Docket ID No. EPA-HQ-OAR-2013-0602

Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units

COMMENTS OF THE UTAH PHYSICIANS FOR A HEALTHY ENVIRONMENT ON THE EPA's PROPOSED CARBON EMISSION GUIDELINES FOR EXISTING POWER PLANTS[1]

(December 1, 2014)

The Utah Physicians for a Healthy Environment (UPHE) is a volunteer organization of over 300 physicians and consultants from other scientific fields including toxicology, biology, engineering, and ecology. There is a growing body of scientific evidence that indicates that air pollution, even at concentrations below those currently allowed under the Clean Air Act, causes or exacerbates many of the illnesses that we are asked to treat. CO_2 emissions are inevitably accompanied by toxins that directly affect human health. They also affect human health indirectly by disrupting the earth's climate. We offer our expertise to inform the public policy debate over how society should deal with carbon emissions as they impact public health.

Climate experts are nearly unanimous in concluding that greenhouse gas emissions are disrupting the planet's climate, and doing so at an accelerating pace. Unless greenhouse gas emissions are curtailed, the effect on the health and wellbeing of Utah's residents is likely to be severe, particularly in the long run.

Last winter, most of the towns along Utah's heavily populated Wasatch Front were under siege by chronic air pollution that exceeded the concentrations allowed under the Clean Air Act. This caused almost 5,000 people to gather on the steps of the State capital building to demand that the legislature deal with the public health crisis that this pollution is causing. They were calling for "Clean Energy, Clean Air, and a Clean Future" for Utah.

A poll taken last winter by the Salt Lake Tribune showed that Utah residents, by a 3 to 1 margin, want tighter regulation of industrial pollution. That same poll showed that 99% of Utah residents were willing to make personal sacrifices to reduce air pollution. Another poll showed that reducing air pollution and improving education were tied as the top priorities of Utah voters.

---

[1] Because Section I has been recently revised to reflect newly published research, references in that section are provided in internal footnotes. References supporting Sections II through V are provided in an attachment to this document.

I. COMPARING BENEFITS TO COSTS UNDER THE PROPOSED EMISSION REDUCTION STANDARDS

A. Even When the Clean Power Plan's Benefits Are Only Partially Modelled, the Benefit/Cost Ratio is Overwhelmingly Positive Under the Proposed State Standards, Implying That The Proposed State Standards Should Be Raised

Section 111(d) of the Clean Air Act obligates the EPA to control air pollution emitted from sources that already exist if it poses a danger to human health. On June 18, 2014, the EPA proposed a Clean Power Program to implement this section with respect to carbon dioxide emissions. It would require each state to prepare a plan to meet a CO_2 emissions performance target for its electric power sector. The performance target is expressed as the ratio of CO_2 emissions to unit of power generated. Utah produces almost 41 Terawatts of electric power each year, emitting 34 million metric tons of CO_2 in the process. Its emissions rate is 1,814 pounds of CO_2 per Megawatt-hour. In terms of carbon intensity, it is in the upper sixth of all the states.

The EPA has set a unique target emissions rate for each state to achieve by 2030. To develop this target, the EPA first determined a carbon emissions baseline (using 2012 data) based on each state's level of CO_2 emissions from fossil-fuel fired power plants divided by the total electric power that it generated from all sources (fossil fuel, nuclear, and renewables). Targets for 2030 were then established based on the ability of each state to 1) make its coal-fired power plants more efficient, 2) to switch coal to natural gas combined cycle (NGCC) plants, 3) to build more low-carbon power sources (nuclear and renewables), and 4) to reduce demand for electricity through conservation measures. Under the Clean Power Plan, a state that builds new low-carbon generating sources and exports the output to another state will get credit for the carbon emissions saved (honoring the practice of selling Renewable Energy Credits to other states), but an state that exports power will not get credit for in-state efficiency measures that affect the source of power that it exports.

After evaluating these factors, the EPA's proposed target for Utah is to lower its CO_2 emissions rate to 1,322 pounds per Megawatt-hour by the year 2030—a reduction of 27.1%. Prior to the announcement of the Clean Power Plan, PacificCorp (which is the corporate owner of Utah's electric utility Rocky Mountain Power) already planned to reduce the share of its power produced from coal from the current 62% to 46% by 2024[2] This is a 29% reduction. The implication is that Rocky Mountain Power will surpass the carbon emission's reduction target assigned by the Clean Power Plan well before 2030 for reasons that are unrelated to the proposed Clean Power Plan. This suggests that the emissions-rate reduction target that the EPA has assigned to Utah under the Clean Power Plan is so lenient that it gives PacificCorp no additional incentive to reduce its already-planned emissions.

If shifting from coal to natural gas (particularly fracked natural gas) is the primary reason that PacificCorp's share of power produced from coal is expected fall rapidly by 2024, the EPA should view the benefits of that shift with some skepticism. Recent studies of the rate of fugitive methane emissions from fracked natural gas in the Uinta Basin found that it was 9% of all gas produced.[3] Over a 20-year time frame, a pound of methane is 72 times more powerful at increasing the retention of heat in the atmosphere than a pound of CO_2. It is estimated that fugitive methane accounts for up to 8% of all gas produced from shale. If true, electricity produced from burning shale gas would warm the globe as much as producing electricity from coal. A study conducted last year by Robert Howarth of Cornell University concluded that methane will contribute 44% of all climate warming going forward. Id.

The benefits of curbing methane emissions are enormous. The EPA projects that if methane and fluorinated gas emissions could be effectively regulated, over the next 20 years, the increase in the heating of the atmosphere could be reduced by a third.[4] The Clean Power Plan must take into account the risk that shifting from coal to natural gas may not, in fact, reduce greenhouse gas emissions overall.

In 2012, Utah got 76% of its electricity from coal. This is nearly double the national average 39%. It got only 2.3% from eligible renewables, which is less than half the national average of 4.9%.[5] Utah's electric rates are 20% below the national average.[6]

Even though it has invested relatively little in renewable energy, Utah has enormous unused potential for utility-scale solar power, as well as substantial potential for wind and geothermal power. The Utah Geological Survey prepared a Utah Renewable Energy Zone assessment in 2009. It identifies 826 Gigawatts of utility-scale

---

[2] See statement of Rocky Mountain Power spokesman Paul Murphy reported in the May 29, 2014 edition of the Deseret News. The article reports that, under the privately compiled Benchmarking Air Emissions report, Utah ranks 6th in the nation in the carbon intensity of its electric power supply. www.deseretnews.com/article/865604170/Utah-ranks-No.-6-in-the-country-on-carbon-dioxide-pollution.html?pg=all.

[3] www.ecowatch.com/2013/01/04/fugitive-methane-emissions-fracking/.

[4] www.epa.gov/climatechange/EPAactivities/nonco2projections.html.

[5] United States Energy Administration, www.eia.gov/state/print.cfm?sid=UT.

[6] U.S. Energy Information Agency, www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t_5_6a.

capacity, 9.1 Gigawatts of utility-scale wind capacity, and 2.2 Gigawatts of utility-scale geothermal capacity. (1 Gigawatt is enough to light over 5 million homes.)

Of particular significance is the UREZ assessment's finding that a high concentration of solar, wind, and geothermal resources comes together in three southwestern Utah counties (Iron, Beaver, and Millard). Their close proximity would make it feasible to construct shared transmission lines to Utah's heavily-populated Wasatch Front communities. Utah's exceedingly modest carbon emissions rate reduction target does not seem to recognize the relative ease with which Utah could shift investments from dirty to clean energy by the year 2030.

Utah's exceedingly modest carbon emission-rate reduction target also does not seem to recognize how little Utah has done so far to adopt regulatory incentives to shift its electric power generation from dirty to clean sources. Utah is nominally a member of the Western Climate Initiative—a regional organization of states whose purpose is to reduce the causes and mitigate the effects of climate change in the West. It recommends a diverse set of regulatory measures to achieve these goals, almost all of which must be implemented by the Utah state legislature.

The Western Climate Initiative has a diverse list of recommended regulatory steps designed to encourage a shift from dirty to clean energy that the Utah legislature, so far, has refused to take. Utah has no restrictions on greenhouse gas emissions on any timetable, no enforceable Renewal Energy Portfolio standard for electric power or for transportation fuel, no provision allowing utilities to combine heat and power service, no automobile fuel economy standards, and no energy efficiency standards for appliances.[7] The large potential for such regulatory programs to shift investment in power generation from dirty to clean sources, therefore, remains largely untapped.

