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The Effects of the Mining Industry on the Colorado Plateau

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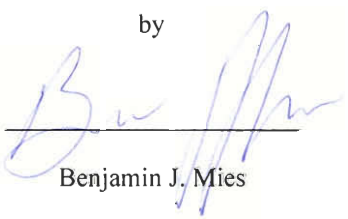

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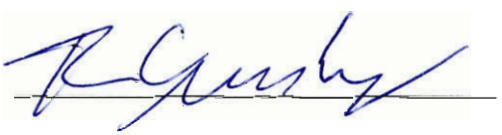

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Abstract

The environmental effects of mining on the Colorado Plateau are discussed. Topics covered range from physical damage to the landscape to the psychological consequences brought on by loss of wilderness. Both positive and negative results of the mining industry are explored.

Working Map of the Colorado Plateau

Figure 1 – Map of the Colorado Plateau

Introduction

Covering an area of roughly one hundred and thirty thousand square miles, the Colorado Plateau encompasses the Four Corners region of southeastern Utah, northern Arizona, northwestern New Mexico, and western Colorado. High mountain peaks blanketed with conifers, barren yet remarkably colorful painted deserts, and deep seemingly endless mazes of canyons all contribute to a strikingly harsh landscape. This exceptionally beautiful yet brutally rugged region seems impermeable. The expanse of rock, earth, and life remains one of the most untouched places we can experience here in the United States; still, we have certainly made sizable impacts, scarring the surface, and leaving serious environmental consequences in our path.

Hindsight is always 20/20. It is easy to criticize past efforts as modern scientists have the advantage in technology, time, and effects. Enough time has passed for us to realize the effects that some past mistakes have had on our surroundings and selves. Who can say that in another 50 years, experts, at that time, will not find serious faults in our current practices? Still, it remains important to learn from past mistakes, adjust our current operations accordingly, and plan ahead towards future approaches to land use.

It is a special place, an area written about by authors enamored by its rugged beauty. Cresting one of the surrounding peaks and gawking at the endless sea of earth and islands of rock that are the Colorado Plateau, one feels as though they are standing on the verge of a new discovery, utterly captivated. The place is entirely different from the landscapes that most of us are so familiar with. Of course, this is to be expected when there are fewer than 2 people living on average per square mile. Maybe this is why a place with such few people gets so much attention. The things that stand out most, that are different, are often focused upon the most. Or, maybe the huge boom of mineral

exploration, energy production, and settlement over the past one hundred and fifty years has truly damaged a very fragile environment. The following is a brief exploration into the environmental consequences that plague the land, animals, and people of the Colorado plateau due to the mining industry.

Geography, Geology, and History

The Colorado Plateau is like that empty lot in your neighborhood, neglected by geologic and human development. Surrounding this "empty lot" are the Rocky Mountains to the east and the Great Basin and range country to the west. As these areas were built-up and changed by nature's geologic forces stretching, pushing, and fracturing the earth's surface into our empty lot's impressive neighbors, the Colorado Plateau stayed intact. In fact, there have been very little drastic or significant changes to the structure, as a distinct mass of continental crust, in over 500 million years of existence.

Subscribing to the theory of continental drift, the relative stability of this unfathomable mass of earth crust is incredible. A tremendous amount of movement, on a geologic scale, took place in the North American continent to force it into the position that it fills today. Over a period of 300-400 million years, the land mass that is now North America drifted inch by inch from the South Pole, breaking off from Africa, Asia, and South America. The Colorado Plateau, on its western edge, accumulated tremendous quantities of sediment due to a rising sea level. Getting buried under its own weight, the plateau sunk, allowing pressure and heat to harden the sediment deposits into a several mile thick mantle of sedimentary rock.

This great pressure brought on by sediment and the rising sea level bred the mineral resources that we now harvest. Coal seams formed slowly as vegetation became buried under the pressure of sediment layers and sea water. Oil and Natural Gas were

formed in much the same way. Coil, oil, and gas are the 3 fossil fuels. Gold and silver were gathered into veins in the rock by the pressure and movement of the crust. Carnotite is formed as oxygenated water dissolves uranium from uranium containing minerals. This uranium is then deposited in reducing environments more suitable for the formation of carnotite. Most deposits are in sandstones in which fossils and petrified trees are prevalent and thus it can be assumed that the decaying material contributed to the reducing environment.

Approximately ten million years ago, the land mass that represents the western United States began to rise into mountain ranges with peaks nearly three miles high. The earth's crust was broken with tremendous force forming the jagged peaks and valleys of the Rocky Mountains. Yet, the Colorado Plateau remained stable. Like that glass of red wine on the mattress in the television commercials, the Plateau remained unshaken and intact, floating on Earth's mantle. These forces that formed the Sierra Nevada and Rocky Mountain ranges had a much less dramatic effect on the Colorado Plateau. Sharp ridges, valleys, peaks, and cracks in the earth, characteristic of the surrounding ranges, were replaced by gentle waves and bulges on the Plateau. Furthermore, relatively little evidence, compared to the surrounding area, of volcanic activity exists on the Colorado Plateau. Spectacular eruptions were generally thwarted by several vertical miles of sedimentary rock. Hot magma could do no more than cause a bulge in the crust before hardening. There lies something beneath the Plateau that "cushions" its crust from sharp changes; therefore, the rugged landscape, which captivates us all, is due primarily to forces outside the tectonic realm.

This is not to say that the thick crust is completely impervious to the molten rock underneath. The Plateau harbors some of the most spectacular evidence of past volcanic

activity in the world. Furious explosions and hellish lava flows have left behind some incredible impressions. Intrusive rock formations litter the plateau. Laccolithic mountain ranges are formed when magma cools between layers of rock forcing the overlying layer to warp and leaving spectacular domes of rock. These can be found protruding from the earth's surface. Fins of rock poke out of the earth in volcanic dikes formed beneath the surface from magma cooling in fractures. When un-earthed by erosion, they resemble the Great Wall of China. Furthermore, there are areas resembling an aged battlefield with volcanic bombs of obsidian strewn in every direction. However, impressive volcanic evidence is just the tip of the iceberg when it comes to fascinating geological topics.

