parks, such as the Great Smokey Mountains National Park in North Carolina and Tennessee, the Shenandoah National Park in Virginia, and the White Mountain National Forest in New Hampshire and Maine provide revenue to conserve the area's natural prestige. National Parks also act as ideal research grounds for scientific research by institutions, such as the Twin Creeks Natural Resources Center in the Smokey Mountains National Park, which has created the All Taxa Biodiversity Inventory, one of the most comprehensive biodiversity inventories in the world.[13]

HUMAN/MOUNTAIN INTERACTIONS

The Appalachians had a poverty rate of 18 percent in 2008, higher than the national average of 14.3 percent.[14,15] In 2010, the Appalachian unemployment rate was at 9.7 percent, 0.1 percent higher than the national average; the former having risen from 5.0 percent and the latter from 4.7 percent in 2001. The Central Appalachian Region had the highest unemployment of the

---

10 Davis, Donald, and Kevin O'Donnell. Encyclopedia of Appalachia, 1st ed., s.v. "Erosion." Knoxville: The University of Tennessee Press, 2006.

11 Constantz, George. Encyclopedia of Appalachia, 1st ed., s.v. "Birds." Knoxville : University of Tennessee Press, 2006.

12 Appalachian Hardwood Manufacturers, "HOW MUCH FOREST WE HAVE AND WHO OWNS IT?" Accessed November 17, 2011. www.appalachianwood.org/forestry/quantity.htm.

13 Davis, Donald, and Kevin O'Donnell. Encyclopedia of Appalachia, 1st ed., s.v. "Research Institutions." Knoxville: The University of Tennessee Press, 2006.

14 Appalachian Regional Commission, "The Appalachian Region." Accessed November 16, 2011. www.arc.gov/appalachian_region/TheAppalachianRegion.asp

15 Bishaw, Alemayehu, and Suzanne Macartney. American Community Survey, "Poverty: 2008 and 2009." Last modified Sep. 2010. Accessed November 16, 2011. www.census.gov/prod/2010pubs/acsbr09-1.pdf.

region in 2010 at 10.9 percent.[16] The number of adults age 25 and older who completed high school is 76.8 percent, while the national average is 80.4 percent.[17]

The health and sustainability of the Appalachian region is often fairly weak and has been described as an "enduring sense of resignation, deep depression, and disrupted relationships" caused by a "culturally transmitted traumatic stress syndrome."[18]

The majority of people living in Appalachia are fundamentalists (Southern Baptists and Methodist), and are recognized for their "puritanical sense of morality, biblical fundamentalism, revivalism, fatalism, and a clergy that differs from the laity only in the extent of its zeal for universal salvation."[19] Despite how fundamental religion is in Appalachian culture, the organizational factors of religion are often ignored so that 65 percent of religion is un-churched in this region.[20]

The area explores new energy sources with the drilling of Marcellus Shale and Utica Shale as well as landfill methane energy conversion projects by Energy Xchange.[21,22] These benefit America because they help to preserve the environment, create jobs, provide energy sources locally and nationwide, and save money.[23] Coal is the most important resource mined in Appalachia and has "determined patterns of settlement and residence, transformed cultures and values, influenced local and state politics, and set the course of the region's economic development. Coal mining also has greatly affected the natural environment in the region, causing deforestation; acid mine drainage and siltation of streams; air pollution: and soil degradation."[24] One important nonmetallic resource mined in Appalachia is limestone ($CaCO_3$), which can be ground into a powder and used to neutralize the acidic Appalachian soils.[25]

Despite a decline in the demand, many farmers continue to grow tobacco in order to preserve it as an important part of Appalachian culture, and children in some tobacco regions are still given time off of school in the fall to help their families to harvest the tobacco[26].

16 Appalachian Regional Commission, Regional Planning & Research Division, "Appalachian Region Employment Report - 2011." Accessed November 19, 2011. www.arc.gov/images/appregion/Sept2011/EmploymentReportSept2011.pdf

17 . "Economic Assessment of Appalachia: An Appalachian Regional Development Initiative Report." Accessed November 16, 2011. www.arc.gov/images/newsroom/publications/EconomicAssessmentofAppalachiaJune2010.pdf.

18 Anglin, Mary. "Lessons from Appalachia in the 20th Century: Poverty, Power, and the "Grassroots"." American Anthropologist , New Series. 104. no. 2 (2002): 565-582. www.jstor.org/stable/684006 (accessed November 16, 2011).

19 Martin, M.. "Appalachians." Encyclopedia of World Cultures. 1996. Encyclopedia.com. (November 18, 2011). www.encyclopedia.com/doc/1G2-3458000023.html

20 Appalachian Regional Ministry, "Culture." Accessed November 17, 2011. www.arministry.org/culture/default.html.\

21 geology.com, "Utica Shale - The Natural Gas Giant Below the Marcellus?: Stacked plays in the Appalachian Basin produce multiple natural gas pay zones.." Accessed November 19, 2011. geology.com/articles/utica-shale/

22 Owen, Steve, and Jeff Boyer. "Energy, Environment, and Sustainable Industry in the Appalachian Mountains, United States." Mountain Research and Development. 26. no. 2 (2006): 115-118. www.jstor.org/pss/3674630 (accessed November 19, 2011).

23 geology.com and Owen et al.

24 Davis, Donald, and Kevin O'Donnell. Encyclopedia of Appalachia, 1st ed., s.v. "Coal Mining." Knoxville: The University of Tennessee Press, 2006.

25 Byerly, W. Don & John J. Renton. Encyclopedia of Appalachia, 1st ed., s.v. "Nonmetallic, Nonfuel Deposits." Knoxville : University of Tennessee Press, 2006.

ADDENDUM

The Appalachian Plateaus Province is located in Kentucky, Pennsylvania, New York, Tennessee, Alabama, West Virginia, Virginia, and Mississippi, occupying 157,888 miles^2 (408,929 km^2), with their highest point at Spruce Knob, West Virginia at 4,861 ft (1,482 m), and includes the Allegheny Plateaus, Catskill Mountains, Allegheny Mountains, Cumberland Plateau, and Cumberland Mountains. Natural resources include petroleum and coal, which have been important for the development of the Appalachian Plateau Province.

- The Catskill Mountains are located in New York, occupying 5,891 mi^2 (15,259 km^2, with their highest point at Slide Mountain at 4,180+ ft (1274+ m).[27]

- The Allegheny Mountains are located in West Virginia, Pennsylvania, and Maryland, occupying 15,628 mi^2 (40,476 km^2), with their highest point at Spruce Knob, West Virginia at 4,861 ft (1,482 m).[28]

- The Cumberland Mountains are located in Kentucky, Virginia, Tennessee, and West Virginia, occupying 7,590 mi^2 (19,659 km^2), with their highest point at High Knob, Virginia at 4,223 ft (1,287 m).[29]

The Blue Ridge Mountains are located in Virginia, North Carolina, Tennessee, Georgia, Maryland, Pennsylvania, South Carolina, and West Virginia, occupying 34,563 mi^2 (89,517 km^2), with their highest point at Mount Mitchell, North Carolina at 6,684 ft (2,037 m).

- The northern Blue Ridge is located in Virginia, Maryland, Pennsylvania, and West Virginia, occupying 13,678 mi^2 (35,426 km^2), with its highest point at the Apple Orchard Mountain, Virginia (4,225 ft/1288 m). Protected land includes the Shenandoah National Park (Virginia) and Appalachian National Park, which act as tourist attractions.[30] "In recent years, the park has been plagued increasingly by deteriorating infrastructure, staff shortages, and environmental degradation, generally attributed to pollution, budgetary crisis, and, ironically, overuse."[31]

- The Southern Blue Ridge Front is located in North Carolina, Georgia, Virginia, South Carolina, and Tennessee, occupying 12,428 mi^2 (32,188 km^2), with its highest point at the Grandfather Mountain, North Carolina (5,946 ft/1812 m).[32]

26 Best, Michael, and Curtis W. Wood. Encyclopedia of Appalachia, 1st ed., s.v. "Tobacco." Knoxville: University of Tennessee Press, 2006.
27 Peakbagger.com, "Catskill Mountains." Accessed December 2, 2011.
28 Peakbagger.com, "Allegheny Mountains." Accessed December 2, 2011. www.peakbagger.com/range.aspx?rid=1622.
29 . Peakbagger.com, "Cumberland Mountains." Accessed December 2, 2011. www.peakbagger.com/range.aspx?rid=1624.
30 Peakbagger.com, "Northern Blue Ridge." Accessed December 4, 2011. www.peakbagger.com/range.aspx?rid=1640.
31 Howell, Benita J. Encyclopedia of Appalachia, 1st ed., s.v. "Shenandoah National Parks." Knoxville : University of Tennessee Press, 2006
32 Peakbagger.com, "Southern Blue Ridge Front." Accessed December 4, 2011. www.peakbagger.