There are large potential reductions in carbon emissions if Utah were to catch up to its fellow members of the Western Climate Initiative. The Southwest Energy Efficiency Project (SWEEP) has conducted a study that identifies end-user efficiency programs alone that could reduce Utah's electricity consumption by 1.4 Gigawatts (20%) by 2020. Exploiting these opportunities would increase employment by 3,100 jobs by 2020, and save 3.2 billion gallons of water a year. Over the period 2010-2030, it would save $1.7 billion.[8]

If it is economically and technically feasible for Utah to reduce its carbon emissions through end-user efficiency by 20%s by 2020, it would seem that by 2030

---

[7] See Institute for Energy Research summary at www.instituteforenergyresearch.org/media/state-regs/pdf/Utah.pdf .

[8] See Geller, H., *The $20 Billion Bonanza: Best Practice Utility Energy Efficiency Programs and Their Benefits for the Southwest*, Southwest Energy Efficiency Project, 2012, (High Efficiency Scenario). http://swenergy.org/publications/20BBonanza/20B_Bonanza-COMPLETE_REPORT-Web.pdf.

technology would have advanced enough to bring that level to 27%. In other words, it should allow Utah to reach its carbon emission-rate target without further investment in other alternatives to coal—either NGCC or renewables. This suggests that the EPA should take more account of the large potential of end-user efficiencies to quickly reduce Utah's carbon emissions, and use it to set a more ambitious final emissions target for the state of Utah.

The evidence of the nationwide impact of the emission-rate reduction standards in the Clean Power Plan leads to the conclusion that the benefits outweigh the costs by so many orders of magnitude that a more ambitious national goal could be achieved with very little adverse effect on the national economy or employment levels. As will be discussed below, a more ambitious national carbon reduction goal is necessary to keep global warming within the 2°C limit that most nations of the world agreed in Copenhagen is the maximum safe level.

In its Notice of Proposed Rulemaking, the EPA estimated that its Clean Power Plan would reduce CO_2 and other pollutant emissions (SO2, NOx, PM2.5) by 30% with respect to 2005 levels. The EPA estimates that this co-benefit of CO_2 reduction would save from $48 to $84 billion in health-related costs (primarily, the economic value of lives saved). The EPA estimated the cost of complying with the Clean Power Plan would be between $7.3 and $8.8 billion in the year 2030. This, it estimated, would raise electricity prices by 3%. The EPA estimated that the ratio of benefit to cost for the Clean Power Plan ranges from 7:1 to 12:1.[9]

These estimates of the effect of the Clean Power Plan on CO_2 and related emissions, however, are much too low because they look at only part of the benefits of carbon reduction, and they are based on stale data. The most recent data relied on by the EPA is 2010. The Natural Resources Defense Council has data provided since 2010 and updated the EPA estimate. The new data reflects both a sharp drop in the demand for electric power and a sharp drop in the cost of utility-scale wind and solar power. The NRDC has input the new data into the same Integrated Planning Model that the EPA used to generate its initial cost estimates. The updated model's estimate of reduced CO_2 and related emissions for 2030 is 30% *with respect to 2012 levels.* (The EPA's initial estimates use carbon emissions in 2005 as the base point for calculating emission reductions.)

The updated model's estimate is that complying with the Clean Power Plan will save from $28 to $63 billion in health related costs in 2030, due to reduced emissions of ozone precursors and fine particulates. When environmental benefits are added to these health benefits, the savings range from $64 to $99 billion in 2030. The NRDC

---

[9] See Notice of Proposed Rulemaking, *Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units*, June 18, 2014, 79 FR 13726, section X.A.

update also estimates that the Clean Power Plan would *reduce* the annual costs to electric power consumers by between \$6.4 and \$9.4 billion in the year 2030.[10] That translates to an expected *reduction* in consumer's electric bills of 3% in 2030.

The updated cost/benefit analysis strongly suggests that the EPA's national standard for reduced carbon emissions rates will pick only that carbon reduction "fruit" that hangs lowest on the tree. This analysis also indicates that the EPA has plenty of elbow room to adopt more ambitious carbon reduction standards without harming the nation's economy. It is extremely important that the EPA adopt more ambitious standards, because that is the only way that the United States can do its part to achieve the 2°C limit on global warming that the world embraced in 2009 in Copenhagen, and the only way that it can achieve the carbon reductions that it announced jointly with China this November.

On November 12, 2014, the International Energy Agency issued its *World Energy Outlook 2014* report. According to that report, by the year 2040, the world will emit all the carbon it can afford to if global warming is to remain below 2°C—the threshold above which truly dangerous levels of climate disruption set in. Because the effect of carbon in the atmosphere is cumulative, the IEA explains, staying below that threshold requires a hard limit on the amount of carbon that can be sent into the atmosphere. If current plans are adhered to (plans that *include* the Clean Power Plan as proposed, and the carbon restriction goals jointly announced this month by the Obama administration and China), all world carbon emissions would, nevertheless, have to immediately drop to zero after 2040 if global warming is to remain under 2°C. While the IEA expects renewables to grow rapidly to supply one-fourth of world energy by 2040, the other three-fourths of the world's energy will still come from coal, natural gas, and oil--in approximately equal amounts. That, according to IEA, puts us on course for roughly 3.6°C of global warming by 2100.[11]

The IEA notes that because investments in energy infrastructure have long lead times, the sources of energy in use by 2040 will be determined by the investments that are made now. It says that annual investments in sources of renewable energy would have to be boosted to \$ 1 trillion, starting immediately, if the 2°C limit on warming is to be met. This, it says, is four times current annual pace of investment in renewables (\$230 billion). It expects the current pace to remain unchanged through 2040 unless world governments dramatically change their energy policies at the Paris conference

---

[10]See http://www.nrdc.org/air/pollution-standards/.

[11] See summary of the IAE's Word Energy Outlook 2014 report at http://thinkprogress.org/climate/2014/11/17/3593093/iea-report-carbon-budget-2040/. The IEA analysis that current carbon emission agreements put the world on a course that will warm the earth by 3.6°C by the end this century is independently corroborated at http://www.decodedscience.com/china-us-climate-agreement-business-usual/50805.

scheduled in 2015. The IEA observes that it is urgent that investments in energy sources shift immediately from carbon-based to carbon-free if dangerous levels of climate disruption are to be avoided. Id.

The IEA's research demonstrates the urgent need to shift more investment from carbon to non-carbon sources of energy than is currently called for by the governments of the United States, Europe, and China, but its research also shows that such a shift is likely to *increase*, rather than slow, the growth of those economies. In September, a coalition of 340 global investors representing $24 trillion in assets reached a similar conclusion. It issued a statement calling on national governments to institute meaningful and reliable carbon pricing policies in order to help accomplish such a shift in global investment.[12]

A study by the New Climate Economy Project[13] and a working paper from the International Monetary Fund[14] recently corroborated the results of the NRDC's update of the EPA's Integrated Planning Model found. They conclude that because of recent advances in renewable technology and the second-order health benefits of cutting fossil fuel emissions, the choice between a strong economy and a strong response to climate change is a false one. They found that ambitious policies to cut carbon emissions would either have a very small drag on economic growth or lead to faster growth.[15] Recent modeling of an extremely aggressive national carbon tax for the United States found a similar result, even before the health benefits are factored in.[16] A recent assessment of upcoming British policy to cut emissions from its economy reached a similar conclusion.[17]

The costs of a more ambitious national carbon emission-rate standards, according to all of these studies is would be at, or near zero, while the benefits of a more ambitious national standard would be in the hundreds of billions of dollars annually. Our own analysis of benefits that are not considered by these studies is

---

[12] See http://www.unep.org/newscentre/Default.aspx?DocumentID=2796&ArticleID=10984&l=en.

[13] See *New Climate Economy Project*, Global Commission on the Economy and Climate, available at http://newclimateeconomy.report/.

[14] See *Carbon Pricing, Good for You, Good for the Planet*, iMF direct, the International Monetary Fund's Global Economy Forum, available at http://blog-imfdirect.imf.org/2014/09/17/carbon-pricing-good-for-you-good-for-the-planet/.

[15] See Jeff Spross, *Would Limiting Carbon Emission's Destroy the Economy?*, October 16, 2013, at http://thinkprogress.org/climate/2013/10/16/2730271/carbon-regulations-economy/.