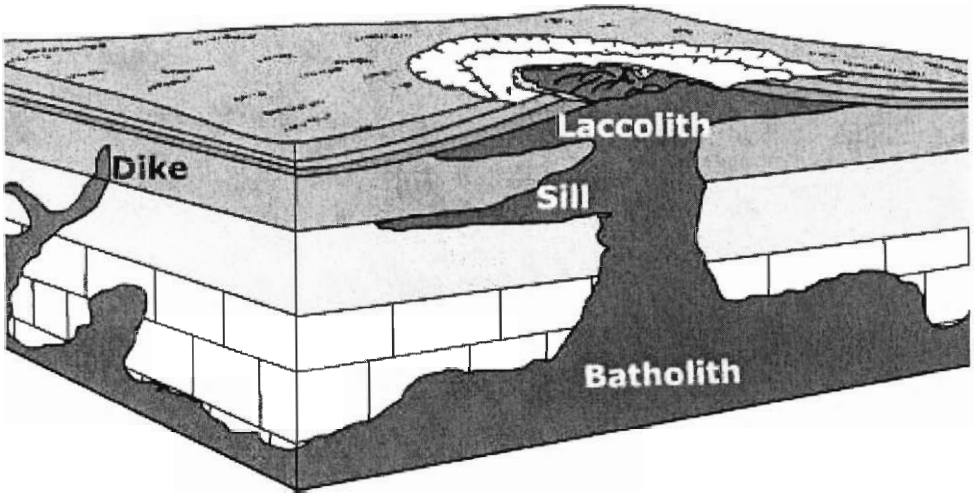

Figure 2 - Igneous Rock Formations.

Figure 3 - Dikes at Shiprock.

One may therefore ask, where did all of the intricate slots, complex canyons, towering buttes, and spectacular sheer faces come from? Erosion is doing an incredible job of creating more breathtaking artwork than even the most obscure minds can produce. Each of the thousands of miles of canyons or slots in the rock is like a sculpture garden filled to the brim with wonder, color, and masterpieces all carved by wind and water. There are natural mazes, each with its own special combination. There are at least 25 major plateaus, thousands of buttes, hundreds of mesas, endless towers, and domes, and 200 foot arches, and so much more that we couldn't hope to duplicate.

Searching for a purpose for the Colorado Plateau region, the National Park Service deployed two teams of geologists to identify potential National Landmarks. Like schoolchildren with a camp scavenger hunt, the men dashed into the relatively unknown and returned with no less than 110 potential sites that deserved recognition for being geologically phenomenal. "In no other province in America," they wrote in their report, "are the relationships between morphology and geology more clearly or graphically revealed."[1] The area of choice for many modern geological field trips, the Colorado Plateau truly is a place of wonder.

Time is suspended in the layers of the Colorado Plateau. It is America's leading museum of natural history; one giant museum with free admission. Erosion has opened a time capsule with treasures from millions of years ago. Treasures petrified by tremendous pressure and then uncovered by the forces of time. Ripples in sand dunes, inverted valleys, water ways, and entire forests of trees all preserved in a petrified rock state provide answers to our questions about times long since past. And, of course, the remains of those that inhabited the continent before us can also be dug from beneath the layers.

By dropping into the Plateau's canyons, one experiences history in reverse. Layers of earth, strata, represent time in the geologic calendar and provide evidence of past life. Fossils of single celled organisms, dinosaurs, and humans can be found readily. Three hundred dinosaur skeletons were uncovered in a single quarry at Dinosaur National Monument, UT. At Cowboy Cave in Utah, the dung of extinct camel, mammoth, and sloth has been found underneath human artifacts nearly 7000 years old.

The time travel does not stop with the long dead. Thousand year old juniper trees and 3000 year old bristlecone pines exist on the plateau. They have seen the cliff dwellers of Mesa Verde National Park (CO) come and go, and now they listen to tour guides in golf carts. Beyond the ancient, there are extant life forms with bizarre traits. Cryptobiotic organisms can be found in dried up potholes. Time is literally suspended for them, as they can lay dormant for as much as 25 years waiting for rain. Hiding in the slots and canyons, isolated from the desert above, the sundry biota is as diverse as the landscape. Spread amongst the rivers, creeks, and ponds of the plateau are nearly 80 species of fish. Three hundred and forty species of plants can be found on the surface and deep in the canyons. Furthermore, 80 of these species of plants are listed as

endangered or threatened.[2] The harsh and assorted conditions of this land have bred a variety of plants and animals with some being more susceptible to outside influences than others.

Taking into consideration the human occupation of the plateau, 12,000 years of development can be traced in the remains found. Ranging from the Paleo-Indian culture to the modern Pueblo Indians, frozen in time, is evidence spanning the entire temporal range of human prehistoric development. Thousands of prehistoric stone structures can be found strewn about the canyons and mesas of the plateau. Entire cities of stone, cliff-houses, kivas, watch-towers, pit-houses, tools, bowls, and human remains have been unearthed at archeological sites. In southeastern Utah, the density of these sites is as high as 80 per square mile. San Juan County alone hosts 15,000 known archeological sites. Even so, this is a dismal 10 percent of the estimated total number. Many of these sites are open to public view. Climbing amongst the stone homes of the Anasazi (the ancient ones in Navaho), meandering amid evidence of civilizations long since left behind, a visitor gains a deep appreciation for time.

The Colorado Plateau has been plagued by extreme population changes in the last thousand years. The current population of the Plateau is around one million; however, that number may be rivaled by the Anasazi's occupation some 700 years ago. Around 1300 AD, the civilization mysteriously collapsed. The Native American population continued to dwindle as the Spanish explorers brought European disease and then their military. In the 1700s and early 1800s, there were a good number of explorers and traders venturing into the interior of the plateau, but they had little effect on population or the environment. The arrival of Mormon pioneers and Anglo-American settlers finally brought an end to the Native American domination of the plateau and, consequently, the

pristine landscape. Currently, only a quarter of the population on the Plateau is from Native American roots.

Since 1900, the human population of the plateau has risen six fold. Furthermore, in the 30 years between 1960 and 1990, it more than doubled with a growth rate nearly two and a half times the national average. People fleeing the big cities of the west and east are fleeing come to enjoy the recreational promise land of the Colorado Plateau. Instead of going with their motor-homes and then leaving, they go in U-Haul trucks and stay. Not all can be blamed on the mining industry promoting the disturbing increase in population. The Colorado Plateau is a beautiful place, who wouldn't want to enjoy it.

The history of mineral exploration and excavation on the Plateau closely parallels the waves of more modern human settlement. Manifest Destiny, the drive for settlers moving west, and government incentives fiercely promoted the population growth of the Colorado Plateau. With the passage of the 1872 Mining Law, settlers and explorers could make mining claims on federal land for just a few dollars. Furthermore, when the market was viable, they could extract ore without paying any royalties to the U.S. treasuries. Since the plateau is nearly as rich in valuable, accessible natural resources as it is beauty, settlers took advantage of the cheap startup cost and mining towns began to spring up across the plateau.