- The Great Smoky Mountains are located in Tennessee and North Carolina, occupying 2,065 mi^2 (5,349 km^2), with their highest point at the Clingmans Dome, Tennessee/North Carolina (6,643 ft/2025 m). Protected land includes the Great Smoky Mountains National Park (521,000 mi^2), which is "the most significant tourist attraction in the southern Appalachian region" and contributes more than $600 million dollars annually to the local economy due to an estimated 11 million tourist visits per year.[33]

The Piedmont Province is located roughly in Georgia, North Carolina, South Carolina, Virginia, and Florida, occupying 140,186 mi^2 (363,081 km^2), with its highest point at Buzzard Roost, North Carolina (2980 ft/908m). Despite its cultural identification with Appalachia, the Piedmont Province lacks the high elevations and steep relief characteristic of the Appalachian region, and there is some debate as to whether it should be considered one of Appalachia's four main provinces. "Although thousands of acres of good farmland in the Piedmont have been lost to roads, homes, and industry, row crops can be successfully grown on large areas if well managed."[34]

The Northern U.S. Appalachians, although not an official province is located roughly in Maine, New Hampshire, Vermont, Massachusetts, New York, Connecticut, New Brunswick, Pennsylvania, Québec, New Jersey, and Rhode Island, occupying 85,762 mi^2 (222,123 km^2), with their highest point at Mount Washington, New Hampshire (6,288 ft/1917 m), and including the White Mountains and Green Mountains.

- The White Mountains are located in New Hampshire and Maine, occupying 3,440 mi^2 (8,910 km^2), with their highest point at Mount Washington, New Hampshire (6288 ft/1917 m).[35]

- The Green Mountains are located in Vermont and Massachusetts, occupying 5,802 mi^2 (15,028 km^2), with the highest point at Mount Mansfield, Vermont (4,393 ft/1,339 m).[36]

com/range.aspx?rid=1641.

33 Howell, Benita J. Encyclopedia of Appalachia, 1st ed., s.v. "Great Smoky Mountains National Park." Knoxville : University of Tennessee Press, 2006.

34 Byerly, W. Don & John J. Renton. Encyclopedia of Appalachia, 1st ed., s.v. "Soils." Knoxville : University of Tennessee Press, 2006.

35 Peakbagger.com, "White Mountains." Accessed December 2, 2011. www.peakbagger.com/range.aspx?rid=1612.

36 Peakbagger.com, "Green Mountains." Accessed December 2, 2011. www.peakbagger.com/range.aspx?rid=1613.

CASCADE RANGE

By: Josh Harding and Kevin Wrigley

The Cascade Mountain region is one of the most beautiful ranges in the entire world. It stretches 700 miles (1,130 km) from Northern California through Oregon and Washington and into British Columbia.[1] It contains many vast national forests and parks with many different kinds of wildlife living within the habitat. It has great potential in many areas of producing hydroelectricity and geothermal energy. With hundreds of rivers and streams running throughout the region, this potential seems almost limitless. Many active and dormant volcanoes are dotted throughout the range, including the famous Mt. St. Helens. The largest peak in the Cascade Region is Mt. Rainier, which also is an active volcano.[2] This volcanic activity in the Cascades over millions of years has produced in many areas of the range fertile ground that is great for farming. Tourism also can play a major role in the sustainability of the population's workforce.

ECOLOGY/RAINFALL

The Cascades' national parks are filled with natural beauty that takes locals' and tourists' breaths away. The North Cascades National Park is a prime example of the diversity within the range. "Located in the northwest corner of the state of Washington, it is one of America's younger national parks. The park contains spectacular mountains; 300 glaciers; forests with huge Douglas fir, red cedar, hemlock, and Ponderosa pine trees; rivers; lakes; and some 360 miles of trails."[3] There are many diverse forms of trees and plant life that grow in the Cascade Mountains. The western side of the range receives in the lowlands around 30 inches of rain, while in the mountains around 100 inches of rainfall fall annually. On the eastern side of the range, the rainfall is much less and the terrain is dryer and less lush. The temperatures vary greatly between the eastern and western sides of the Cascade Range.[4] Since 1920, temperatures have increased by around 1.5°F.[5]

HYDROELECTRIC/GEOTHERMAL ENERGY

The large amounts of rainfall and glaciers make the Cascades an ideal place for hydroelectric production. According to the National Parks Service, the Cascades contain "60% of the total glacier-covered area in the contiguous United States."[6] There are many dams throughout the region that provide power to entire cities. The dams range in varying sizes and capacity. A very large dam, which produces huge amounts of electricity, is the John Jay Dam. The John Jay Dam was built in the 1970s and produces "enough energy for more than two cities the size of Seattle."[7] Such massive production of electricity allows the inhabitants of the region to have an efficient means of obtaining electricity for their homes. This makes the region stable

1 "Columbia Books" www.columbia.edu/cu/cup/
2 USGS Information" vulcun.wr.usgs.gov/Volcanoes/ Rainier/description rainier.html
3 "North Cascades National Park" www.shannontech.com/ParkVision/NorthCascade/NorthCascade.html#treesflowersplants
4 "Fish and Wildlife Service" www.fws.gov/pacific/Climatechange/changepnw.html
5 "Fish and Wildlife Service" www.fws.gov/pacific/Climatechange/changepnw.htm
6 "Park information and Links" www.north.cascades.national-park.com
7 Huebsch, Russell, "Hydroelectric Dams in Oregon." ehow contributor

and sustainable from an electric/energy standpoint. Geothermal energy also is a very viable resource, according to the Washington/Oregon Bureau of Land Management. The Bureau of Land Management stated that in 2005 geothermal plants produced enough energy annually for 500,000 people.[8]

FARMING/SOILS

Farming and cattle ranching have both made great strides in the region in recent years. Many farmers have now turned to growing organic foods to provide for the growing trend. They raise these crops in smaller quantities but at a very high quality. Also, the beef is purely grass fed hoping to reach a specific market of buyers.[9] The ability of farmers and ranchers to produce high quality produce and livestock will continue to add to the sustainability of the population living in and around the range by providing them with food. The areas surrounding the range have very fertile farm/grazing produced by millions of years of volcanic activity in the region. The three types of soils found throughout the Cascade Range, Andic Cryocherepts, Andic Xerochrepts, and Typic Cryorthods, come from volcanic ash.[10]

The Cascade Range contains many beneficial qualities, which help to make it a very sustainable environment for human life. With continued focus on hydroelectricity and geothermal energy, the region will continue to prosper. The natural beauty of the range will continue to beckon to tourists, which will ensure a major source of income for the residents of the range.

ADDENDUM

Skagit Range

The highest peak in the range is Mount Baker and rises to 10,781ft/ 3286 m. The range rests 63 percent in the United States and 37 percent in Canada. The total area that the range covers is 3,611 miles^2 (9,353 km^2). It is a sub-range of the larger Cascade Region.[11] Located in the range are large granite cliffs that are great for mountain climbing, including areas such as the Chilliwack Pluton and Mt. Barr.[12] The total population of Skagit County where much of the range is located is 117,500. The average precipitation per year is around 33 inches. The average temperature rests around 54°F. Unemployment rests at around 9.5 percent, which is higher than the Washington State average of 8.6 percent. There are many Native American Tribes that have long histories in the Skagit Range. These include the tribes Lummi, Clallam, Swinomish, and Skagit. They have resided along the banks of the Skagit River for thousands of years. The tribes have a large casino in Washington State that provides an income for many tribal members. Three major dams are in the range including the Ross, Diablo, and Gorge Dams. These three dams provide electricity to the Seattle Electric Company.[13]

---

8 "Bureau of Land Management" www.blm.gov/or/energy/geothermal/
9 Raftery, Isolde, "In New Food Culture, a Young Generation of Farmers Emerges." March 5, 2011
10 "Soil Types/Information" www.ehow.com/list_7178757_north-cascades-soil-types.html
11 www.peakbagger.com/range.aspx?rid=12501
12 www.bivouac.com/ArkPg.asp?ArxId=1587
13 www.bivouac.com/ArkPg.asp?ArxId=1587

Okanogan Range

Mount Lago is the highest peak and rises to 8,745 ft/2665 m. The range rests 75 percent in the United States and 25 percent in Canada. The total area of the range covers 3,426 miles^2 (8,872 km^2).[14] The range contains the Okanogan-Wenatchee National Forest. The forests are very diverse and the surrounding area includes high glaciated peaks to deep lush valleys of old forest growth. The eastern portion of the range is the driest section. The range receives more than 70 inches of rainfall annually in the mountains and the eastern edge of the range receives less than 10 inches annually.[15] Residing in the range is a Confederation of Native American Tribes. The tribes included are the Colville, Nez Perce, Palus, Wenatchi, Moses-Columbia, Entiat, Chelan, Nespelem, Sanpoil, Arrow Lakes, and the Methow. Agriculture and forestry combine to make the two most important economic aids for the area. Also in the range is the Grand Coulee Dam, which is the highest energy producing hydroelectric dam in the United States. The total population of Okanogan County is 38,400 residents.[16]