[16] Nystrom, S., *The Economic, Climate, Fiscal, Power, and Economic Impact of a National Fee and Dividend Carbon Tax*, REMI/Synapse Energy Economics, June 9, 2014, commissioned by Citizen's Climate Lobby, available at http://citizensclimatelobby.org/wp-content/uploads/2014/06/REMI-carbon-tax-report-62141.pdf.

[17] Cambridge Economics (Pollitt, H. et al.), *The Economics of Climate Change Policy in the UK: An Analysis of the Impact of Low Carbon Policies on Households, Businesses, and the Macro Economy*, 10 September, 2014, available at http://www.camecon.com/Libraries/Downloadable_Files/WWF_Final_Report_1.sflb.ashx.

presented toward the end of this section. There, we conclude that the annual benefits of a more ambitious national standard for reduced carbon emissions could exceed $1 trillion by 2030 if the labor productivity gains from reducing the future workforce's exposure to neurotoxins is fully accounted for.

B. A More Complete Modelling of the Clean Power Program's Economic Impacts Shows That they Would Be Enormously Positive

The opponents of the EPA's Clean Power Plan rest their opposition on the premise that energy obtained from burning carbon is a boon to the economy because it is modestly cheaper than carbon-free alternatives. Energy obtained by burning carbon, however, is "cheap" relative to renewable forms of energy only when most of the costs of carbon-based energy are left out of the price of that energy.

By insisting that the price of carbon-based power reflect only a small part of its costs, goods that are lower in economic value on a per-unit basis (those produced with relatively more dirty energy) are overproduced and goods that are higher in economic value on a per-unit basis (goods produced with relatively less dirty energy) are underproduced. Labor and other resources are diverted from producing more valuable goods to producing less valuable goods. Maintaining a price for carbon-based power that badly understates its true cost makes the nation's economy inefficient, and reduces its overall level of employment.

If the price of a product does not reflect both its direct and social costs, economic efficiency is sacrificed. If the social costs that are left out of the sale price are large relative to the direct costs, the sale price misrepresents the product's total cost. If the product is an important part of the overall economy, this sale price will cause large inefficiencies in the way society allocates its resources. That is the case with electric power obtained from fossil fuel.

While coal-fired power plants provide the direct benefit of slightly cheaper power than clean alternatives (a premise that will remain valid for only the next two or three years), the indirect costs of such costs are staggering. This is because coal-fired power plants are essentially enormous toxin factories—an economic reality that has yet to be reflected in the price the power that they produce.

Burning coal produces airborne compounds, known as fly ash and bottom ash (collectively referred to as coal ash), which can contain large quantities of heavy metals that settle or wash out of the atmosphere into oceans, streams, and land. In 2012, coal plants in the United States produced over 75 million short tons of coal ash, 70% of which was disposed on in landfill.[18]

In 2010, utilities in the United States burned 1.05 billion tons of coal.[19] This coal contains 109 tons of mercury, 7884 tons of arsenic, 1167 tons of beryllium, 750 tons of cadmium, 8810 tons of chromium, 9339 tons of nickel, and 2587 tons of selenium.[20] On top of emitting 1.9 billion tons of carbon dioxide each year, coal-fired power plants in the United States also create 120 million tons of toxic waste. That means each of the nation's 600 coal-fired power plants produces an average 240,000 tons of toxic waste each year. A power plant that operates for 40 years will leave behind 9.6 million tons of toxic waste. This coal combustion waste (CCW) constitutes the nation's second largest waste stream, after municipal solid waste.[21]

When coal is burned, toxins in the coal are released into the smokestack. If modern air pollution controls are in place, airborne toxins are captured through filtration systems before they can become airborne. The captured toxins end up in coal ash. As a result, heavy metals such as mercury are concentrated in what the EPA considers "recycled air pollution control residue." This only delays the exposure of the public to these toxins. The EPA concedes that all coal ash landfills eventually leak, and there is no Federal regulation of coal ash landfills in place. Rain falling on ash piles leaches out these heavy metal compounds, which eventually end up in ground water, or in lakes and streams, contaminating drinking water sources.

Only by ignoring its enormous health and environmental impacts can coal-fired power be considered a “low-cost” energy source, the use of which promotes economic efficiency and job creation. Failing to reflect all of the cost of a product in the product’s sale price misallocates resources. If society, through a tax or a regulation, shifts a dollar of spending away from a product that is less valuable to society to a product that is more valuable to society (on a unit basis) it creates more jobs than it “kills.” These comments provide evidence that, depending on how many of the product’s indirect costs are accounted for, a kilowatt/hour obtained from coal is actually worth from one-half to one-one tenth as much to society as a kilowatt/hour obtained from a non-polluting source.

There are over 3,500 peer-reviewed scientific studies that document the harm to public health from air pollution, especially in urban environments in developed economies.[22] Fossil fuel combustion is responsible for the vast majority of air pollution

---

[18] See epa.gov/epawaste/conserve/tools/warm/pdfs/Fly_Ash.pdf.
[19] U.S. Coal Supply and Demand: 2010 Year in Review. Eia.gov (2011-06-01).
[20] http://www.precaution.org/lib/laid_to_waste.000601.pdf., p. 2.
[21] See http://www.precaution.org/lib/08/prn_is_coal_green.081106.htm.
[22] See, e.g., D’Amato, G., et al., Urban Air Pollution and Climate Change as Environmental Risk Factors of Respiratory Allergy: An Update, J. Investig. Allegol. Clin. Immunol., 2010, Vol. 20(2): 95-102.

in developed countries.[23] Air pollution has been found to damage every major organ system in the human body. These studies have caused the World Health Organization to conclude that air pollution is the most important environmental cause of cancer, more important than second-hand cigarette smoke. These studies show that the risk to public health from burning fossil fuel is comparable to the risk from exposure to second-hand cigarette smoke. http://www.usatoday.com/story/news/world/2013/10/17/cancer-air-pollution-carcinogens/3002239/.

Cigarette smoke contains 69 known carcinogens. Coal-fired power plant emissions contain 67 known carcinogens or neurotoxins[24]—many of the same ones found in cigarette smoke. Cigarette smoke and power-plant emissions both contain

- Fine particulate matter (PM2.5)
- Carbon monoxide
- Ozone precursors
- Volatile Organic Compounds (VOCs), such as benzene, toluene, and formaldehyde;
- Acid gases, such as hydrogen chloride and hydrogen fluoride;
- Dioxins and furans;
- Lead, arsenic, and other toxic heavy metals;
- Mercury;
- Polycyclic Aromatic Hydrocarbons (PAH); and
- Thorium, Uranium, Polonium and other radioactive metals

The harm to public health that second-hand cigarette smoke and fossil fuel emissions pose are remarkably similar with the difference being primarily quantitative, not qualitative. A typical life-long smoker will shorten his life by ten years. The American Lung Association reports that the typical urban dweller in the United States is exposed to enough airborne particulate fine particulate matter to shorten his life by one-

[23] Emissions from the burning of fossil fuels come directly from the production of electric power and domestic heat, or indirectly in mining, construction, or transportation activity. Several natural processes contribute to air pollution including forest fires, volcanic eruptions, windstorms, and turpene emissions from conifers. The extent and damage from these natural sources, however, is a minute portion of the air pollution emitted by manmade activities. www.eoearth.org/view/article/149931/.

[24] U.S. Environmental Protection Agency, Study of Hazardous Air Pollutant Emissions from Electric Utility Steam Generating Units – Final Report to Congress, February, 1998. 453/R-98-004a.

to-three years.[25] Nearly all of that exposure is due to pollution from the burning of fossil fuels. This shortened life span of a typical urban dweller is just the effect of his exposure to fine particulate pollution. Exposure to other components of air pollution caused by burning fossil fuels--such as ozone and Hazardous Air Pollutants (HAPs)--causes further shortens his life.

One major difference between second-hand cigarette smoke and fossil fuel emissions is that second-hand smoke is localized. One can usually escape second-hand smoke and its effects by leaving the building where the smoke is generated. Fossil fuel emissions permeate entire air sheds of most urbanized regions of the country. The largest single source of fossil fuel emissions is coal-fired power plants. To escape fossil fuel pollution, one would have to find a region without coal-fired power plants or concentrated automobile traffic. Air quality maps show that most regional air sheds in the United States are moderately or heavily polluted—almost entirely the result of burning fossil fuels.