At first, most of the mining operations focused on coal, gold, silver, and copper. However, as available technology and market demands changed so did the mining operations. At the end of the 19th century, miners were extracting vanadium, radium, and uranium from pitchblende and carnotite ore. However, methods of mining and processing the radioactive material at the time were slow and limited the economic and environmental impacts. The twentieth century brought new technology that opened the

floodgates to a burst of population growth, wealth, health problems, and environmental havoc. Fossil fuels such as coal, oil, and natural gas are mined all over the Plateau. In fact, the largest coal strip mine in the world is located at Black Mesa, Arizona. But, the impact of these mines is often forgotten as the hunt for uranium swept the Colorado Plateau and brought with it an array of consequences.

The Navajo and Ute Indians discovered a colorful ore called carnotite and put its colorful red and yellow hues to use as body paint. In 1898, uranium, vanadium, and radium were found to exist in the same mineral. The same year, radium was isolated from pitchblende by the Curies and Bemont triggering a small prospecting boom in Southeastern Utah that dwindled prior to the World War I. However, when it was found that vanadium added to molten steel would greatly increase both the tensile strength and elasticity of the metal, the tailings dumps at the mines had a new use, and the vanadium industry flourished on the Plateau. At the front of the Cold War, some twenty five years later, uranium, previously seen as a useless by-product of the vanadium industry, became crucial to the production of nuclear weaponry. Evidence of an untapped domestic source of uranium became evident in the waste piles. At the end of World War II the Atomic Energy Commission launched the first federally sponsored mineral rush in history. The Colorado Plateau soon teemed with prospectors guaranteed a minimum price for their buried treasure and armed with maps, Geiger counters, and other sophisticated equipment. In 1952 Charles Augustus Steen at Moab, Utah, proved that the "mother load" did exist under U.S. soil.[3]

Driving into Moab, Utah is like stumbling upon an oasis in the middle of the desert. It is a small spot of green trees and colorful structures amidst an endless expanse of red sandstone. Today, it bustles with tourists, river runners, hikers, off highway

vehicles, and mountain bikers. Before the mining burst in the early 1950s, Moab was a little known farming and oil town. Making a dramatic uranium strike just south of Moab, Charlie Steen changed the prospects for the town and the entire Colorado Plateau.

Leaving his wife and four sons in a tarpaper shack, Charles Steen, an unemployed oil geologist from Texas, took off alone to find wealth in the Utah desert. Unable to afford the standard Geiger counter to detect radioactive material, he ventured out with a second hand drilling rig and a theory. Steen's theory, or "Steen's Folly" as fellow prospectors on the plateau put it, was that the uranium was collected on the downward slopes of anticlinal regions, or folds in the rock, much in the same way that oil was. He ended up hitting it big at his Mi Vida mine in the Big Indian Wash of Lisbon Valley southeast of Moab and quickly made himself a fortune. [4]

Steen's find gave hope to those that were currently involved with this search for wealth and encouraged more to join. Moab's population jumped from 1,275 people in 1950 to 4,682 ten years later. Named the Uranium Reduction Company (URC), Steen completed the world's second largest uranium processing mill outside Moab in 1957 employing more than 200 workers. In 1962, the Atlas Corporation bought the URC, the nation's first large independent uranium mill, but it was eventually shut down in 1984. The boom brought new motels, schools, stores, and businesses into the city. As the burst of development from the uranium rush died down and the demand was weakened, potash became the new boom market. A potash plant was constructed in 1963. However, by the early 1970s, after people came and went, tourism began to grow in Moab. Certainly today this industry keeps the town alive. [5]

Steen's exploits at Moab is an interesting story, but similar stories could be found all over the plateau. There were around 800 mines delivering high-trade ore on the

Colorado Plateau by 1955. By the end of 1962, Utah alone had produced about 9 million tons of ore valued at over 25 million dollars, but then the rush died almost as quickly as it was brought to life. With so many mines spread out on the Plateau, the Atomic Energy Commission (AEC) now held ample reserves. They completely stopped buying uranium in the 1970. When nuclear power plants began to come online in the mid-70s, it triggered a small aftershock in the private uranium market, but foreign prices and federal regulations soon put a huge damper on domestic mining. However, the industry didn't leave without marking its territory. While the majority of uranium mining is done with, there remain other types of mines still open. [6]

Coal Mining

The coal mining industry has left its mark all around the country. Coming from the southeast, the author has stumbled upon numerous small coal shafts hidden beneath the undergrowth. Strip mining evidence riddles the landscape with shelves of earth and deep pits on the face of the earth. While hydroelectricity provides fairly clean energy to a great deal of the area, much of our energy still comes from smoky, ashy coal-fired power generation facilities. The demand for coal stands firm. Even further, as far as this is concerned, the Colorado Plateau is plagued by being sparsely populated with large expanses of open land. Large, nearby cities who would rather not burden their citizens with viewing smokestacks or mining operations can just place this burden out of sight and out of mind on the Plateau. Not only are the resources there, but the mining activity effects far fewer people. Over the last 25 to 30 years, several major coal-fired power generating facilities have been constructed on the Plateau that supply electricity to the metropolitan regions such as Phoenix, AZ and Las Vegas, NV. Two of the regions

largest coal power generators are the Four-Corners Power Plant in New Mexico and the Navajo Generating Station near Page, Arizona.

Tracing backwards from the final product, electricity, there lies an unsuspecting consequence of the process. Mines are close enough to the power plant that it is effective to link the mine directly to the power generating facility. In the case of the Mohave Generating Station, about 5 million tons of coal, in the form of slurry, was transported each year from a mine 273 miles to the east. Mixed with 3800 acre feet of water annually, the coal slurry traveled the nearly 300 mile journey pumped along a pipeline. The nearly 1.3 billion gallons of water used on average per year to transport the coal comes from 8 wells tapping aquifers under Black Mesa, Arizona. The aquifer from which the majority of this water comes is the primary water source for municipal users in the 5,400 square miles of the Black Mesa area. As arid as the Colorado Plateau is, the importance of an adequate supply of clean water is paramount. There is concern that the mining operation is damaging the water supply and lowering the water table. This would be an un-excusable consequence that would greatly alter the ways of life of those people depending on this valuable resource. Beyond the issues of transportation by water, all mines require access in and out for large amounts of materials and equipment. The physical structures created by the mining process (i.e. roads, railways, bridges, buildings, etc) can be found all over the Plateau abandoned, in use, and adapted to other uses.