Hozameen Range

The highest peak in the range is Jack Peak, which has a summit of 9,066 ft/2,763 m. Seventy-seven percent of the range runs through Canada, while the other 23 percent runs through the United States. The total area that the range covers is 1,398 mi^2 (3,620 km^2). To the northwest of the range lies the Bedded Range. It is neighbored on the east by the Okanogan Range and also another to the northeast with the unofficial name of the Coquihalla Range, which lies between the Coquihall River and the Fraser River.[17]

14 www.peakbagger.com/range.aspx?rid=12503
15 www.fs.usda.gov/detail/okawen/home/?cid=fsbdev3053647
16 www.okanogancounty.org/demographics.htm
17 "North Washington Okanogan County" www.okanogancounty.org/demographics.htm

APPENDIX C

LAURENTIAN MOUNTAIN RANGE

By: Debbie Tudor, Trevor Tippets, and Byron Olsen

PHYSICAL

The Laurentian Mountains are located in the province Quebec, Canada and are partially bounded by the Ottawa, St. Lawrence, and Saguenay Rivers. The mountains are some of the oldest in the world with rock dating over 540 million year old.[1] These mountains are approximately 500m to 1000m tall with Mont Tremblant, Mont Bleu, Mont Raoul-Blanchard, and Mont des Conscrits measuring as the highest peaks in the range. Movement of glaciers during the warming Pleistocene era has shaped the mountains and valleys, leaving behind lakes, rivers, mineral deposits, and other sediments.[2] The soil includes peat, muck, marl, clay, silt, sand, gravel and boulders.[3] Mining in the Laurentians focuses on industrial minerals (graphite) and stones (quartzite and sandstone); mining of crushed stone and gravel for construction also is performed.

ECOSYSTEM

The northern Laurentians contain black and white spruce, balsam, fur, and white birch, while in the south, sugar maple, beech, and hemlock mix together with white pines.[4] The abundance of trees led to the construction of several sawmills that harvest the trees for use in building windows, cabinets, particleboard, and other building materials.[5] This vast forest provides habitat to a variety of mammals including black bear, deer, snowshoe hare, and a variety of migratory bird species. Hunting and fishing are a major part of recreation in this mountain range.

Average temperatures for the region range from 35°F to 50°F, and winters are long. There are approximately 100-140 days that are frost free, which place further restrictions on agriculture. Annual precipitation is 24 to 45 inches per year.

HUMAN INTERACTION

In 2009, the Laurentides reported a population of 542,416. This region accounts for 6.9 percent of the population of Quebec and is growing quickly. The unemployment rate was 8.5 percent in 2009.[6] The 2006 census reported a median income of 20,719 CAD for the Laurentides region,

1 Encyclopædia Britannica Online, s. v. "Laurentian Mountains," accessed November 16, 2011, www.britannica.com/EBchecked/topic/332432/Laurentian-Mountains.
2 Drummond, R.N. The Canadian Encyclopedia. 2011. www.thecanadianencyclopedia.com/index.cfm?PgNm=TCE&Params=A1ARTA0004555 (accessed November 15, 2011).
3 Chappel, Sarah. The Encyclopedia of Earth. June 2, 2009. www.eoearth.org/article/Laurentian_Mixed_Forest_Province_%28Bailey%29 (accessed November 15, 2011).
4 Drummond, R.N. The Canadian Encyclopedia. 2011. www.thecanadianencyclopedia.com/index.cfm?PgNm=TCE&Params=A1ARTA0004555 (accessed November 15, 2011).
5 Government of Quebec. Ressources Naturelles Et Faune Quebec. 2008-2011. www.mrnf.gouv.qc.ca/english/laurentides/overview/index.jsp (accessed November 15, 2011).
6 Economic Development Agency of Canada. "Laurentides (15) Region - Socioeconomic Profile ." Last modified Nov 15, 2010. Accessed November 18, 2011. www.dec-ced.gc.ca.

and a median household income of 41,267 CAD.[7] The percentage of the population considered low income after tax (often used as a measure of poverty) is 12.5 percent.[8]

In 2006, 28 percent of the Laurentides population aged 15 and over reported education that they had less than a high school education. Twenty two percent obtained a high school diploma; 19 percent received an apprentice/trade certificate; 14 percent graduated from a CEGEP (an institute similar to a junior college) or other non-university; 12 percent completed some college, and 5 percent graduated with a bachelor degree or higher from a university.[9]

The workforce in the Laurentides can be divided into four sectors. The tertiary, or service sector, comprises 77.5 percent of the workforce; the manufacturing sector is 15.6 percent; the construction sector is 4.5 percent, and the primary sector is 2.5 percent. The Laurentides are a world renowned tourist destination; the economy relies heavily on the success of the tourist industry. Over 2,785,000 tourists visited the region in 2008. Retail trade; accommodation and food services; and arts, entertainment and recreation account for 27.7 percent of all jobs.[10] Stony soil, poor drainage, and a cold climate limit agricultural development.[11]

In an attempt to maximize the benefit of their extensive water resources, the Government of Quebec has made development of hydroelectric power a priority. This commitment has allowed Quebec to become a leading player in the field of electricity generation. The Laurentides region is home to seven hydroelectric power stations; hydroelectricity accounts for 97 percent of all the electricity used in the region has allowed communities to take charge of their economic development.[12]

French is claimed by 88 percent of the residents of the Laurentides as their mother tongue. With 55.97 percent who speak French only, 42.55 percent are bilingual speaking both French and English, and 1.28 percent speak only English.[13]

ADDENDUM: LAURENTIAN SUB-RANGES

Principle sub-ranges in the Laurentian Upland are the Opeongo Hills, Misquah Hills, Huron Mountains, and the Porcupine Mountains. Due to massive erosion, the mountains in this region are not suitable to farming, but contain extensive forests and nearly untouched wilderness. The

7 Statistics Canada. 2007. Québec, Quebec (Code2423027) (table). 2006 Community Profiles. 2006 Census. Statistics Canada Catalogue no. 92-591-XWE. Ottawa. Released March 13, 2007.
8 Economic Development Agency of Canada. "Laurentides (15) Region - Socioeconomic Profile ." Last modified Nov 15, 2010. Accessed November 18, 2011. www.dec-ced.gc.ca
9 Statistics Canada. 2007. Québec, Quebec (Code2423027) (table). 2006 Community Profiles. 2006 Census. Statistics Canada Catalogue no. 92-591-XWE. Ottawa. Released March 13, 2007.
10 Economic Development Agency of Canada. "Laurentides (15) Region - Socioeconomic Profile ." Last modified Nov 15, 2010. Accessed November 18, 2011. www.dec-ced.gc.ca.
11 Cross, L.D. "The Land of the Laurentains." Laurentains Heritage Web Magazine. (2004). laurentian.quebecheritageweb.com/article/land-laurentians (accessed November 18, 2011).
12 Ressources Naturelles et Faune Quebec, "Overview of Natural Resources in the Laurentides Region." Accessed November 19, 2011. www.mrnf.gouv.qc.ca.
13 Statistics Canada. 2007. Québec, Quebec (Code2423027) (table). 2006 Community Profiles. 2006 Census. Statistics Canada Catalogue no. 92-591-XWE. Ottawa. Released March 13, 2007.

Misquah Hills are located primarily in the Superior National Forest conservation area, and are primarily used for hiking and canoeing, as most of the area is accessible only by water.[14] The Huron Mountains also are home to pristine natural forests and are preserved by the Huron Mountain Club.[15] There also has been massive erosion and relatively recent glacial activity that prompted the formation of the aforementioned club.

The Porcupine Mountains are a little different. After intermittent attempts at copper mining, the Porcupine Mountains Wilderness State Park was created to protect the vast expanses of old growth forest.[16] While agriculture was attempted in the Opeongo Hills region, it was never able to develop because of the lack of good soil. Today, it is instead covered in roads and small municipalities.

14 United States Forest Service "Superior National Forest" United States Forest Service. Accessed 2011. www.fs.usda.gov/wps/portal/fsinternet/!ut/p/c5/04_SB8K8xLLM9MSSzPy8xBz9CP0os3gjAwhwtDDw9_AI8zPwhQoY6IeDdGCqCPOBqwDLG-AAjgb6fh75uan6BdnZaY6OiooA1tkqlQ!!/dl3/d3/L2dJQSEvUUt3QS9ZQnZ3LzZfMjAwMDAwMDBBODBPSEhWTjBNMDAwMDAwMDA!/?ss=110909&navtype=BROWSEBYSUBJECT&cid=FSE_003853&navid=091000000000000&pnavid=null&position=BROWSEBYSUBJECT&ttype=main&pname=Superior%2520National%2520Forest-%2520Home/recreation/

15 Flaspohler, David and Meine, Curt. "Planning for Wilderness: Aldo Leopold's Report on the Huron Mountain Club". Michigan Technology University. Published February 2006. Accessed 2011.