1. Clean Air Standards Have Yet to Catch Up to the Science

Up to now, the approach that Federal and state governments have taken to regulating fossil fuel emissions has been based on an assumption that the harm from these pollutants at concentration levels commonly experienced is minor, and is a small price to pay for a healthy economy. This reflects a precept that has been central to the science of toxicology--that “the poison is in the dose.”

This precept assumes that most poisons, including those in ambient air, are harmless below a certain threshold concentration, and the public policy task is to find that threshold and keep the poisonous substance below it. This precept, however, has been shown to be false by a wealth of more recent studies that show that the principal fossil fuel pollutants (lead, mercury, fine particulates, and ozone) harm human health at every level of concentration.

In a major survey of recent research,[26] the World Health Organization concluded:

> The potential for serious consequences of exposure to high levels of ambient air pollution was made clear in the mid-20th century, when cities in Europe and the United States experienced episodes of air pollution, such as the infamous London Fog of 1952 and Donora Smog of 1948, that resulted in large numbers of excess deaths and hospital admissions. Subsequent clean air legislation and other regulatory actions

---

[25] Pope, C.A. III, Epidemiology of fine particulate air pollution and human health: biologic mechanisms and who's at risk?, Environ Health Perspect. Aug 2000; 108(Suppl 4): 713–723.

[26] *Comparative Quantification of Health Risks: Global and Regional Burden of Diseases Attributable to Risk Factors*., Ezzati, M., Lopez, A.D., Rodgers, A., Murray, C.J.L., Eds., World Health Organization Press (2204), Ch. 17, Urban Air Pollution, 1355.

> led to the reduction of ambient air pollution in many regions of the world, and particularly in the wealthy developed countries of North America and Europe. New epidemiological studies, however, conducted over the last decade, using sensitive designs and methods of analysis, have identified adverse health effects caused by combustion-derived air pollution even at the low ambient concentrations that now generally prevail in cities in North America and western Europe (Health Effects Institute 2001).

If fact, many studies show that these pollutants not only cause significant damage at very low concentrations, but that the damage is proportionally the greatest (on a parts per billion basis) at the lowest concentrations. Just as the first five cigarettes have been found to do more damage to the lung, per cigarette smoked, than the next 15, the relationship between concentrations of such pollutants as fine particulates and their impact on health shows a similar non-linear curve, i.e. further reductions in atmospheric levels have even more public health benefit when levels are comparatively low than when they are high.[27]

The U.S. Center for Disease Control ranks toxic heavy metals as the number one environmental health threat to children.[28] Recent research on the effects of lead pollution, for example, invalidates the notion that exposure to lead is safe below a particular threshold concentration.

Human activity has increased the concentration of lead in the environment more than 1,000-fold over the past three centuries. This reflects the fact that lead does not break down, so its concentration in the environment continually increases.[29] A typical coal-fired power plant without pollution controls emits 114 pounds of lead each year. http://www.ucsusa.org/clean_energy/coalvswind/c02c.html#.VG4Z3YvF-H4. Lead pollution from power plants enters the environment by several pathways. It begins as vapor, is deposited in the soil, leaches into streams, lakes, and aquifers, and ends up in drinking water and food supplies.

Lead is a powerful neurotoxin. At levels that currently prevail in developed countries, it causes substantial harm to public health. In the United States, for example, until very recently the Center for Disease Control defined an "elevated" lead blood level (the level assumed to require additional pollution controls and/or medical intervention) as 10.0 micrograms per deciliter.[30]

---

[27] Peters, A., *Air Quality and Cardiovascular Health: Smoke and Pollution Matter*. Circulation. 2009: 120:924-927.
[28] ATSDRA/EPA Priority List for 2005: Top Hazardous Substances. Agency for Toxic Substances and Disease Registry, U.S. Department of Health and Human Services, www.atsdr.cdc.gov/clist.html.
[29] http://www.atsdr.cdc.gov/PHS/PHS.asp?id=92&tid=22.
[30] www.cdc.gov/mmwr/preview/mmwrhtml/mm5420a5.htm.

Recent research indicates that the 10.0 µg/dL tolerance level of lead exposure is too high by a factor of 50. Acknowledging the findings of more recent research, the CDC conceded in 2012 that there is no blood lead level that is small enough to be considered "safe." At that time, the CDC cut its tolerance level for blood-level lead from 10.0 µg/dL to 5.0 µg/dL (rather than zero) without a clear explanation of the basis for the new tolerance level.[31] Even CDC's current tolerance level of 5.0 µg/dL is 25 times too high, according to the most recent research.[32]

An example of the current research on the toxicity of lead is provided by a major study of the relationship between lead exposure levels and reduced intellectual capacity was completed in Italy in 2012.[33] The study found that the I.Q. of Italian teenagers is reduced in proportion to their lead exposure, no matter how small their lead exposure is. Specifically, the study demonstrated that every 0.19 micrograms per deciliter in an adolescent's blood is accompanied by a one-point reduction in his/her I.Q.

According to this study, the I.Q. of Italian adolescents has been reduced by 9 points on average, given their average blood serum lead level of 1.71 micrograms. The most recent blood lead level data available for the United States focuses on the 1-5 year-old age group. For the years 2007-2010, their average blood lead level was 1.3 µg/dL. Id. The Italian study results imply that the I.Q. of preschoolers in the United States has been reduced by 7 points, on average, due to their exposure to lead pollution.

It is estimated that average blood lead levels are 50 times higher than natural lead levels were before the industrial revolution.[34] In the United States, as in Italy, lead exposure has historically had three main sources: lead paint, leaded gasoline, and coal-fired power plants. Lead exposure from paint and gasoline has largely been brought under control. Coal-burning power plants are now the primary source of lead exposure for young children in most of the United States. The loss of intellectual capacity from unnecessary exposure to lead in the United States (and in the rest of the developed world that relies on coal to generate power) is not only a personal and social tragedy, it

---

[31] See www.cdc.gov/mmwr/preview/mmwrhtml/mm6213a3.htm.
[32] It is important to note that the EPA's current National Ambient Air Quality Standard (NAAQS) for lead [0.15 µg/m³] was adopted in 2008. Because it has yet to be reconciled with the current research, the EPA's NAAQS for lead pollution that is now in effect still reflects the CDC's now-abandoned (and exceedingly lax) blood-lead tolerance level of 10.0 µg/dL.
[33] Lucchini, R.G., et al., Inverse Association of Intellectual Function with Very Low Blood Level Lead but Not With Manganese Exposure in Italian Adolescents, Environ Res. Oct 2012; 118: 65–71. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3477579/.
[34] Flegal A.R., Smith D.R., N Engl J Med. 1992 May 7; 326(19):1293-4.

has caused a drastic reduction in the productivity of the workforce in the economies of countries that obtain their energy primarily from burning coal.[35]

The harm to public health from lead pollution from coal-fired power plants, however, is modest compared to the harm that they cause through mercury pollution. Estimates of the amount of mercury in the environment that is generated by human activity range from 70 to 96%. The World Health Organization estimates that total world-wide mercury emissions have tripled as a result of the industrial revolution. The single largest source of environmental exposure to mercury in the United States (65%) is from coal-fired power plants.[36]

A typical coal-fired power plant without modern pollution controls emits 170 pounds of mercury each year. In 2009, coal-fired power plants in the United States injected 134,365 pounds (more than 67 tons) of mercury into our environment. Ninety percent of this mercury could be removed by using activated carbon injection (ACI) technology combined with baghouses. As of 2011, however, only 8% percent of coal-fired power plants were equipped with this technology.[37]

When coal is burned by a power plant without controls, mercury is released into the air and settles onto bodies of water where it is converted to its organic form (methylmercury). Methylmercury accumulates in the tissue of fish and shell fish. Eating fish is the main source of methyl mercury exposure for most of the population.

Methylmercury is the most powerful non-radioactive neurotoxin in nature. It is many times more toxic than lead. This is confirmed by a recent study conducted at the University of Calgary medical school. In the study, brain neurons were exposed in vitro to a series of metals that were known or suspected neurotoxins. At concentrations so small that neither lead, cadmium, aluminum, nor manganese affected neuron integrity, methylmercury caused 77% of exposed neuron endings to disintegrate.[38]

---

[35] Baghouse technologies for eliminating most of this aerosol lead are effective and readily available, but are not widely implemented. Wider adoption of this technology will be a major indirect benefit of implementing the Clean Power Plan.