The Colorado Plateau is home to a few large active coal mines, including the largest strip mine in the world. The Kayenta and Black Mesa mining complex is located near Kayenta, Arizona and ships out around 12 million tons of low-sulfur subbituminous coal per year from coal seams ranging in thickness from 3ft to 18ft. In 1968, the Peabody Coal Company began strip-mining operations on this land leased from the Hopi and

Navajo tribes. The mines continue to operate today on this controversial sacred land; however, one must be aware that 850 Native Americans are employed in the mining operation, so there may be some benefit. Aside from the potential aquifer damage, the reclamation activities have transformed an area once littered with pinyon-junipers into a grass land. [7]

Although some areas on the Colorado Plateau are permanently changed forever due to the abusive process of coal strip mining, some progress has been made to preserve beautiful and truly special areas. One of the more incredible success stories lasted nearly 40 years. In the 1960s a consortium of Arizona and California power companies put plans into motion to build 4 open pit coal mines on the Kaiparowits Plateau, UT. The mines would have provided 3,000 megawatts of power to cities surrounding the Plateau, cost around 3.5 billion dollars to construct, and provide jobs for eight to ten thousand workers necessitating a new town. However, the certain and extreme environmental damage caused by such a mine spurred an uproar from environmental groups nationwide. The project finally collapsed in 1976 after a long and arduous trial process. It seemed as though opinions in general on the treatment of the remote western lands was in fact turning towards conservation. Not until 1991 did anything further happen when a Dutch owned company introduced a plan for a much smaller scale operation in that area. Immediately, environmentalists opposed any mining at all in the area arguing that even though the technique planned for the operation was fairly environmentally sound, all of the other effects like roadways and noise pollution were unacceptable. The fighting between activists for and against the proposed mining operation lasted until 1996. In September of that year, President Clinton established the Grand Staircase-Escalante National Monument which encompassed the plateau and preserved the unspoiled natural

area. A great victory had been won. [8] However, any decision protecting the resources and the natural beauty of the area could be reversed. What resides under the Grand Staircase-Escalante National Monument, and other similar protected areas, is saved for future generations to make a decision regarding its use.

Oil and Natural Gas Mining

As with nearly anything, mineral wealth brought positive and negative effects to the Colorado Plateau and its people, including the Navajo and Hopi. In 1933, the Navajo reservation was enlarged by the United States and, with this enlargement, they promised that the Navajo Nation would receive a percentage of oil and natural gas royalties from the profits of mining on their soil. Since the 1956 discovery of oil and gas at Aneth, UT, nearly 600 wells have been drilled producing over 370 million barrels of oil and almost 350,000 cubic feet of natural gas. The impressive numbers were not without equally impressive consequences. They contaminated groundwater and area springs through injection of carbon dioxide and saltwater in hopes of increasing production. Almost 37,000 acres of fields were damaged in 1990 when there were 99 oil, saltwater, and chemical spills. Compensation and cleanup for these actions has been lax. It appears as though this is just another case of making money off the little guy who can't do anything about it.

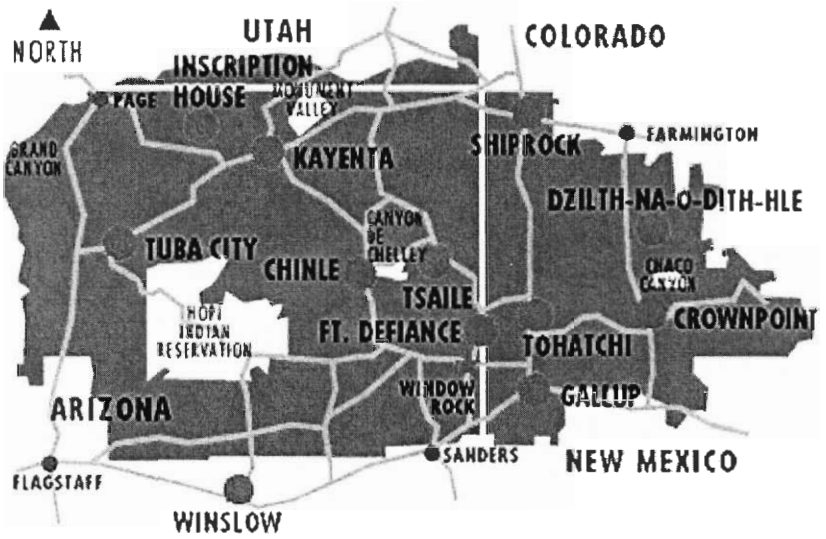

Figure 4 - Map of the Navajo Nation.

However, there are usually two sides to every coin. One hundred and eighty million dollars in royalties have been paid to the Navajo Nation in some way. But, it appears that one side of this coin shine's a lot brighter than the other. Of the 6,500 Utah Navajos in the region around the mines, seventy-five percent have no electricity or even running water. In fact, they have to make a one hundred mile trip each week to haul it in. On the plus side, in 1994, the Navajo Nation Council created its own oil and gas company and called for enforcement of the federal environmental protection laws. There is no end in sight to oil and natural gas consumption. Although the drilling and pumping goes on, the people around it are beginning to have a say in how it is done. [9]

Cinder and Pumice Mining

An area of young volcanoes along the southern margin of the Colorado Plateau, the San Francisco Peaks, has been home to cinder and pumice mines. From personal experience, having stood on the rim of SP Crater just outside Flagstaff, Arizona, these

cinder cones are a surreal change from the landscape around them. Both cinder and pumice are used in construction materials while pumice is also widely used as the material that gives jeans the stone washed look.

A highly controversial issue in the 1980s and 90s was the White Vulcan Pumice mine located on the eastern slopes of the San Francisco Peaks. Tufflite, a company that produces the material for "stone wash" for denim, a gardening agent, "redimix", and cement blocks, operates this 320 acre operation. Compared to the large scale of coal strip mining and uranium devastation, this "little" 90 acre pumice quarry may be small beans, but to a great number of concerned citizens including 13 Native American Tribes stopping the expansion of the mine has been important.

After operating the mine for nearly 50 years under the laws of the 1879 Mining Act, Tufflite proposed to expand the mine another 30 acres in 1998. This proposal only seemed to unite those in opposition to the mine. Animosity towards the company rose for a variety of reasons both environmental and spiritual. Apparent violations of the Clean Water Act played a part as did destruction of spiritual land shared by 13 different Native American Tribes. On August 28, 1999, an agreement was reached to shut the mine down entirely within 6 months and reclaim the land within 5 years. A great victory had been won. [10]

Uranium Mining and the Church Rock Disaster

In the morning hours of July 16, 1979 a twenty foot section of a thirty foot wide and twenty five foot high damn in Church Rock, New Mexico gave way. A dusty spot of a town in the arid desert southwest, its most distinguishing feature is a murky pond, curious in such parched terrain. A mill, scattered industrial machinery, scattered Navajo families, some goats, cattle, sheep, and underground uranium mine shafts also grace the

space. On this morning, eleven hundred tons of radioactive mill wastes and ninety million gallons of contaminated liquid burst from the pond in a wall of murky water headed towards Arizona. Twenty miles downstream on the Rio Puerco, in Gallup, sewers backed up and man-hole covers lifted.