16 Michigan Department of Natural Resources. "Porcupine Mountains Wilderness State Park". Michigan.gov Accessed 2011. www.michigandnr.com/parksandtrails/Details.aspx?type=SPRK&id=426

COAST RANGES

By: David Banks, Brooke Hodson, and Lindsey Burton

The Coast Ranges of the United States span 1,000 miles (1,600 km), from the Transverse Ranges of Southern California to the Olympic Ranges in Washington State.[1] The Northern Ranges consist of the Olympic Ranges in Washington State, the Oregon Coast Range in Oregon, the Calapooya Range in Oregon, and the Klamath-Siskiyou Range in Oregon and Northern California. The Southern Ranges consist of the Northern Coast Ranges in California, and the Central California Coast Ranges and the Transverse Ranges in California. The Coast Ranges have an average elevation of 3,300 ft (1,006 m) above sea level.[2]

PHYSICAL CHARACTERISTICS

Precipitation is very variable along the length of the Coast Ranges, ranging from 17 to 220 inches in different areas. From northern California northward, the mountains are among the wettest in the world, and support temperate rain forests. The southern reaches of the ranges are more similar to the other ranges of the American west, with dry, open forests rising from dry desert plains.[3] Due to compression, soil erosion creates a great deal of granite in the Southern Ranges including the Northern California Ranges, Central California Ranges, and Transverse Ranges.[4] Lake Elsinore is the largest body of fresh water, located in the southern part of the ranges.[5] The Pacific Coast Ranges are home to the largest temperate-latitude ice fields in the world.[6] Currently, there are 266 glaciers (reaching down to 5,000 ft/1,500 m) according to the last inventory of glaciers compiled in 1982. Mount Olympus, the highest peak in the Olympus Mountain Range (7,980 ft/2,427 m), has 8 glaciers. Most of the mountains are protected by the Olympic National Park. Major peaks include Mt. Olympus, Mt. Constanc, Mt. Anderson, The Brothers, Mt. Deception, and Mt. Angeles. The Klamath Mountains consist of a mixture of granite, sedimentary, metamorphic, and extrusive rocks. They are designated as a Level III Ecoregion by the U.S. Environmental Protection Agency. The highest peak is Mount Eddy (9,038 ft/2,755 m). There are no glaciers in the Klamath Mountains; the rivers include the Klamath River, Trinity River, Smith River, Salmon River, Rogue River, Scott River, Sacramento River, and Castle Lake.[7]

1 Encyclopedia Britannica, "Coast Ranges," Encyclopedia Britannica, www.britannica.com/EBchecked/topic/123106/Coast-Ranges .

2 Encyclopedia Britannica, "Coast Ranges," Encyclopedia Britannica, www.britannica.com/EBchecked/topic/123106/Coast-Ranges

3 "Pacific Ranges," last modified November 11, 2004, www.peakbagger.com/range.aspx?rid=12.

4 U.S. Geological Survey and California Division of Mines and Geology, Geologic map of California," Miscellaneous Geologic Investigations (1966) Map I-512.

5 "Rocky Mountain Recreation", last modified 2006, www.rockymountainrec.com/lakes/lake-elsinore.htm.

6 Encyclopedia Britannica, "Major Ice Fields," Encyclopedia Britannica, accessed November 27, 2011, www.britannica.com/EB

7 2006 C.N. Skinner, A.H. Taylor & J.K. Agee. Klamath Mountains bioregion. In: Fire in California's Ecosystems. Edited by N.G. Sugihara, J.W. van Wagtendonk, J. Fites-Kaufman, K.E Shaffer, A.E. Thode. University of California Press, Berkeley. pp. 170-194.

BIOLOGICAL/ECOLOGICAL CHARACTERISTICS

In Washington, Oregon, and California together, there are 10.3 million acres of forest; of this 80 percent are on federal land.[8] Much of this protected forest falls into the Pacific Coast Range. Flora and fauna includes, but are not limited to, the Redwood Forest in the northern ranges to more desert friendly vegetation in the southern ranges.[9,10] Other natural resources, such as timber and fish, along with oil and gas regions in the San Joaquin Basin Province (located next to the Temblor Range in California), are available as well.[11,12] A wide variety of species are indigenous to the Northern Ranges, including, gray wolves, black bears, and the national symbol of the United States - the bald eagle.

HUMAN/MOUNTAIN INTERACTIONS

Although mountainous regions, people along the Costal Ranges of the United States tend to live more around the mountains than actually on the ranges themselves. The most recent census was taken in the United States in 2010. The following chart displays results of the 2010 census relevant to population and economics in the Pacific Northwest areas.

	Population	Persons Per Square Miles	Persons below poverty level, percent, 2009	Median Household Income
USA[13]	308,745,538	87.4	14.30%	$50,221
Washington[14]	6,724,540	101.2	12.30%	$56,479
Oregon[15]	3,831,074	39.9	14.30%	$48,325
California[16]	37,253,956	239.1	14.20%	$58,925

Conservation of natural resources takes several forms throughout the Pacific Coast Ranges. National parks, such as Lewis and Clark National Historical Park in Oregon, Olympic National Park in Washington, and Redwood National Park in California, provide revenue to conserve the area's natural prestige and support a wide variety of ski resorts, especially the Olympic venues in Washington.[17] Conservation of indigenous mountain flora and fauna is key to further developing

8 Bolsinger, Charles L.; Waddell, Karen L. (1992) Area of old-growth forests in California, Oregon, and Washington. United States Forest Service, Pacific Northwest Research Station. Resource Bulletin PNW-RB-197.
9 "Redwood National and State Parks," last modified February 16, 2011, www.nps.gov/redw/index.htm
10 Plants of Southern California", last modified March 8, 2006, tchester.org/plants/lists/unlabeled_links.html
11 "Pacific Coast Collaborative," November 15, 2011. www.pacificcoastcollaborative.org.
12 Scheirer, A.H., Tennyson, M.E., Magoon, L.B., Charpentier, R.R., Cook, T.A., Klett, T.R., Pollastro, R.M., and Schenk, C.J., 2007, "Assessment of Undiscovered Natural Gas Resources of the Sacramento Basin Province of California," 2006: U.S. Geological Survey Fact Sheet FS-2007-3014, 2 p., pubs.usgs.gov/fs/2007/3014/.
13 "State And County Quick Facts," US Census Bureau, accessed November 19, 2011, quickfacts.census.gov/qfd/states/53000.html.
14 IBID.
15 "State And County Quick Facts," US Census Bureau, accessed November 19, 2011, quickfacts.census.gov/qfd/states/41000.html.
16 "State And County Quick Facts," US Census Bureau, accessed November 19, 2011, quickfacts.census.gov/qfd/states/41000.html.
17 "The National Parks Index 2009–2011," National Park Service. Accessed November 15, 2011. www.nps.gov/history/history/online_books/nps/nps/part2.htm#olym.

resources because of the research and growing developments of biofuels being produced from wood and crop waste as a clean fuel source.[18] Much has been done in the area, and a great vision is seen for the future through the Pacific Coast Collaborative. They are working to ensure that energy conservation and natural resources are the top priority.

The Southern areas are exploring new alternative energy sources such as wind farms near Palm Springs and nuclear energy.[19,20] The Northern Ranges also are exploring alternative energy sources, such as geothermal energy.[21]

18 "Pacific Coast Collaborative," November 15, 2011. www.pacificcoastcollaborative.org.
19 "Butterflies in West Mohave Desert", last modified November 19, 2011, www.presscom.com/windfarms.shtml.
20 "Nuclear Energy in California", last modified March 3, 2011, www.energy.ca.gov/nuclear/california.html.
21 Alison Holm and Leslie Blodgett and Dan Jennejohn and Karl Gawell, "Geothermal Energy: International Market Update," Geothermal Energy Association (2010): 47-50 www.geo-energy.org/pdf/reports/GEA_International_Market_Report_Final_May_2010.pdf.

APPENDIX E

ROCKY MOUNTAINS

By: Jonathan Latham and Troy Bradley

The Rocky Mountains (the Rockies) are a pre-historic wonder of the American West. The Rockies range from 70 to 400 miles wide and from 5,000 to 14,443 feet high.[1] This mountain range stretches south to north, from central New Mexico to the southern Canadian border (roughly 3,000 miles in length), with its highest point, Mt. Elbert (located specifically in the Sawatch Range), reaching 14,433 ft.[2]

PHYSICAL

The Rocky Mountain Region is located mainly in Colorado, Wyoming, and Montana. Sub-ranges can be found in states such as New Mexico, Utah, and Idaho. Some of these sub-ranges include the Teton Range (extending north-south 40 miles in Wyoming and Idaho [its highest point being The Grand Teton at 13,770 ft located near Jackson Hole]); the Wasatch Range (extending 150 miles north-south in Idaho and Utah [famous Mt. Timpanogos peaking at 11,749 ft located by the cities of Orem and Provo, Utah]); the Uinta Range (home to the 2002 Winter Olympic games [highest point is King's Peak at 13,528 ft located by Park City and Midway, Utah]); and more than 40 other sub-ranges.[3,4,5]

Many of the names of the states, mountains, and towns that lie within the Rockies derive from indigenous languages. For example, 'Utah' comes from the Native Ute language meaning 'people of the mountains'. 'Mt. Timpanogos' comes from the Timpanogots Tribe and translates as rock (tumpi-) and water mouth or canyon (panogos).[6] Kamas, is a bulbous plant that was a staple of the natives' diet and also means a small grassy plain among the hills.[7] These native names along with modern language names (such as Montana, which is derived from the Spanish word montaña, meaning 'mountain') give the Rockies a "colorful" (or "colored" [Colorado in Spanish]) history. The major river systems in the Rockies are the Colorado, Columbia, Snake, Yukon, Rio Grande, Platte, Arkansas, Saskatchewan, and Missouri Rivers.[8] Snow and rainfall averages are highly diverse and are never constant. Thus, finding an accurate median is difficult.