[36] AMAP/UNEP, Technical Background Report for the Global Mercury Assessment 2013, Artic Monitoring and Assessment Program, Oslo Norway, at 3-4. The main sources of man-caused mercury pollution are the proliferation of coal-fired power plants, the use of mercury in small-scale, low-technology (and typically illegal) gold and silver mining in less developed countries, and the use of lead in dental amalgum. See also www.psr.org/assets/pdfs/coal-fired-power-plants.pdf.

[37] U.S. Environmental Protection Agency, TRI Explorer: Releases: Trends Reports, 28 October 2010. http://www.epa.gov/cgibin/broker?view=USYR&trilib=TRIQ0&sort=_VIEW_&sort_fmt=1&state=All+states&county=All+counties&chemical=N458&industry=2211&year=All+years&core_year=&tab_rpt=1&_service=oiaa&_program=xp_tri.sasmacr.tristart.macro.

[38] Leong, C.C., Syed, N.I., Lorscheider, F.L., *Retrograde Degeneration of Neurite Membrane Structural Integrity of Nerve Growth Cones Following In Vitro Exposure to Mercury*, Neuroreport, 2001 Mar 26; 12(4):733-7.

According to the World Health Organization, exposure to methylmercury damages not just the nervous system, but the digestive, respiratory, and immune systems as well. It causes intellectual impairment during fetal development and childhood, attention deficit disorder, impaired vision and hearing, tremors, paralysis, insomnia, and emotional instability.[39] In adults, mercury poisoning closely mimics the symptoms of Alzheimer's.[40] The World Health Organization observes that "mercury may have no threshold below which some adverse effects do not occur." Id.

As an indication of its potency, just 1/70th of a teaspoon of mercury deposited in a 25-acre lake can make all of the fish in that lake unsafe to eat or a year.[41] It is estimated that over 6 million acres of lakes, reservoirs, and ponds in the United States have unsafe concentrations of mercury.[42] In 47 of the 50 states, wild fish cannot be eaten because their methyl mercury exceeds safe levels.[43]

Human fetuses five to ten times more vulnerable than adults to the brain-addling powers of methyl mercury. There are two reasons: they typically receive a 70% greater exposure to mercury than the mother (because of the placenta's concentrating action), and their brain cells need to move from the center of the brain to the surface before they multiply. Methylmercury paralyzes brain cells, blocking this movement and multiplication.[44]

In the United States, one in six mothers of childbearing age has enough mercury in her blood to put her fetus at risk of intellectual impairment. Id. This implies that 689,000 of the 4.1 million babies born every year are at risk of reduced mental capacity as a result of mercury exposure.[45] The estimate that one in six mothers of childbearing age have blood lead levels that are unsafe for a fetus, however, is almost certainly understated because it is based on the EPA's definition of a safe blood level of 0.58

---

[39] World Health Organization, *Mercury in Health Care*, Geneva, Switzerland, August 2005: 1. http://www.whoint/water_sanitation¬_health/medicalwaste/mercurypolpaper.pdf

[40] Mutter J., Curth A., Naumann J., Deth R., Walach H., *Does inorganic mercury play a role in Alzheimer's disease? A systematic review and an integrated molecular mechanism*, J Alzheimers Dis. 2010;22(2):357-74. doi: 10.3233/JAD-2010-100705.

[41] J.G. Weiner et al, *Partitioning and Bioavailability of Mercury in an Experimentally Acidified Wisconsin Lake,* Environmental Toxicology and Chemistry, 1990.

[42] U.S. Environmental Protection Agency, *Watershed Assessment, Tracking, & Environmental Results*, 28 December 2010. http://iaspub.epa.gov/waters10/attains_nation_cy.control?p_report_type=T#tmdl_by_pollutant.

[43] www.ucsusa.org/clean_energy/coalvswind/c02c.html#.VHQPMfRDuSq.

[44]Kathryn Mahaffey, Robert P. Cliffner, and Catherine Bodurow, *Blood Organic Mercury and Dietary Mercury Intake: National Health and Nutrition Examination Survey, 1999 and 2000*, Environmental Health Perspectives, 112(5): 562-570, april 2004; Kathryn R. Mahaffey, U.S. EPA, "Methylmercury Epidemiology Update," Slide #9 of presentation given at the National Forum on Contaminants in Fish, San
Diego, January 2004.

[45] National Center for Health Statistics. National Vital Statistics Reports, Vol. 58, No. 25. *Births, Marriages, Divorces, and Deaths: Provisional Data for 2009.* Aug. 27, 2010, pg. 1.

micrograms per deciliter. This is higher than the EPA's definition of a safe blood level of lead [0.5 μg/dL]. The recent research described above, however, strongly implies that the neurotoxicity of methylmercury is much higher than that of lead and other toxic metals, and, therefore, the definition of a safe blood level of methylmercury (if there were one) should be well below that of lead and other toxic metals.

There is evidence that the neurotoxic effects of methylmercury in the presence of other heavy metals in blood and tissues is not merely additive, but is synergistic, amplifying the neurotoxic effects of those metals.[46] Child development experts have recently been warning of an increasing chemical and metal brain toxicity causing a silent, global pandemic of a wide spectrum neurobehavioral disorders and intellectual compromise in children.[47]

The rapid proliferation of neurotoxins that children are exposed to, and the likelihood that they act synergistically, provide a powerful argument for the Federal government to become more aggressive in controlling exposure. At the top of the list of known neurotoxins that are contributing to this tragic trend are lead, mercury and arsenic--the most potent toxins in coal power plant emissions.

While overall exposure to some neurotoxins like lead has decreased in recent years for a variety of reasons having nothing to do with reduced coal power plant emissions, mercury exposure has increased. A study showed that 30% of women had detectable levels of mercury in 2006, compared to only 2% in 2000.[48]

Mercury is also implicated as a cause of Alzheimer'sDisease. A recent meta-analysis reviewing 1,041 studies clearly showed a strong relationship between this increasingly common neurodegenerative disease and mercury exposure.[49] Research shows that Alzheimer's was the underlying cause in 500,000 deaths in the United States in 2010. This represents a 68% increase from 2000.[50] More money is spent on Alzheimer's patients than on any other disease. Care for Alzheimer patients is costing the nation about $200 billion, a figure which does not reflect the costs of lost productivity, nor the emotional and financial burden of the "free care" family members provide. If the rapid growth of Alzheimer's continues, it has the potential to bankrupt the nation's health care system.

---

[46] Schubert J, Riley EJ, Tyler SA., *Combined effects in toxicology. A rapid systematic testing procedure: cadmium, mercury, and lead.* Toxicol Environ Health 1978;4(5/6):763-776.
[47] Grandjean P, Landdrigan P., *Neurobehavioural effects of developmental toxicity*. The Lancet Neurology, Volume 13, Issue 3, Pages 330 - 338, March 2014. doi:10.1016/S1474-4422(13)70278-3.
[48] Laks, D., *Assessment of chronic mercury exposure within the US population*, National Health and Nutrition Examination Survey. Biometals (2009) 22:1103=1114, DOI 10.1007/s10534-009-9261-0.
[49] Mutter J, et al., *Does inorganic mercury play a role in Alzheimer's disease? A systematic review and an integrated molecular mechanism*. J Alzheimers Dis. 2010;22(2):357-74. doi: 10.3233/JAD-2010-100705.
[50] http://www.alz.org/alzheimers_disease_facts_and_figures.asp#cost.

2. Accounting for the Combined Effect of Exposure to Methylmercury and Lead on Intellectual Capacity and Workforce Productivity

What the combined effect of exposure to methylmercury and lead is on the public's intellectual capacity is a crucial question. Not knowing precisely how much more toxic to the nervous system methylmercury is than lead, or how synergistic it is with lead, one could adopt the very conservative hypothesis that the neurotoxicity of methylmercury is merely additive to that of lead. Under this conservative hypothesis, to account for the combined impact of currently prevailing blood levels of both methylmercury and lead on the intellectual capacity of the preschool population, one would have to double the effect on I.Q. of lead alone. The necessary conclusion is that, on average, preschool children in the United States have had their intellectual capacity reduced not just by 7 I.Q. points from their exposure to lead, but by another 7 points from their exposure to methylmercury, for a combined reduction of 2 x 7 = 14 I.Q. points.