A small gully leads from the mine site and into the Rio Puerco. The gulley, once only wet after heavy spring rainfall, now stayed flowing with water pumped from the mine shafts to keep them from flooding. The water was laced with radioactive isotopes. The damn above the gulley once held back a wall of radioactive waste.

If the process of mining uranium ore is a messy one, the ordeal of extracting uranium from the ore is downright disgusting. Usable uranium is extracted from the sandstone where it is found through a process called acid leaching. The sandstone where uranium is found is ground into a fine dust and then leached with sulfuric acid which carries off the desired isotopes. Waste is left, the undesirable material, called tailings. 99.9 percent of the ores initial volume and 85 percent of its original radioactivity are left behind as waste. Hundreds of millions of tons of this waste are scattered about the west at various sites. These acid milling liquids also dissolve dangerous levels of thorium 230, radium 222, lead 210, and other isotopes. The waste tailings and milling liquids must be kept isolated from the environment. [11]

One such method involves a tailings pond such as the one at Church Rock. Here, several hundred million gallons of the liquid were kept in the waste pond. The liquid should slowly evaporate off and leave only solid tailings which would be moved to storage. Owned by the United Nuclear Corporation (UNC), the pond was to remain for 18 months. Twenty five months later the pond remained as there had been no headway on finding other suitable sites for disposal.

The damn at Church Rock broke. The resulting wall of water, in its immediate sense, did not kill anyone directly. Along its path through the Rio Puerto, it left residues of radioactive uranium, thorium, radium, and polonium, as well as traces of metals such as cadmium, aluminum, magnesium, manganese, molybdenum, nickel, selenium, sodium, vanadium, zinc, iron, lead and high concentrations of sulfates. [12] In the desert, there is little more precious than water to life. Being responsible for the incident, the UNC had threatened the lives of all of those that depended on this water downstream. An investigation revealed that the incident could have been avoided.

A U.S. representative, Morris Udall, admitted soon after the spill that at least three federal and state regulatory agencies had ample time to conclude that such an incident was likely to occur. Even before the dam had been licensed "the company's own consultant predicted that the soil under this dam was susceptible to extreme settling which was likely to cause [its] cracking and subsequent failure."[13] These consultant's predictions were obviously looked passed as there were cracks forming the year that the dam opened according to Udall. Aerial photographs revealed that the milling liquids kept in the damn, which were supposed to be kept from the dam's face, were in fact lapping against it. The seepage devices and monitoring wells required by the state had never been installed. [14]

Soon after the spill, the UNC sent a 30-35 man cleanup crew downstream brandishing shovels and 55 gallon drums. Smaller crews had already been deployed; however, stern complaints from locals brought upon this increase in the effort. A representative of the UNC remarked that they had cleaned up "3500 tons of potentially affected sediment from the streambed to a distance of more than 10 miles from the mil… The combination of these clean-up efforts, and natural effects, such as rain, have largely

restored normal conditions in the area."[15] In fact, only 1 percent of the liquid and tailings spilled from the damn had been removed. Eighteen months after the incident, it became evident that radiation and other pollutants from the spillage had seeped to a depth of over 30 feet into the ground. A Cincinnati-based firm brought in as a consultant by the United States Environmental Protection Agency (USEPA) reported that at least two nearby aquifers had been affected. [16]

Even more troublesome, when the Rio Puerco overflowed, small pools of water were left on its banks. These pools, stagnant with radioactive waste, became the playgrounds of small children. The state ordered the UNC to monitor them. In response, the UNC chose to check for Uranium. Uranium was the very thing they were trying to remove from the sandstone in the first place. Of course, low levels of uranium were present which the UNC knew would be the case. In reality, "those pools showed levels of radiation one hundred to five hundred times natural background. What UNC might have missed were substantial quantities of thorium 230 and radium 226."[17] Both are extremely dangerous if ingested or inhaled and stay dangerous longer than any of us will live.

A silver-white metal, thorium tends to find its way into the liver, lymphatic tissue, and bone marrow. Leukemia and cancer can be caused by the smallest of quantities. Thorium 230 has a half life of eighty thousand years. Radium 226 also results from the radioactive decay of uranium isotopes, in particular, uranium 238. Its half life is much less than that of thorium at around sixteen hundred years. Radium emits several types of radiation including both alpha and gamma rays. Inhaled or ingested radium will increase

the likelihood of lymphoma, bone cancer, leukemia, and aplastic anemia. However, the greatest concern is of radium's by product radon which is discussed later.[18]

The UNC's data were far from conclusive. Dr. Thomas Gesell, a professor at the University of Texas School of Public Health and staff member of the Presidential Kemeny Commission on the effects of the accident at Three Mile Island, remarked on the UNC's findings. He concluded that the monitoring data from the UNC was entirely out of phase with the state's own data. So far off that one of the UNC reports found levels to be lower than before the spill and their claimed radiation levels were 150 times lower than the state's.[*19*]

Beyond the faults of the UNC, the contamination had spread to animals of the area. Abnormal radiation levels had been found in the tissue of goats and sheep that used the Rio Puerco as their drinking source. The Center for Disease Control (CDC) confirmed the findings of a local veterinarian in a study of eleven animals. They warned that kidneys and livers of the livestock could contain high levels of radiation and therefore should not be eaten. [20] Furthermore, the CDC warned locals not to drink water from the river and to avoid its banks during heavy wind due to the potential for airborne contaminated particles. However, the CDC did make clear that the levels of radiation found in the local animals did not exceed New Mexico's state standards, yet one should still be cautious as "the health risks of low doses of radiation" were "not completely understood."[*21*] Even so much as a year after the incident, the Environmental Improvement Division of the state declared that the water from the river was still too dangerous for human or animal consumption, and some buildup of radiation in the animals tested had been found. [*22*] It is also important to note that some of the

animals tested were found to have drunk water from upstream of the incident. It is clear that detrimental conditions were present even before the spill occurred.