ECOLOGY

Natural wildlife (flora and fauna) of the Rocky Mountains includes (but is not limited to) elk, moose, mule deer, mountain lion, black bear, red squirrels, chipmunk, California gull, hawks, blue grouse, great horned owl, peregrine falcon, swallows, broad-tailed hummingbird, black-

1 "Rocky Mountains." Dictionary of American History. 2003. Encyclopedia.com. (November 16, 2011). www.encyclopedia.com/doc/1G2-3401803639.html
2 www.worldatlas.com
3 www.johncletheroe.org/usa_can/mountain/index.htm
4 www.johncletheroe.org/usa_can/mountain/index.htm
5 www.summitpost.org/mt-timpanogos-ut/151365
6 www.johncletheroe.org/usa_can/mountain/index.htm
7 www.kamascity.net/
8 Rocky Mountains." Dictionary of American History. 2003. Encyclopedia.com. (November 16, 2011). www.encyclopedia.com/doc/1G2-3401803639.html

billed magpie, mountain bluebird, Douglas fir, Engelmann and blue spruce, juniper, water birch, quaking aspen, cottonwood, maple, ash, sagebrush, prickly pear, and mountain ball cacti. There is some dispute about the exact number of national/state parks in the Rocky Mountain region. However, it is evident that millions of visitors every year come to enjoy these areas of preservation/recreation. Yellowstone National Park, for instance, "is the world's oldest national park (est. 1872)…and contains the world's most extensive assemblage of hydrothermal activity."[9] In 2007, it was recorded that 3.2 million visitors passed through Yellowstone National Park. During that same year, the Rocky Mountain National Park only received 2.9 million visitors, but was ranked in the top 10 most visited national parks in the country.[10] More recently (2010), the number of visitors has gone up: Yellowstone National Park had 3,640,185 visitors, Rocky Mountain National Park had 2,955,821 visitors, and Glacier National Park had 2,200,048.[11]

The Rockies also are a hub for coveted natural resources, including (but are not limited to) gold, silver, natural gas, coal, and oil. Concerning the Rockies, "Recent studies estimated that the region contained nearly 2 billion barrels of proven oil reserves, 186 billion feet cubed of proven natural gas reserves, and enough coal to supply the country for the next 120 years...No other region of The United States is equally endowed."[12] A few of the economic and environmental drawbacks in mining/drilling for these resources are "cyanide leaks (e.g. Zortman-Landusky gold mine), spills, and acid drainage points."[13] These and other pollutants cause Colorado and Wyoming's mountain lakes to be more acidic.

HUMAN INTERACTION

Tourism plays a crucial role in sustainable mountain development and the economy. As the government creates habitats/preserved environmental areas, jobs are created for maintenance and upkeep. Unfortunately, there is a price to be paid in maintaining clear/simple routes to these exotic destinations. "The 2005 report by the National Parks Conservation Association placed Yellowstone's maintenance and repair backlog at an estimated $22 million, whereas Glacier, too often ignored, face a $400 million backlog…(this) multiplied and resulted in a huge $150 million repair project."[14] Millions of tourists' dollars in cities like Estes Park or Grand Lake would be lost if these parks (or clear access to them) were not available.[15] Even, Wyoming, the least populated state in the U.S. (with only 493,782 inhabitants according to 2000 census and 563,626 from the 2010 census) depends heavily on tourism and recreation.[16]

Education/awareness is crucial in maintaining sustainable mountain development. Some of the leading academic institutions in the Rocky Mountain region include Colorado, Utah, Wyoming,

9 Butcher, D. Russell. 'Guide to Natural Parks' Rocky Mountain Region'. Pgs. 17 (1999)
10 usparks.about.com/od/natlparkbasics/a/Natlparkvisitor.htm
11 usparks.about.com/gi/dynamic/offsite.htm?zi=1/XJ&sdn=usparks&cdn=travel&tm=2219&gps=350_296_1245_481&f=10&su=p284.12.336.ip_&tt=2&bt=1&bts=0&zu=http%3A//www.nature.nps.gov/stats/park.cfm
12 Smith, Duane A. 'Rocky Mountain Heartland: Colorado, Montana, and Wyoming in the Twentieth Century.' Chapter 10, Into a New Millennium pgs. 257 (2008)
13 Smith, Duane A. 'Rocky Mountain Heartland: Colorado, Montana, and Wyoming in the Twentieth Century.' Chapter 10, Into a New Millennium pgs. 259 (2008)
14 Smith, Duane A. 'Rocky Mountain Heartland: Colorado, Montana, and Wyoming in the Twentieth Century.' Chapter 10, Into a New Millennium pgs. 250 (2008)
15 Ibid.
16 'US Census Bureau' for 2000 & 2010, Wyoming.

Montana, and Idaho State Universities, as well as Colorado Tech University, Brigham Young University, Wind River Tribal College, and Utah Valley University.

ADDENDUM

There are more than 40 ranges of mountains in the Rockies. The most well known of these ranges are the Teton, Wasatch, and Uinta Ranges. Many of the towns in these ranges started as simple mining and/or lumber camps in the 1800s. The completion of the Trans-Continental Railroad (completed in 1869 at Promontory, Utah) aided many visitors and settlers in their journey west.[17] This continental connection between east and west coasts enabled businessmen, prospectors, traders, trappers, and supplies to make their way more quickly to the Rockies and other places.

A city that profited during this movement west was Park City, Utah. Park City (located in both the Wasatch and Uinta ranges) was a silver mining town settled in the 1860s. Silver was mined from this area (as well as surrounding areas) until the early 1970s.[18] Later, the town would attract tourists to its world-class ski slopes, including the Deer Valley Mountain, Canyons, and Park City Mountain resorts. These slopes are conveniently located between the Wasatch and Uinta ranges. In 2002, the surrounding cities (Salt Lake, Midway, and Park City, Utah) would host the Winter Olympic Games. Other events such as the annual Sundance Film Festival and Swiss Days attract tourists and other outsiders. This combination of their creative works of art, talents, and various cultural displays provide annual sources of income to these small tourist towns. Tourism is the lifeblood of these cities.

There are many recreational activities available throughout the year. These activities provide a constant flow of money to the local and statewide economy. These activities include, but are not limited to boating, snow tubing, cycling, off-road and/or mountain biking, snow surfing, ice skating, hunting, fishing, mountaineering, golfing, snowshoeing, mountain/cross country skiing, and many more. Some places have well-established recreational parks, such as the Alpine Slide (a downhill track used in the summer) and Solider Hollow/Gorgoza (a downhill snow tubing slide [includes mechanical device which pulls you to the top effortlessly]). Rodeos, demolition derbies, and parades bring record numbers of visitors, campers, and of course, tourists.

17 www.nps.gov/gosp/index.htm
18 www.parkcity.org/index.aspx?page=280

SIERRA NEVADA

By: Esteban Nunez and Andrew Reams

The Sierra Nevada region is located in California and western Nevada, extending approximately 450 miles from north to south and is anywhere from 40 to 50 miles wide. It has the highest point in the contiguous United States (Mt. Whitney 14,505 ft). The region provides for 65 percent of the State of California's water supply and is increasing in importance as the region continues to grow. Some estimates have predicted that the area will triple in population by 2040.[1] Average precipitation levels range from 10 to 90 inches annually, with a majority of that occurring in the fall, winter, and spring.[2] The Sierra Nevada covers about 63,118 km^2, 15 percent of which are in designated conservation lands.[3]

PHYSICAL

The Sierra Nevada soils are classified as Alfisols, Andisols, Aridisols, Entisols, Inceptisols, Mollisols, and Ultisols in combination with mesic, frigid, or cryic soil temperature regimes, and xeric, udic, aridic, or aquic soil moisture regimes.[4] The major rivers of the Sierra Nevada are the Feather, Yuba, American, Cosumnes, Mokelumne, Stanislaus, Tuolumne, Merced, San Joaquin, Kings, Kaweah, Kern, Owens, and Truckee.[5] The Sierra Nevada has 497 glaciers covering an area equal to 50 kilometers[2,6].