A standard deviation of I.Q. is 15 points. If the next generation of American workers were to be spared from both methylmercury and lead exposure, their average I.Q. could be expected to be a standard deviation higher. Reducing intellectual capacity by a full standard deviation, either in a positive or negative direction, transforms the intellectual capacity of a population. National average I.Q. has a strong correlation with GDP per worker. Research suggests that while an increase of 1 standard deviation results in a 15% increase in average wages, it results in national productivity increases of approximately 150%, due to a multitude of external effects of intellectual capacity on productivity.[51]

The loss of intellectual capacity from the unnecessary exposure of America's children to methylmercury and lead pollution is a personal and social tragedy. Recent epidemiological and macroeconomic studies imply that this loss of intellectual capacity is drastically reducing the productivity of the Nation's workforce. A major co-benefit of the Administration's Clean Power Plan is that it requires states to substantially reduce the level of exposure of their workforce to methyl mercury and lead pollution as an indirect effect of reducing the amount of coal burned to generate electricity or improving the efficiency of the coal burning process.

As noted earlier, the EPA's Notice of Proposed Rulemaking estimates that its Clean Power Plan would reduce CO_2 and other pollutant emissions (SO_2, NO_x, $PM_{2.5}$) by 30% in 2030 relative to 2005 levels. This, it estimates will have compliance costs by 2030 of between \$7.3 and \$8.8 billion annually, but benefits of from \$48 to \$84 billion in

---

[51] See, e.g., research summarized in Jones, G., *National I.Q. and National Productivity: the Hive Mind Across Asia*, Asian Development Review, June 2011.

health-related costs saved by reducing exposure to the pollutants referred to above.[52] And, as noted, putting fresh data into the EPA's Integrated Planning Model yields a revised estimate that compliance with the Clean Power Plan would reduce CO_2 and related emissions for 2030 by 30% with respect to 2012 levels, reduce the annual costs to electric power to consumers by between $6.4 and $9.4 billion, and yield health and environmental benefits of from $64 to $99 billion due to the reduction in SO_2, NO_x, $PM_{2.5}$ emissions.[53]

On the other hand, if the Clean Power Plan is not adopted, and coal-fired power plants are allowed to continue to inject neurotoxins into the environment at the current pace, the productivity of those entering the nation's workforce could be held to half what it would otherwise be. A rough estimate of the reduction in GDP from lost productivity due to intellectual impairment from exposure to lead and methylmercury should begin with an annual measure of total labor output as a reflection of the value of what labor has produced. Total annual wages earned is a very conservative proxy for total labor output (because it excludes benefits, which are between one-fourth and one-third of wages, on average). In 2013, total wages earned were slightly over $6 trillion.[54]

The next step in the analysis is to estimate lost workforce productivity due to exposure to methylmercury and lead. This can be done in a crude way by holding total workhours constant while increasing labor productivity by 150%. This is the arithmetic: $6 trillion x 1.5 = $9 trillion. The implication of the Italian study is that the intellectual capacity of America's future workforce could be a full standard deviation higher, and its workforce's annual production would increase by $9 trillion, if its future workforce were spared all exposure to just two neurotoxins—methyl mercury and lead.

To find the contribution of the Clean Power Plan toward realizing this potential $9 trillion gain in annual labor productivity, one must estimate how much the Clean Power Plan would reduce the future labor force's exposure to methylmercury and lead. The updated estimate of the reduction in CO_2 and related emissions for 2030 recently published by the NRDC is 30% with respect to 2012 levels. Assuming that mercury and lead emissions from power plants scale down in proportion to reductions in CO_2 emissions, the Clean Power Plan, would be responsible for a 30% reduction in those emissions.

---

[52] See Notice of Proposed Rulemaking, *Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units*, June 18, 2014, 79 FR 13726, Section X. A.
[53] http://www.nrdc.org/air/pollution-standards/.
[54] Total wages earned in 2013 is calculated as product of the mean annual wage of $46,440 and total employment of 132,588,810. See United States Bureau of Labor Statistics News Release USDL-14-0528, Table 1, line 1. www.bls.gov/news.release/pdf/ocwage.pdf.

Since coal-fired power plants produce only of 39% of total CO_2 emissions in the United States,[55] an estimate of the Clean Power Plan's likely impact on the exposure of the workforce to both methylmercury and lead (30%) itself needs to be reduced by 39%. (This adjustment is conservative. The CO_2 emissions that come from coal-fired power plants are proportionately higher in lead and mercury than the remaining sources of CO_2 emissions, e.g., transportation, which is the next largest source of CO_2 emissions.)

To estimate the increase in labor productivity that the Clean Power Plan could be expected to achieve, therefore, it would be necessary to multiply the roughly $9 trillion in higher labor output that would result from the elimination of all mercury and lead exposure by 0.3 x 0.39 = 0.117. Multiplying an annual productivity gain of $9 trillion attributable to the workforce's improved intellectual capacity by 0.117 yields an estimated increase in annual economic output of $9 trillion x 0.117 = $1.053 trillion. This increase in annual economic output would be due solely to the Clean Power Plan's reduction of the public's exposure to neurotoxins.

The $1.053 trillion figure represents the estimated annual productivity increase from reduced exposure to mercury and lead if the reduction were to occur in 2014. The Clean Power Plan's effects, however, won't be fully realized until 2030. Therefore, the $1.053 trillion figure should be adjusted to reflect its net present value. At an assumed interest rate of 2.3%, compounded annually, its net present value would be $732 billion.

Assuming the validity of the NRDC's updated model results, the Clean Power Plan cost/benefit analysis for the year 2030 should show (in billions):

Reduction in cost of electricity to consumers	--	$6.4	to	$9.4[56]
Health and environmental benefits	--	$64.0	to	$99.0[57]
		$70.4	to	$108.4
Increased productivity from reduced neurotoxin exposure	--	$732.0	to	$732.0
		$802.4	to	$840.4

---

[55] www.epa.gov/climatechange/ghgemissions/sources/electricity.html.
[56] Reported in http://switchboard.nrdc.org/blogs/ddoniger/epas_plan_to_curb_carbon_pollu.html.
[57] Id.

The likely net economic benefits of implementing the Clean Power Plan are impressive enough even without factoring in the expected workforce productivity gains from reduced exposure to neurotoxins. When that effect is included, the net economic benefits are so great that it strongly implies the EPA's emission reduction goals should be substantially more ambitious because of the overwhelming external benefits that they could capture.

On a general level, the estimates by the EPA and the NRDC that implementing the Clean Power Plan would have a positive benefit/cost ratio are corroborated by a number of other studies that find reducing coal emissions would have external benefits that are far greater than the price of coal.

The EPA conservatively estimates that the health care costs imposed on society as a whole from burning a ton of coal (which it calls the Social Costs of Carbon) would be $43 in 2020 ($36 on a present value basis at 3%).[58] An alternative Social Cost of Carbon estimate based on middle-of-the-road assumptions is that the SCC of coal would be $62 in 2020 ($55 on a present value basis at 2%).[59] The average price of a short ton of coal delivered to the electric power industry in 2012 was $45.77.[60] The future value of $45.77 in 2020 at 2.3% interest is $52.46. These Social Cost of Carbon estimates indicate that the price of coal in 2020 would need to increase by from 82% to 105% if it were to cover its social costs.

A study by the faculty of Harvard Medical School published in 2011 compiled a more comprehensive estimate of the social costs incurred in the United States annually by using coal to generate electric power. The study noted that each stage in the life cycle of coal—extraction, transport, processing, and combustion—generates a waste stream and carries multiple hazards for health and the environment. These costs are not imposed on the coal industry, but on the rest of society. It estimates that the life cycle effects of coal and the waste stream generated are costing the American public from one-third to over one-half of a trillion dollars annually. The costs of complying with the proposed state CO_2 standards for existing power plants (if there are any positive costs at all) proposed in the Clean Power Plan are utterly trivial in comparison to the more comprehensively analyzed social costs of coal-based energy developed by the Harvard study.

The Harvard study monetized damages due to climate change that include public health damages from NO_x, SO_2, $PM_{2.5}$, and mercury emissions; fatalities of members of

---

[58] Technical Support Document, *Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866*, available at: http://www.whitehouse.gov/sites/default/files/omb/assets/inforeg/technical-update-social-cost-of-carbon-for-regulator-impact-analysis.pdf.