Despite the warnings and cautionary words of many, the UNC mine and mill were back in operation less than five months after the incident. The same pond that had caused so much damage was still in use with only minor changes to the dam. Constant seepage was a day to day reality with upwards of eighty thousand gallons of contaminated liquid leaking out each day.[23] Clean drinking water was promised, but only half of what was guaranteed was actually delivered. The government denied a request by the downstream residents, who's lives depended on livestock grazing on contaminated food and water, for emergency food-stamps.[24] At least one family had to eat a sheep known to have ingested radioactive residues.

The incident was an eye opener not only to residents of Church Rock and the surrounding towns, but it also incited the concerns of people all over the area. It raised questions about the effects of mining on the Colorado Plateau and about the integrity of dams owned by Anaconda, Kerr-McGee, UNC-Homestake Partners, and Sohio. Frank Paul, vice-president of the Navajo Tribal Council spoke his feelings.

> *"Somehow, United Nuclear Corporation was permitted to locate a tailings pond and a dam on an unstable geologic formation. Somehow UNC was allowed to design an unsafe tailings dam not in conformance to its own design criteria. Somehow UNC was permitted to inadequately deal with warning cracks that had appeared over two years prior to the date the dam failed. Somehow UNC was permitted to continue a temporary dam for six months beyond its design life. Somehow UNC was permitted to have a tailings dam without either an*

adequate contingency plan or sufficient men and material in place to deal with a spill. Somehow UNC was permitted to deal with the spill by doing almost nothing."[25]

Other mines, near similar towns, would be allowed the same leeway. The pursuit of wealth had hastily kicked dirt over the line that separates a safe operation and one certain to cause serious damage to people, animals, and the environment.

Church Rock was the worst tailings spill on record, but it certainly was not the only one. Congressman Morris Udall's feelings on the entire mining situation were clear. He remarked that other spills in the west had dumped "millions of gallons of hazardous liquids", jeopardizing much of the west's water supply.[*26*] He cited an incident that sent twenty-five thousand gallons of mining slurry straight into the Colorado River, and another Utah flood swept fourteen thousand tons of tailings from a pile directly into the Green River.[27] Statistics from the Nuclear Regulatory Committee (NRC) accredited at least fifteen incidental releases of tailings to the eighteen years between 1959 and 1977. That's almost one documented incident per year. They included seven dam breaks similar to the one in Church Rock, six pipeline failures, and two floods. At least ten of these events resulted in findings of radioactivity reaching a major watercourse.[*28*] These were only the documented events. Recall that some of the animals tested in the Church Rock disaster had actually drunk water upstream from the incident, a water source that was fed from the uranium mines much like many other mines. This was normal practice and apparently not the result of a documented incident. Safety precautions were hardly adequate in the uranium mining industry.

The uranium milling process renders many of the resultant isotopes in the tailings highly soluble, and thus contamination to runoff areas, streams, and water tables during heavy rain is highly probable. Evidence from a study by the Oak Ridge National Laboratory in Oak Ridge, Tennessee, home to nuclear weapons construction, noted groundwater contamination at two New Mexico tailings piles.[29] High solubility promotes the travel of the isotopes down waterways as well as into the ground. Edwin Swanson, a water-quality expert for the state of Arizona, remarked on the Church Rock dam break, explaining that "traces of the spill--though dilute and possibly undetectable--would eventually reach Arizona's Lake Mead, 470 miles downstream".[30] In fact, according to an article in the Las Vegas SUN from 1998, levels of radiation in Lake Mead had been creeping above federal standards for several years prior to the article's publication. Alpha radiation had exceeded the federal regulation levels of 5 picocuries per liter in 1993, 1994, and 1997. However, according to the Safe Drinking Water Act, the levels are not considered unsafe until a level of 15 picocuries is reached. Milling and mining operations upstream from the water source were cited as possible sources of the radiation. [31]

This evidence promoted the idea that while the majority of uranium mining operations are far removed from major population centers, people in southern California, Las Vegas, and parts of Arizona should not sit easy as their water is supplied from Lake Mead, downstream from mining operations. Although the distances are quite great to some of the mills upstream, the half-lives of the isotopes are sufficiently long. Even in 1972, before the greatest concern had been raised, H. Peter Metzger, from *The Atomic Establishment*, acknowledged that tests on samples taken from the bottom sediments of

Lake Mead indicated levels of radium three times those of samples taken upstream of the operations.[32]

Even more impressive are the long term effects caused by the mining process. In estimating the long term effects of the radon gases emitted from the tailings piles, the NRC made the assumption that the piles would eventually be covered with dirt. Even so, some believe that the issue of radon gas in the air is even more severe than the immediate consequences to water and soil. Reginald Gotchy, a staff member of the NRC, remarked that even with a short half life of just under four days, gas from the tailings piles in New Mexico could still reach the East Coast. Even though the doses are considered miniscule, traces would be found all over the country.[*33*] As stated above, the plan was to cover the piles with dirt. In this case, the gas emitted would be trapped and, with the short half life, turn into solid elements that were less likely to disperse.

The Colorado Plateau has been shaped by erosion; erosion that has moved earth around in great quantities. Who's to say that the earth covering the tailings piles would stay in place? The tailings underneath this dirt blanket last for millennia. Furthermore, could the tailings piles even be covered? Some stand over one hundred feet tall and cover hundreds of acres. For enough dirt to cover those kinds of piles, large strip mining operations would have to be undertaken.[34] Another option would be to return the piles to the old mine shafts from which they came. The material was removed so it could be returned. While this is true, the scale of operation necessary to do so would be enormous. Returning just 140 million tons of the hundreds of millions of tons of tailings lying around the U.S. would require more than 5.5 million trips in twenty five ton dump trucks.

Tremendous amounts of fuel would be consumed and countless workers contaminated in the process.[*35*]

It should come as no surprise that remedial action against the waste problem has been moving slowly, messily, and costly. Tailings piles lie open to the elements. Wind and rain carry the toxins. Children have played in these massive dust dunes. Material from the piles has been used for building homes. The effects of the mining and milling process are widespread and costly. For example, high levels of background radiation from thorium have been linked to spontaneous abortion and mental retardation. [36] Monticello, Utah hosted a large uranium mill from 1949-1960. In the mid 1960s 4 of the 1900 citizens died of leukemia and another began a long battle to fight it. All five grew up within a half mile of the mill. Any other town this size would have a "normal" leukemia rate of 1 person suffering every 25 years. A study by the Center for Disease Control indicated gamma readings at the edge of the tailings piles almost 20 times background and, furthermore, there existed a hazard of increased risk due to heavy winds blowing the dried up tailings. [37] Examples of problems like these are numerous.