The Sierra Nevada's most valuable resource is considered to be water. Whereas mining was the primary reason for dam building for the first 100 years of Sierra Nevada settlement, starting in the 1950s, new dams were built for the purpose of supporting an ever-growing California population. There are at least 490 large-to-medium-sized dams throughout the region, with about 120 hydroelectric plants and thousands of smaller water diversions. Natural resources (water and timber) in the Sierra Nevada account for 75 percent of the region resource value, with agriculture, recreation, and tourism making up the other 25 percent.[7] There are concerns about the effects of climate change and the availability of water resources. According to the Sierra Nevada Ecological Project, many of the assessments for resources and resulting land use and management strategies have been made under the expectation that the current climate of the Sierra Nevada will remain stable. There have been periods within the last 1,200 years of Sierra Nevada's climate where there were century-long droughts.[8]

---

1 "Looking to the Source: Watersheds of the Sierra Nevada," Sierra Conservancy, www.sierranevada.ca.gov/regional-info/wef2011.pdf
2 "Sierra Nevada," Ecological Subregions of California www.fs.fed.us/r5/projects/ecoregions/m261e.htm
3 "The Sierra Nevada region," University of California Santa Barbara, www.biogeog.ucsb.edu/projects/gap/report/sn_rep.html
4 "Sierra Nevada," Ecological Subregions of California www.fs.fed.us/r5/projects/ecoregions/m261e.htm
5 "Major Sierra Nevada Rivers", Sierra Nevada Photos, www.sierranevadaphotos.com/geography/sierra_rivers.asp#
6 Raub, W., Brown, C.S. and Post, A., 2006, "Inventory of Glaciers in the Sierra Nevada, California," U.S. Geological Survey Open-File Report 2006-1239, 232 p., online only
7 "People and Resource Use," 1996 Sierra Nevada Ecosystem Project Vol I, Chp 2 pg 26-30
8 "Summary of the SNEP Report," 1996, ceres.ca.gov/snep/pubs/web/PDF/exec_sum.pdf

ECOLOGY

The Sierra Nevada contains 3 national parks: Yosemite, Kings Canyon, and Sequoia; and 20 wilderness areas preserved by the federal government, which accounts for 52 percent of the land in the Sierra Nevada region.[9] Infrastructure is relatively rare in the region due to federal protection, but an exception is the O'Shughnesy dam, which impounds the Tuolumne River and provides 500 megawatts of power annually for San Francisco.[10]

The Sierra Nevada has been experiencing a much wetter, warmer and stable climate in its recent human settlement than the previous two millennia. There remains a possibility that the region could experience prolonged drought seasons, which is much more common to the region.[11]

The Sierra Nevada is home to 570 vertebrate species, 150 of which are included on the state's endangered species list.[12] The prevalent climate of the Sierra Nevada is "dominated by a 'mediterranean' pattern of a cool, wet winter followed by a long dry period in summer."[13] It has a unique plants and vegetation distribution with more than 50 percent of the state of California's plant diversity originating in the region. There are 3,500 native plant species found in the region, with extremely rare and endemic plants growing throughout the many diverse areas of the range. Vegetation ranges from chaparral and grasslands on the west side to sagebrush steppe and bitterbrush on the east. Woodlands consist of a number of different species of trees with deciduous and evergreen oak, foothill pine, ponderosa and pinyon pine, juniper, Douglas fir, white fir, sugar pine and incense cedar. Mixed conifer zones tend to be at the lower elevations with a more noticeable pattern of changes in tree species at the higher the elevation. At the highest elevations, there are low shrubs and cushion plant communities that have adapted to the ice and wind zones.

HUMAN AND MOUNTAIN INTERACTION

Population in the Sierra Nevada reached 819,000 residents in 2000. At the current pace, the Sierra Nevada will surpass 1 million full-time residents by 2020.[14] In 2000, second homes in the Sierra Nevada made up 15.7 percent of the region's total housing units, significantly higher than the state average of 2 percent. Sierra Nevada residents aged 35-54 accounted for 35 percent of the Sierra Nevada's population, while residents aged 15-34 comprised only 22 percent.[15] From 1980 to 2000, the proportion of Sierra Nevada residents 45-54 years old increased by 286 percent.[16] This particular rate of growth was nearly 50 percent greater than the state as a whole. Thirty percent of the population has some college, 17 percent have a bachelor degree, and 8 percent have a graduate degree. The North Central led all sub-regions in every category of educational attainment.

9 Hogan, Micheal, ed. Encyclopedia of Earth 2011. "Sierra Nevada Forests."
10 Olson, D., and J. Sawyer, ed. Wild World. 2011. s.v. "Sierra Nevada forests."
11 "Summary of the SNEP Report," 1996, ceres.ca.gov/snep/pubs/web/PDF/exec_sum.pdf
12 Sierra Nevada Legacy. 2011. "Biodiversity and the Sierra Nevada."
13 "Sierra Nevada Ecosystems," 1996 ceres.ca.gov/snep/pubs/web/PDF/v1_ch01.pdf
14 These numbers account only for full-time residents, not the growing "shadow population" of recreational visitors and second homeowners.
15 Matthew Samelson, The State of the Sierra, (Sierra Business Council, 2007), 14.
16 Matthew Samelson, The State of the Sierra, (Sierra Business Council, 2007), 27.

Average pay per job in the Sierra Nevada was $31,770. However, those earnings only equated to roughly 75 percent of the statewide average. Tourism contributes 10 percent of the region's total payroll, and tourism-related jobs account for 10.4 percent of total employment in the Sierra Nevada.[17] The North Central sub-region, which has the highest per capita income and highest economic diversity in the Sierra Nevada, has tourist economy numbers that are closer to that of the entire state of California than with the Sierra Nevada. In 2001, local wages provided only 50 percent of the Sierra Nevada's income, significantly less than the 70.9 percent that local wages contributed to California's economy. The Sierra Nevada ecosystems produce about $2.2 billion worth of commodities, including water resources, agriculture, timber products, ranching, mining, tourism, and recreation. More than 60 percent of that - $1.3 billion a year - is the direct value of water for irrigation, municipal, and hydroelectric use.[18]

The core area of the Sierra Nevada consists of 20,663,930 acres, 36 percent of which is privately owned. The publicly-owned land is operated by the U.S. Forest Service (USFS), the Bureau of Land Management (BLM), the National Park Service (NPS,) and the State of California.[19] Social institutions remain a key factor in maintaining sustainable mountain development, aiming to close the gap between what is taken from the ecosystem and what is given back. These institutions can include the previously referred to government entities (i.e., USFS, BLM, NPS), but also consist of other organizations, such as the Sierra Club and the Sierra Watch, which have the goal of promoting a sustainable exchange between people and the ecosystem in the Sierra Nevada region.[20,21]

ADDENDUM

Gold Prospectors Association of America suggests that about 50,000 to 100,000 Californians a year engage in recreational prospecting in the Sierra Nevada. An additional 10,000 to 20,000 nonresidents are thought to participate as well. The average recreational prospector spends from 3 to 10 days a year in this activity and spends perhaps $50/day in the local areas. Under the Mining Law of 1872, placer deposits can be claimed, and the claimholder acquires the mineral rights. In 1994, to increase public access to placer deposits for recreational prospecting, the BLM has removed from Mining Law coverage the 11 km (7 mi) stretch of the Mokolumne River from Highway 49 to Electra, and now issues two-week permits for prospecting in placer deposits there.[22]

In 1916, deposits of scheelite, a tungsten-bearing mineral, were discovered in the Pine Creek area (Bateman 1965). The Pine Creek mine began operation in 1918 and has been among the free world's largest tungsten producer. The Pine Creek mine and associated deposits, which lie just outside the eastern boundary of the John Muir Wilderness in the Pine Creek pendant, form the largest, most productive tungsten reserves in the United States (du Bray et al. 1982),

17 Matthew Samelson, The State of the Sierra, (Sierra Business Council, 2007), 24.
18 Watersheds of the Sierra Nevada, (Water Education Foundation), 15.
19 "Sierra Nevada Ecosystems," Sierra Nevada Ecosystems Project Report, ceres.ca.gov/snep/pubs/web/PDF/v1_ch01.pdf
20 www.sierrawatch.org/history/
21 "Who We Are," Sierra Nevada Alliance, 2011, www.sierranevadaalliance.org/whoweare/
22 Diggles, Michael, ed. U.S. Geological Survey . 2001. s.v. "Geology and Minerals Issues."

with proven reserves of 1.5 million tons of mineralized rock as of 1995. Availability of low-cost Chinese tungsten and the lower demand for bomb casings since the end of the Vietnam War have kept the world price at a level too low for the Pine Creek mine to be reopened.