[59] See L.Johnson and C.Hope, *The Social Cost of Carbon in U.S. Regulatory Impact Analyses: an Introduction and Critique*, Journal of Environmental Studies and Sciences (September 2012).

[60]

the public due to rail accidents during coal transport; the public health burden in Appalachia associated with coal mining; government subsidies; and the lost value of mined land after it has been abandoned. The estimate is conservative in that it does not account for damages outside of Appalachia, nor does it account for unquantifiable costs, such as the cost to a family of losing a wage earner due to black lung disease. It notes that many of these so-called externalities are, moreover, cumulative.[61]

The Harvard study conservatively estimates that if the external costs of coal were accounted for, they would double or triple the price of coal. If electricity produced from burning coal were priced to cover its social cost, the price would go up by 9—27 cents per kilowatt. Although the EPA's proposed Clean Power Plan would not tax carbon, it would achieve the same economic efficiencies by regulatory means. On a dollar-for-dollar and kilowatt/hour-for-kilowatt/hour basis, it will shift investment from carbon-based forms of energy that have high social costs to investments in forms of energy with much lower social costs (conservation and renewables). This will increase economic efficiency and boost total economic output and employment.

II. IMPACTS OF RISING CO_2 ON THE WESTERN UNITED STATES

A. Great Basin Climate Change in the Fossil Record

The Great Basin is North America's largest desert, encompassing 135 million acres of land between the Rocky and Sierra Nevada Mountains. As Figure 1 shows, it includes parts of Nevada, Utah, Idaho, Oregon, and California.

Figure 1

[61] Epstein, et al., *Full Cost Accounting for the Life Cycle of Coal* Issue: Ecological Economics Reviews; doi: 10.1111/j.1749-6632.2010.05890.x; Ann. N.Y. Acad. Sci. 1219 (2011) 73–98 c 2011.

Its climate is arid. Over half of the area receives less than 12 inches of annual precipitation. Its climate has fluctuated widely both on a relatively short and long time frame. It can experience extremes in precipitation in which an occasional wet year can be followed by several years of droughts and high temperatures.

National Forest Service scientists maintain that to understand what abrupt climate change is currently doing to the Great Basin ecosystem, it is necessary to understand what impacts more gradual climate change has had in the past. They describe that history briefly. See Humboldt-Toiyabe National Forest Climate Change Vulnerability Report, available at http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5294901.pdf./

At the end of the Pleistocene epoch (11,000 years ago) the Great Basin was emerging from the most recent ice age. Its climate was cool and moist. Lakes, marshes, and rivers were abundant in valley bottoms. Sagebrush, perennial grasses and forbs (such as clover) were the dominant vegetation. Biodiversity was relatively high. Juniper and Pinyon Pine were relatively rare. Fir, spruce, and pine were more abundant than now, growing at elevations 3,000 to 6,000 lower than at present.

During the Holocene Drought (2,500 to 550 years ago), the temperature rose. Winters became mild and short. What precipitation there was fell mostly in the spring and summer. Wildfires increased. The increased heat, drought, and fire, removed much of the sagebrush/perennial grass vegetative cover. As a result, soils were stripped from the hillsides and deposited on valley floors and on side-valley alluvial fans. Streams became heavily sedimented, and streambeds had a natural tendency to incise and erode, rather than recharge groundwater. This caused a lowering of water tables.

The Holocene Drought ended with the Holocene Little Ice Age (550 to 160 years ago) when a cooler, wetter climate allowed the sagebrush/perenial grass ecosystem to recover, and the Great Basin ecosystem to heal. This process lasted until 160 years ago, when it was interrupted by two severe disturbances--man started intense grazing, mining, and logging activity, and the climate began a rapid warming trend. Now, patterns of soil erosion and stream incision reminiscent of the Holocene Drought have resumed, but is occurring much more rapidly.

B. Evidence That Current Climate Change is Abrupt

In the last 100 years, the Great Basin has warmed by 1 to 3°F and is projected to warm another 3.6 to 9°F by the end of the century. (Chambers and Pellant, 2008, pp. 29-33.) Since about 1980, winter temperatures in the western U.S. have been consistently above the historical average, and winter snow packs have declined. Periods of slightly higher than average precipitation have partly offset the effects of declining snow packs. (McCabe and Wolock, 2009.)

This pattern is consistent with general climate trends. Across the globe, winter temperatures are rising more rapidly than summer temperatures, particularly in the northern hemisphere, and there has been an increase in the length of the frost-free period in mid- and high-latitude regions of both hemispheres. (Loehman, R., 2010.)

Eighty-five percent of the water available in the Great Basin for human use comes from snowmelt. (Loehman, R., 2010). The onset of snow runoff in the Great Basin is currently 10–15 days earlier than 50 years ago, with significant impacts on the downstream utilization of this water. (Ryan, M., et al., 2008, p. 362). Annual precipitation increased slightly. (Chambers and Pellant, Id.). Future precipitation is the most difficult to predict with existing Global Circulation Models. However, higher temperatures are predicted, which will increase evapotranspiration. The Palmer Drought Index, which measures the deficit of water compared to the needs of natural systems, is expected to increase as the region becomes more arid. (Chambers, J., 2011).

Since 1986, the length of the active wildfire season has increased by 78 days and the average burn duration of large fires has increased from 7.5 days to 37.1 days. Forest wildfire frequency is nearly four times higher and the total area burned by these fires is more than six and a half times its previous levels. (Westerling, A., 2008). In 1999, a consortium of organizations led by The Nature Conservancy identified the Great Basin as the third most endangered ecosystem in the United States. It described native sagebrush and perennial grasses, weakened by heat, drought, and overgrazing, succumbing to juniper, Pinyon Pine, and exotic annuals and weeds. These replacement plant communities are more fire-prone, shallow-rooted, and less able to hold the soil in the face of floods, winds, and drought.

These effects are expected to accelerate as global warming accelerates. Compared with other ecosystems, the impact of climate change on Great Basin ecosystems is magnified because its environment is more arid and its ecosystems are more fragile than most. Rangelands in the Great Basin exist at the margin of viability, given the uncertain timing and quantity of precipitation, the pressure from invasive species, intensified fire regimes, and increasing human population pressures. (Humboldt-Toiyabe Report, 2011).

C. Causes of Climate Trends in the Great Basin.

Among earth scientists there is nearly complete consensus that accumulating greenhouse gas emissions have the planet on a long-run path to an ever hotter atmosphere and ocean, and ever greater climate disruption. The debate about this survives only at the political level. It is kept alive primarily by commercial interests who are aware of the implications of climate science, but would be disadvantaged if this country were to deal with them seriously. As rangeland scientist Dr. Thad Box observes, the controversy between scientists and climate change critics over whether human-induced changes simply exacerbate “natural” climatic cycles or drive the major changes is irrelevant. The countermeasures required in either case are the same, and the diverts society from making the responses that it must in order to survive.

Greenhouse gases in the upper atmosphere warm the earth by allowing high-frequency radiation from the sun (which includes visible light) to pass through the atmosphere to the earth. When that radiation reflects back off the earth’s surface, it becomes low-frequency (infrared) radiation. Greenhouse gases trap the infrared radiation and recycle it as heat. If it weren’t for this property of greenhouse gases, the average temperature on the earth's surface would be below freezing, and the earth would be far less hospitable to life. To keep the earth hospitable to life, it is necessary to keep its climate in balance. To keep its climate in balance, it is necessary to keep its greenhouse gases in balance. A large and sudden buildup of greenhouse gases has huge adverse impacts on the Great Basin's native species which are not accustomed to short winters, early snowmelt, higher evapotranspiration, and frequent, intense fires. (Humboldt- Toiyabe Report, 2011, p. 4.)

Since the industrial revolution began in the early 1800s, the atmospheric concentration of CO_2 has increased from 280 parts per million (ppm) to 400 ppm—an increase of 40%. Today's CO_2 concentrations are higher than any that have been observed in the past 800,000 years, when CO_2 varied between about 180 and 300 ppm. The concentration of methane, a more potent greenhouse gas, is now 2.5 times as high as at any time in the past 800,000 years. (National Academies of Science Brochure, p. 7, available at http://nas-sites.org/americasclimatechoices/more-resources-on-climate-change/.)