A rise in the birth defect rates of Colorado Plateau states (Colorado, Arizona, New Mexico, and Utah) has been linked to contributions from the uranium mining and milling operations. Dr. Alan Goodman from the University of New Mexico's School of Medicine noted that a distinct pattern of sex ratio changes and birth defects closely parallels the patterns of uranium mining and milling on the plateau.[38]

Focusing on the small town of Shiprock (NM), home to the Navajo Mill operating from 1954-1968, the consequences of carelessness is plenty evident. It is important to note that Shiprock lies in the Arkansas River Basin; however, as an interesting example,

the problems here parallel similar problems around the Plateau. Nearly 2 million tons of uranium mill tailings covering 72 acres were left behind in the heart of the town. Rainwater carried the radioactive particles into the nearby San Juan River. Children swam in it. Cattle drank from it. Wind blew the radioactive particles into playgrounds, city streets, crops, everywhere. In January of 1981, a Shiprock pediatrician, Dr. Evelyn Odin, remarked in *The Albuquerque Tribune* that she had found a disturbing number of premature babies with smaller than normal heads. Furthermore, one child was apparently born with its esophagus and trachea joined together, and another was born with its intestines hanging out as it had no abdominal wall. Another doctor in Shiprock, John Ogle, contributed further to the disturbing evidence. In six months he had seen 3 infants born with heart disease, 2 with cleft lips/ palates, 2 more with skull defects, yet another 2 with Down's syndrome, several with thyroid conditions, and even a newborn with a section of backbone missing. He was hesitant to blame the effects on the uranium operations. At the time there was no clear indication that the problems were due to radiation exposure. It is certainly difficult to believe that in such a small town of 20,000 people, these problems were only a matter of coincidence. [39]

Unknowing exposure to the tailings was also compounded by careless use of the tailings themselves exasperating the problem. Throughout the 50s and 60s it was fairly common for people to use the tailings as building materials, therefore numerous homes were built from radioactive materials. In Grand Junction, Colorado, over six thousand structures are known to have contained tailings materials or have tailings deposits in the landfills under them. For many, this meant direct and prolonged contact, daily, to dangerous radiation levels. Two hundred and seventy thousand tons of tailings were used all together. Remedial action against the faulty construction has cost taxpayers millions

of dollars.[40] The greater cost is of course that of lives lost and the suffering due to high radiation levels. A study by the state of Colorado indicated an acute leukemia rate in Mesa County, of which Grand Junction is the primary population base, twice the state's average. Furthermore, more women than men were suffering from the disease, strengthening the theory of radiation poisoning. [41]

Clean-Up Crews

With all of the evidence of environmental and human health effects of the uranium mining industry, people in the vicinity of mines and mills were understandably very concerned for the health of themselves and their families. Some sort of remedial plan of action for cleaning up this waste and the surrounding areas had to be made. In 1978 the United States Congress passed the Uranium Mill Tailings Radiation Control Act as a response to the public's outcry regarding the health hazards of long term exposure to the radioactive materials left behind by the industry.

The act authorized the Department of Energy (DOE) to stabilize and dispose of contaminated material and uranium mill tailings at 24 mill sites and around 5,200 related properties. Under this act, the goals of the Uranium Mill Tailings Remedial Action (UMTRA) program were to first address the immediate risk and prevent further risk at all sites. Secondly, surface remedial action at all 24 sites and surrounding properties was to be completed by 1998. Thirdly, groundwater quality was to be compliant with EPA standards no later than 2014. The structure of the project is broken up into two distinct parts, the Surface Project and the Ground-Water Compliance Project.

The Surface Project calls for either stabilizing the tailings on site or in some cases, relocating the tailings material to an off site local. Tailings are covered with soil and rock in such a way as to prevent radon release, limit erosion, control bio-intrusuion, and minimize the intrusion of rainwater or snow melt that could leach contaminated particles into the groundwater. The areas are then to be monitored under a long term surveillance plan. The other part of the project, the groundwater compliance portion, is not quite as straightforward as covering up surface contaminants. Remedial action towards groundwater contamination is to undergo careful thought and planning and will be tailored to the individual site. Of particular interest is a site on the outskirts of Moab, Utah.[42]

Moab Again

As was mentioned earlier, the Atlas Minerals Corporation shut down its uranium processing facility in 1984. They left behind what is now the DOE Moab Project Site. The 400 acre site is about 3 miles northwest of the center of the city at the confluence of the Colorado River and Moab Wash. Just 750ft from the river, set on a floodplain, sat up to 16 million tons of uranium mill tailings taking up 130 acres of land. Tailings waste leaked from this site directly into the Colorado River. Atlas had operated the site for over 20 years and the dumped waste had accumulated in an unlined impoundment on the northwest portion of the property. In 1988 Atlas began decommissioning activities and in 1995 placed an interim cover over the pile as they planned to reclaim the pile permanently in its location. However, in 1998 they declared bankruptcy forfeiting their license and reclamation bond. After the bond and the responsibility for clean-up changed hands a few more times, eventually, the title and liability for cleanup was transferred to the U.S. DOE Grand Junction, CO office on October 25, 2001 by government action.[43]

The Floyd D. Spence National Defense Authorization Act that changed cleanup rights also changed the site from Title II to Title I under the UMTRCA act of 1978. This made it necessary to review a broader range of remediation options including off-site removal and other treatment. An Environmental Impact Statement, concerning both the on-site options as well as three off-site areas, was developed by the DOE and published in 2004 to fulfill the National Environmental Protection Act requirements for considering a full range of possibilities. Furthermore, in April of 2005 DOE announced that the preferred alternatives were active ground water remediation and off-site disposal of the tailings pile and other contaminated materials to the Crescent Junction disposal site using rail transportation. July of 2005 brought the final EIS and shortly after in September, a Record of Decision was made available.

Reclamation of mined land is not a quick and easy process, especially when dealing with toxic materials. In Moab, many things must occur before the removal process takes place including, characterizing the Moab and Crescent Junction sites, assembling the required infrastructure, coordination of transportation logistics, and certainly hiring the appropriate personnel. Mistakes are not taken lightly anymore in this kind of business. There are eyes from many directions and organizations looking closely at cleanup operations. A simple screw up could quickly escalate. This project is a good example to use here because of the interesting history and real consequences of tailings in the Colorado River. Information on the project is so available. By observing how the operation has been run and is run today, it is clear how much time, effort, and money is going to have to be expended to make this area relatively safe again.