Recreation is a significant activity in the Sierra Nevada, which serves as a center for a wide range of recreational activities. The Sierra Nevada contains some of the world's outstanding natural features, and they attract visitors from throughout the country and the world. Lake Tahoe, Yosemite Valley, Mono Lake, and the Sequoia Big Trees attract millions of visitors each year. Recreational activities on public lands alone account for between 50 and 60 million recreational visitor days (RVDs) per year, with nearly three-fifths to two-thirds of those RVDs occurring on lands administered by the U.S. Forest Service. The California Department of Parks and Recreation has the second greatest number of RVDs, followed by the U.S. Bureau of Reclamation, the National Park Service, and the U.S. Bureau of Land Management. Additional recreational activities on private lands account for millions more RVDs that are currently not accounted for by any agency in a consistent or reliable format that would allow direct comparisons with public land recreational use data.[23]

23 "Recreation in the Sierra," Timothy P. Duane, ceres.ca.gov/snep/pubs/web/PDF/VII_C19.PDF

SIERRA MADRE MOUNTAIN RANGE

By: Nikko Pederson and Jesler Molina

The Mexican Sierra Madre Mountain Range is comprised of the Sierra Madre Oriental (eastern), the Sierra Madre Occidental (western), and the Sierra Madre del Sur (south). The Sierra Madre runs from north to south from south of the Sonora-Arizona border to parts of Chihuahua, Sinaloa, Durango, Zacatecas, Nayarit, Jalisco, Aguascalientes, Guanajuato, Coahuila, Nuevo León, Tamaulipas, Mexico DF, San Luis Potosí, Hidalgo, Tlaxcala, Oaxaca, Guerrero and Michoacán. The range covers an expanse of 134,900 mi2 (349,500 km2), and has an average elevation of just over 8,000 ft.[1,2,3,4] Wildlife within this region includes 23 different breeds of pine, about 200 species of oak, many diverse endemic birds, and a large assortment of other plants and animals.[5] Due to its extension, Sierra Madre territory functions as 'climate corridors' where different kinds of climates interact; from warm-humid to warm or cold climates, warm subtropical to temperate climates, and between arid and semi-arid to warm-humid areas.[6]

PHYSICAL

The Sierra Madre range contains soil that is very acidic due to high levels of hydrothermally altered rock. The pH levels of the soil deriving from these degrading rocks range from 3.5 to 4.5.[7] Bio-energy, i.e., energy produced from waste, such as the Monterrey III project, is one of the many energy projects in the region.[8] There also are several dams maintained in the Sierra Madre that are used primarily for fresh water and energy. The major minerals found here are silver, gold, iron, cobalt, copper, lead, zinc, antimony, nickel, and uranium.[9] Silver is exceptionally prevalent in this area and contributes to Mexico maintaining its dominance as the world's largest silver provider.[10] Mexico supplies 16 percent of the world's silver.[11] Fresh water is very affluent in each of the Sierra Madre distributions. Each one of them represents a very important source of natural water; however, the most important sources of fresh water are the

---

1 Valero, Alejandra. "Sierra Madre Occidental pine-oak forests." 2001. www.worldwildlife.org/wildworld/profiles/terrestrial/na/na0302_full.html (accessed Nov. 23, 2011).
2 Valero, Alejandra. "Sierra Madre Oriental pine-oak forests." 2001. www.worldwildlife.org/wildworld/profiles/terrestrial/na/na0303_full.html (accessed Nov. 23, 2011).
3 Valero, Alejandra. "Sierra Madre Del Sur pine-oak forests." 2001. www.worldwildlife.org/wildworld/profiles/terrestrial/nt/nt0309_full.html (accessed Nov. 23, 2011).
4 Gilman, Daniel C, Harry T. Peck, and Frank M. Colby. The New International encyclopedia. Vol. 18, Dodd, Mead and company, 1906. books.google.com/books?id=avwaAAAAYAAJ&pg=PA147.(accessed Nov. 23, 2011).
5 Valero, Alejandra. "Sierra Madre Occidental pine-oak forests." 2001. www.worldwildlife.org/wildworld/profiles/terrestrial/na/na0302_full.html (accessed Nov. 23, 2011).
6 Secretary of Environment and Natural Resources. Climate Change Strategy For Protected Areas, 2010. Mexico, DF: National Comission of Protectec Areas, 2011. Spanish document translation.
7 Goldberg, Deborah E. The Distribution of Evergreen and Deciduous Trees Relative to Soil Type: An Example from the Sierra Madre, Mexico, and a General Model. Vol. 63, Ecological Society of America, 1982. www.jstor.org/stable/1937234.(accessed Nov. 23, 2011).
8 "Nuevo Leon Unido." n.d. www.nl.gob.mx/?P=simeprode_bioenergia.(accessed Nov. 23, 2011).
9 Crane, Walter R. Gold and Silver. J. Wiley & Sons, 1908. books.google.com/books?id=Xp5BAAAAIAAJ&dq=gold+. (accessed Nov. 23, 2011).
10 Zihlmann, Peter. "Sierra Madre Gold and Silver Venture Fund." n.d. www.timeless-funds.com/en/sierra-madre-gold-and.(accessed Nov. 23, 2011).
11 "Mexico." 2011. www.nationsencyclopedia.com/economies/Americas/.(accessed Nov. 23, 2011).

Rio Yaqui, Rio Grande, Rio Sotola Marina, Rio San Pedro, and Rio Panuco.[12] Overall the Sierra Madres provide resources such as gas, minerals as outlined above, and wood including various species of oak and pine.[13]

ECOLOGY

Due to deforestation, all but about 300,000 acres, only 2 percent of the initial forest located in the Sierra Madre Occidental Mountains (western sea border of Mexico) remains.[14] This trend appears as a large threat to the Sierra Madre Oriental and Del Sur.[15,16] In 1994, there were 86 protected areas[17], and by 2011 there were approximately 174 sheltered areas covering over 25,384,818 acres, which is approximately 12.92 percent of the area.[18] Conservation is essential to maintaining natural resources within this region and to stopping the disappearance of endemic wildlife, such as the endangered imperial woodpecker, the jaguar, and Mexican gray wolf.

The climate in the Sierra Madre is changing drastically, with a 40 percent increase in fossil fuel use in Mexico.[19] This impacts human communities, biodiversity, and the ecosystem in general. To combat this, the National Commission of Protected Natural Areas introduced the Climate Change Strategy for Protected Areas, which includes two substantive components: mitigation and adaptation.[20,21] Due to the high levels of urbanization, several animals have become endangered and some have become extinct in this region, such as the imperial woodpecker.[22] There are plans in place to prevent this from continuing, such as the Project for the Conservation and Management of the Jaguar in Mexico.[23]

HUMAN INTERACTION

Although Mexico is a developed nation with governmental programs that are working to provide

12 "Sistema de Consulta de las Cuentas Hidrográficas de Mexico." n.d. cuencas.ine.gob.mx/cuenca/ (accessed Nov. 23, 2011). Document in Spanish.
13 Valero, Alejandra. "Sierra Madre Occidental pine-oak forests." 2001. www.worldwildlife.org/wildworld/profiles/terrestrial/na/na0302_full.html (accessed Nov. 23, 2011).
14 Valero, Alejandra. "Sierra Madre Occidental pine-oak forests." 2001. www.worldwildlife.org/wildworld/profiles/terrestrial/na/na0302_full.html (accessed Nov. 23, 2011).
15 Valero, Alejandra. "Sierra Madre Oriental pine-oak forests" 2001. www.worldwildlife.org/wildworld/profiles/terrestrial/na/na0303_full.html (accessed Nov. 23, 2011).
16 Valero, Alejandra. "Sierra Madre Del Sur pine-oak forests" 2001. www.worldwildlife.org/wildworld/profiles/terrestrial/nt/nt0309_full.html (accessed Nov. 23, 2011).
17 "Instituto Nacional de Tecnologia." 2010. www2.ine.gob.mx/publicaciones/gacetas/gaceta36/.(accessed Nov. 23, 2011) Agenda Ambiental/Tres nuevas áreas protegidas. Document in Spanish.
18 "Comisión Nacional de Áreas Protegidas de Mexico." 2010. www.conanp.gob.mx/que_hacemos/ (accessed Nov. 2, 2011). Áreas Protegidas decretadas 2011. Document in Spanish.
19 Cambio Climatico." 2010. www.cambioclimatico.gob.mx/index.php/acciones-d.(accessed Nov. 23, 2011). Document in Spanish.
20 Cambio Climatico." 2010. www.cambioclimatico.gob.mx/index.php/acciones-d.(accessed Nov. 23, 2011). Document in Spanish.
21 "Comisión Nacional de Áreas Protegidas de Mexico." 2010. www.conanp.gob.mx/acciones/proacc.php (accessed Nov. 23, 2011). Programa de Adaptación al Cambio Climatico PROACC. Document in Spanish.
22 Valero, Alejandra. "Sierra Madre Occidental pine-oak forests." 2001. www.worldwildlife.org/wildworld/profiles/terrestrial/na/na0302_full.html (accessed Nov. 23, 2011).
23 Secretaría de Medio Ambiente y Recursos Naturales. Proyecto para la Conservación y Manejo del Jaguar en México, 2006. Mexico: Secretaría de Medio Ambiente y Recursos Naturales, 2006. Document in Spanish.

a better life and quality of life to their people, by 2010 there were 52 million Mexicans living in poverty, and 11.7 million in extreme poverty in a country that is home to the richest man in the world.[24] Most of this poverty is found on the South Mountain range of Sierra Madre. Even though Mexico's education is one of the highest in Latin America, the Sierra Madre Range has disparities. For example, the best scores that Mexico received on the Programme for International Student Assessment test in 2009 were found in the western range, Sierra Madre Occidental, while the lowest where found in the southern range, Sierra Madre del Sur.[25] To improve those scores, the Mexican government has created a program designated to educate the indigenous communities, which are mostly found on the south range of Sierra Madre.[26]

Like the rest of Mexico the predominant religion practised within the Sierra Madre Range is Catholicism (an estimated 90 percent of the population), followed by Protestants and Evangelicals (with an estimated 8 percent).[27] Other than mining and tourism, agriculture also plays an important role in the economic development of the region. Crops of sotol o sereque, used to produce liquor of stool, and mezquel, used to produce mescal wine, are some of the common agricultural products.[28,29]

ADDENDUM

Sierra Madre Occidental (Western):
Jalisco, México DF, Sonora, Chihuahua, Sinaloa, Durango, Zacatecas, Aguascalientes, Nayarit.

- Mining

The most prevalent minerals within the Sierra Madre Occidental region are gold and silver.[30] The veins that contain these precious metals have brought over 250 private exploration companies to the area. This region also contains minerals such as zinc, copper, gold, silver, and lead.[31]

- Renewable Resources

Mini-hydroelectric energy is the most important renewable energy project found in this range. It is based on using existing agricultural irrigation dams to produce electricity. The

24 "CONEVAL." 2010. www.coneval.gob.mx/cmsconeval/rw/pages/medicion..accessed Nov. 23, 2011). Porcentaje de la población en pobreza según entidad federativa, 2010 Estados Unidos Mexicanos.
25 Instituto Nacional Para la Evaluación de la Educación. Informe sobre Mexico en PISA 2009. 2009. Mexico D.F: PISA, Document in Spanish.
26 Secretaría de Educación Pública. COMISION NACIONAL PARA EL DESARROLLO DE LOS PUEBLOS INDIGENAS, 2009. Mexico D.F: Secretaría de Educación Publica, 2010. basica.sep.gob.mx/dgei/pdf/normateca/Desarrollo.
27 Estados Unidos Mexicanos. Instituto Nacional de Estadísticas y Geografía. Religious diversity in Mexico. Mexico D.F: Instituto Nacional de Estadísticas y Geografía, 200. Document in Spanish.
28 Secretaría de Economía. DECLARACIÓN GENERAL DE PROTECCIÓN A LA DENOMINACIÓN DE ORIGEN SOTOL., 2002. México D.F: Instituto Mexicano de la Propiedad Industrial, 2002. Document in Spanish.
29 Secretaría de Economía. MODIFICACION a la declaración general de protección de la denominación de origen Mezcal, 2003. México D.F: Instituto Mexicano de la Propiedad Industrial, 2003. Document in Spanish.
30 "Mining in Mexico - Fresnillo." Fresnillo. Web. 20 Dec. 2011. www.fresnilloplc.com/about-fresnillo/mining-in-mexico.aspx.
31 "La Bufa Property." Lincoln Mining Corp. Lincoln Mining Corp. Web. 20 Dec. 2011. www.lincolnmining.com/projects/la_bufa/summary/.

state of Jalisco has the most prominent of these projects, "Los Tojes," a mini-hydroelectric plant that produces 8 MW of electricity.[32]

•Tourism

Ecotourism is available in Copper Canyon, Waterfall Basaseachi in Chihuahua, and the park and the tourist corridor of Los Dynamos, Villa Donato Guerra, Avandaro in Mexico City. Many thermal waters are available throughout the whole area. Likewise, tourists can visit different Indian villages that offer a warm welcome to all travelers. One of the archaeological sites and tourist attractions in the mountains is the pre-Hispanic settlement Paquime Chihuahua. The settlement represents chichimeca culture and is famous for its adobe buildings and doors in a "T." It was declared a UNESCO World Heritage Site in 1998.[33]

Sierra Madre Oriental (Eastern):

Coahuila, Tamaulipas, Nuevo León, San Luis Potosí, Querétaro and Guanajuato, Hidalgo, Tlaxcala

• Mining

The Sierra Madre Oriental mountain region plays host to some of the biggest silver veins in the world. One of the larger silver mines is the La Encantada mine, which produced 3.8 million ounces of silver in 2010.[34] Silver is the predominant mineral in this region.

• Renewable Resources

Bio-energy is the most relevant renewable energy project found in this range. "Monterrey III" is the first bio-energy program in Mexico to produce electricity from the biogas generated by a landfill site. It produces around 7 MW and is located in Nuevo Leon.[35]

• Tourism

The Eastern Sierra also has plenty of natural reservoirs and Indian villages. Among the different tourist sites are "El Charco del Ingenio" (Guanajuato), which was conceived as a monumental park that promotes conservation of Mexican plants and community environmental awareness, and "Real Catorce" - an old mining town and tourist attraction located in the heart of the Sierra de Catorce.[36,37]

32 Secretaría de Energía. Energías Renovables para el Desarrollo Sustentable en México, 2010. Mexico D.F:

ecretaría de Energía, 2010. Secretary of Energy: Renewable Energy for Sustainable Development in Mexico. Document in Spanish and English. www.energia.gob.mx/res/PE_y_DT/fe/e_renovables_mexico.pdf.

33 "Paquimé: Casas grandes." Instituto Nacional de Antropología e Historia. n.d. cultura-inah.gob.mx/index.php?option=com_conten. (accessed Dec. 02, 2011). Document in Spanish.

34 Explorando Mexico. Istmo de Tehantepec. www.explorandomexico.com.mx/about-mexico/7/273/ (accessed Dec. 15, 2011). Spanish Document.

35 Secretaría de Energía. Energías Renovables para el Desarrollo Sustentable en México, 2010. Mexico D.F: Secretaría de Energía, 2010. Secretary of Energy: Renewable Energy for Sustainable Development in Mexico. Document in Spanish and English. www.energia.gob.mx/res/PE_y_DT/fe/e_renovables_mexico.pdf.

36 "El Charco del Ingenio." 2009. www.elcharco.org.mx/ (accessed Dec. 12, 2011). Document in Spanish.

37 "Real Catorce." 2009. www.realdecatorce.net/home.htm (accessed Dec. 12, 2011). Document in Spanish.

Sierra Madre del Sur (South):
Oaxaca, Guerrero, Michoacán

• Mining

The Sierra Madre del Sur Range contains over 40 different types of natural zeolite minerals with various purposes,[38] as well as metals such as gold, silver, zinc, and lead.[39] Other minerals found on the Sierra Madre del Sur mining belt include a variety of sulfide minerals, such as pyrite, chalcopyrite, argentite, and galena.

• Renewable Resources

On this range, wind energy and mini-hydroelectric energy are the most common types of renewable energy found. Among different projects, the principals are "La Ventosa," a wind energy project in the state of Oaxaca that generates around 150 MW, and "El Gallo," a mini-hydroelectric plant with a 30 MW capacity in the state of Guerrero.[40]

• Tourism

Like the other ranges, the South Sierra has plenty of natural parks. It has the largest native population of all three ranges, but also is the poorest area in the country. However, among the high levels of poverty is Apola Santiago (Oxaca), a small town that is a very important destination for tourists in the area.[41] Another important place is the Isthmus of Tehuantepec, where the Southern end of the Sierra Madre reaches the coast. This tourist location, between sea and mountains, is known as an excellent location for extreme sports and ecotourism.[42]

38 Ostroumov, Mikhail, and Pedro Corona-Chávez. "Mineralogical Study of Mordenite from the Sierra Madre Del Sur, Southwestern Mexico." rmcg.unam.mx. 2003. Web. 19 Dec. 2011. rmcg.unam.mx/20-2/(4)Ostroumov.pdf.
39 Kozich, Franz. "Vendome's Wholly-owned Subsidiary Granted Option to Acquire 50% of San Javier Mine Property (Mexico)." Vendome Resources Corp. 02 Dec. 2011. Web. 19 Dec. 2011. www.vendomeresourcescorp.com/news/vendome-s-wholly-owned-subsidiary-granted-option-to-acquire-50-of-san-javier-mine-property-mexico.
40 Secretaría de Energía Energías Renovables para el Desarrollo Sustentable en México, 2010. Mexico D.F: Secretaría de Energía, 2010. Secretary of Energy: Renewable Energy for Sustainable Development in Mexico. Document in Spanish and English. www.energia.gob.mx/res/PE_y_DT/fe/e_renovables_mexico.pdf
41 Secretaría del Turismo del Gobierno del Estado de Oaxaca. Santiago Apoala, 2009. Oaxaca: Estado de Oaxaca, 2009. www.oaxaca.travel/FOTOS_SIITE/Atractivos/AT0297/Pe_AT02976.pdf Document in Spanish.
42 Explorando Mexico. Istmo de Tehantepec. www.explorandomexico.com.mx/about-mexico/7/273/ (accessed Dec. 15, 2011). Spanish Document.