Much of the work done so far is paperwork, but ongoing, on-site, operations are underway as well. Maintenance activities, site access controls, monitoring, radiological

assessments, dewatering and general stabilization of the pile in preparation for moving, and groundwater cleanup to lower the elevated levels of ammonia and other contaminants have all been started already. Furthermore, groundwater cleanup efforts begun in 2003 and are well on their way to being successful. It would be interesting to see if the profit from the mines was greater than the cleanup cost. Maybe that isn't an issue since a demand is a demand and that demand must be met. But, these cleanups certainly do cost a tremendous amount of money, time, patience, and, certainly, there must be health risks to the employees. [44]

Consequences on a Deeper Level

Consequences of mining the Colorado Plateau are not limited environmental impact or the health of its inhabitants. Some effects are more subdued influences on our mindsets.

> "We need wilderness whether or not we ever set foot in it. We need a refuge even though we may never need to go there. I may never in my life get to Alaska, for example, but I am grateful that it's there. We need the possibility of escape as surely as we need hope; without it the life of the cities would drive all men into crime or drugs or psychoanalysis"[45]

For many, knowledge of a place virtually untouched by mankind is important. The average American spends his day entirely absorbed in the hustle and bustle of a capitalist society. Knowledge of an escape hatch, a place where there is nothing to remind this person of the demands of society, can keep a person balanced. Yes, they may never actually leap into the depths of the wilderness that the Colorado Plateau has to offer.

Knowledge of a place, seeing pictures of a place, hearing of a place, and dreaming of a place where they can stand and turn a full circle without hearing, seeing, or smelling any evidence of another human being; this keeps them sane.

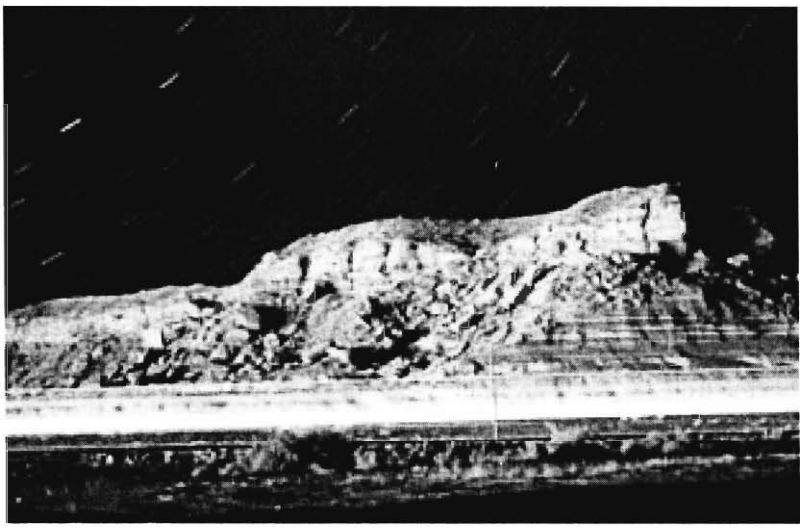

Figure 5 – Illumination of Rocks from an Arizona Power Plant.

Shafts, piles of debris, roads, abandoned towns, craters, and any other evidence of the mining industry spread all over the desert southwest are strangling this dream. There are those areas of protected land, National Parks, Forests, Monuments, and so on, but many of these have come to resemble giant, moving, drive-in movie theatres. We buy our tickets at the gate and then drive along clear paths, viewing the scenery presented along the road. The haven that these people dream of is disappearing as we harvest the Colorado Plateau for our resources and recreation. The irony is that the product being harvested from the coveted land provides these people with everyday things that have come to be necessity.

Towards a Conclusion

Continuing change exemplifies our earth. The topic of discussion, The Colorado Plateau, shines as a premiere example. Layers of color, sheer rock faces, blowing sand, silty streams, and punishing storms can all be seen in plain sight as terrific examples of

change. Part of this change lies in the modifications made by inhabitants of the earth. One cannot only look at the cause of natural change as geological power or weather intensity. Plants and animals are also part of the natural influences on the earth. Residents of the Colorado Plateau, be they plants, animals, or humans, alter the landscape significantly. Without these inhabitants and the structures they create, the land would be far different. It would be devoid of the colors of shrubbery and trees. Hillsides would be washed away as, without the root systems of plants, rainfall would sweep away the earth. No sign of borrows from small animal life could be found. And, yes, there would be no grotesque potash ponds, exposed mine shafts, tailings piles, or gargantuan strip mine holes.

The things we may view as the disgusting effects of the progress of man are in fact natural changes to our earth. As long as one can argue that we are a part of nature, everything that we do is natural, thus, these changes that we see as destroying the natural world are just natural modifications. We can choose where we want these natural changes to take place or to what extent they should take place. Government imposed rules on land use are in place for this purpose. Some areas are preserved, blocking us from allowing some forms of change, and thus giving opportunity for us all to reflect on the amazingly diverse land we live on. Other areas are mined, flooded, eaten, and forested so that we may can obtain the resources to make those reflections in comfort. The depth to which we alter the "natural" world is controlled by the demand for the resultant product and the technology used to obtain the product.

Scientific advancement in harnessing energy is pursued for this purpose. By finding ways around the need for coal burning power plants, we can limit the extent of strip mining. Limiting the amount of energy we use, also limits the amount of energy

that must be harvested from our earth. In order to stop or slow the destruction of these wonders present on the Colorado Plateau and everywhere else, our mindset as a society must be altered.

Recognizing the importance of keeping a place like the Colorado Plateau from our destructive hands, we might not choose to destroy it, but somewhere else will get the same treatment. If we don't get our resources from the Plateau, where will we choose to harvest them from? The issue is really in supply and demand. American demands are and have historically been very high when it comes to energy, power, riches, and basically anything consumable. As long as there is a demand, someone will find a means to supply. As a capitalist society it is our mindset to demand and supply and to make as much money as we can along the way. We may take notice of some things that are in the way, but steamrolling a few pretty mountains, some plants, a few animals, and the occasional person; these are small beans when looking towards the profit in the end.

Without completely changing the mindset that governs our society, these mines will exist, areas will be forested, cattle will tear the grassland apart, and wondrous areas will be flooded, all for the sake of survival, development, progress, and cash. With this in mind, the most reasonable choice that we have is, where should we save? Meaning, if some land is going to get ruined as a result of our mindset, where should it be? Any piece of land in question will have its own special trait that someone wants to cherish and protect. Natives of that area will always appose, and we will likely look back on the decision 60 years from now and find fault in it. The same issues that have arisen presently will come up in the future. The Colorado Plateau bears prime examples that the consequences of our actions will both negatively and positively affect our way of life.

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