These are radical changes in the chemical composition of the earth's atmosphere. The large and sudden rise in greenhouse gases has knocked the earth's climate out of balance. Various lines of evidence point strongly to human activity being the main reason for the recent increase. The main factor is the burning of fossil fuels (coal, oil, gas) with smaller contributions from land-use changes and cement manufacture. Evidence that the global warming now underway is caused primarily by burning fossil fuels includes the consistency between the amount of total CO_2 emitted and the percent that climate models predicted would not be absorbed by natural carbon sinks, but, instead, would build up in the atmosphere. The proportions of CO_2 isotopes in the atmosphere provide a chemical "fingerprint" revealing how much CO_2 comes from natural sources, and how much from the burning of fossil fuels. Finally, the depletion of atmospheric oxygen is the amount that models predicted would result from the amount of fossil fuel that is now being burned. (Id., p. 8)

Since the injection of fossil carbon into the atmosphere began on a large scale in the late 19th Century, only 55% has been absorbed by oceans, forests, and other natural carbon sinks. Forty-five percent has remained in the atmosphere. An appropriate metaphor is to view the earth as a bathtub with carbon constantly coming out of the tap. Forty-five percent of the carbon entering the tub now spills over the rim. With no legitimate place to go, the excess carbon is flooding humanity's "house," undermining its foundation, and, ultimately, will destroy it.

Since 1750, the infrared energy that falls on each square meter of the earth's surface every second has gone up by 1.6 Watts. Over the entire earth's surface, this extra energy amounts to 800 trillion Watts per second. In any given second, the extra heat is 50 times the amount of power produced by all of the power plants in the world combined. (National Academies of Science Brochure, p. 8.) Scientist's ask what physical mechanism could account for this huge increment of energy now being absorbed by the earth's surface. They know that over this period, the amount of solar radiation reaching the earth's atmosphere has been virtually unchanged. (Id.) There is no physical mechanism that can plausibly account for the added infrared energy that now bathes the earth's surface, other than greenhouse gases, whose concentration has gone up more than 40 percent over the same period. This is the "smoking gun" that should put an end to any skepticism that might remain among the scientifically literate about the central role that greenhouse gases play in warming the globe.

D. The Social Cost of Relying on Carbon.

The most recent twelve years account for 12 of the 14 hottest years the earth has experienced since recording of global temperatures began in 1880. As reported in March, 2013, in the journal Science, global temperatures now are warmer than at any time in at least 4,000 years. If this rate of warming continues, global temperatures in the coming decades will exceed levels not experienced since before the last ice age, which ended roughly 12,000 years ago.[62] As a result, for the Western United states generally, and for Utah, in particular, an economic and public health catastrophe looms.

Putting the relevant climate science in a nutshell: Global warming has weakened the force of the giant convection cells (the Polar, Ferrel, and Hadley Cells) that circulate air from the tropics to the North Pole and back. As a result, the subtropical jet stream that brings winter snows and spring rains into the parched Western states has been weakening and retreating northward since the mid-1900s, as predicted by climate models. See http://robertscribbler.wordpress.com/2013/07/16/dr-jennifer-francis-top-climatologists-explain-how-global-warming-wrecks-the-jet-stream-and-amps-up-hydrological-cycle-to-cause-dangerous-weather/; http://www.sciencedaily.com/releases/2008/04/080416153558.htm. The result has been increasingly severe drought expanding from the Southwest through Nevada, Utah, and Colorado, and now into the Northwestern states.

[62] See news article "Global Temperature Highest in 4,000 Years," by Justin Gillis, New York Times, March 7, 2013, summarizing research published in the journal Science. [DOI: 10.1126/science.1228026, Science 339, 1198 (2013); Shaun A. Marcott et al. A Reconstruction of Regional and Global Temperature for the Past 11,300 Years.] This study reconstructed global temperatures over virtually the entire Holocene period (the period since most recent ice age). It used such proxies as the distribution of fossils of microscopic, temperature-sensitive ocean creatures to determine past climate. It suggests that changes in the amount and distribution of incoming sunlight, caused by wobbles in the earth's orbit, contributed to a sharp temperature rise in the early Holocene. Dr. Michael Mann of Penn State University points out that the early Holocene temperature increase was almost certainly slow, giving plants and creatures time to adjust. But, he said, the modern temperature spike is so sudden that it threatens the survival of many species, in addition to putting severe stresses on human civilization.

Added to this phenomenon is the disintegration of the polar vortex due to the rapid melting of the ice cover of the Arctic Ocean. Once a strong, coherent, and relatively predictable east-west flow, this weakened polar jet has begun to wobble erratically. It has lost so much force that the basic storm track that had traditionally moved storms from east to west across North America, has, in the past year, moved from south to north. The loss of polar ice, and the bizarre weather that it caused across the Northern Hemisphere in the most recent 12 months, were predicted by climate change models. See http://e360.yale.edu/slideshow/loss_of_arctic_sea_ice_already_influencing_weather/74/4/.

The disintegration of the polar jet allows it to "kink" or bend in on itself. This has allowed high-pressure areas of unprecedented strength and duration to form over North America. These powerful blocking highs are responsible for Superstorm Sandy and for the unprecedented drought now destroying California's agriculture. It has brought tropical air from the Hawaiian region of the Pacific all the way to Alaska, causing Alaska to have a higher average winter temperature than the continental United States—an upside down weather pattern that has persisted for almost a year. This same powerful blocking high pressure area allowed arctic air to spill down the eastern United States all the way to Florida, while leaving the West parched under a ridge of high pressure. See http://robertscribbler.wordpress.com/2014/01/23/arctic-heat-wave-to-rip-polar-vortex-in-half-shatter-alaskas-all-time-record-high-for-january/.

These phenomena are caused by the rising concentration of greenhouse gases in the earth's atmosphere. With the help of these phenomena, California's twelve-year drought has reached a severity not seen in centuries. The snowpack in the Sierra Nevada, on which California mainly relies to keep functioning during the dry season, is less than 25 percent of normal, reflecting the absence of rain or snow in December and January. An article in the February 1, 2014, New York Times reports that this summer there won't be enough water for many of California's inhabitants to drink, let alone to keep its orchards, vineyards, and livestock alive. That article quotes B. Lynn Ingram, professor of earth and planetary sciences at the University of California, Berkeley, concluding that "We are on track for having the worst drought in 500 years."

California's Central Valley produces the majority of the country's homegrown fruits and vegetables. Larry Bernstein, in an article published in the February 9. 2014, Washington Post, describes grocery and hardware stores in small towns across California's central valley going out of business due to the droiught. By some estimates, half a million acres of San Joaquin Valley farmland will lie fallow during the upcoming growing season.

This climate disruption, traceable primarily to the historically unprecedented warming of the Arctic, is turning California's hills and valleys—the nation's grapevine, orchard, and garden—into a dustbowl before our eyes. The damage to California's agricultural industry is expected to run into the tens of billions of dollars. The water outlook for Oregon, Nevada, Arizona, New Mexico, and Southern Utah is bleak as well. See http://droughtmonitor.unl.edu/. Herds are being sold off because parched rangelands will produce no feed. In once fertile valleys, soil moisture is so low that there is no point in planting crops.

This is just one example of what economists call the "external cost," or "social cost," of continuing to rely on carbon to power our nation. It is a "social cost" because neither the producer nor the consumer of carbon pays it--the rest of society does.

As noted in the previous section, a study by the faculty of Harvard Medical School published in 2011 quantified the social costs incurred in the United States annually by using coal to generate electric power. The study noted that each stage in the life cycle of coal—extraction, transport, processing, and combustion—generates a waste stream and carries multiple hazards for health and the environment. These costs are not imposed on the coal industry, but on the rest of society. It estimates that the life cycle effects of coal and the waste stream generated are costing the American public from one- third to over one-half of a trillion dollars annually. The cost of complying with the EPA's proposed CO_2 standard for existing power plants is trivial in comparison.

The Harvard study monetized damages due to climate change that include public health damages from NOx, SO2, PM2.5, and mercury emissions; fatalities of members of the public due to rail accidents during coal transport; the public health burden in Appalachia associated with coal mining; government subsidies; and the lost value of mined land after it has been abandoned. The estimate is conservative in that it does not account for damages outside of Appalachia, nor does it account for unquantifiable costs, such as the cost to a family of losing a wage earner due to black lung disease. It notes that many of these so-called externalities are, moreover, cumulative.

The Harvard study conservatively estimates that if all of the external costs of coal were accounted for, they would double or triple the price of coal. This would raise the price of coal-generated electricity by 9—27 cents per kilowatt. Adding these social costs to the price of coal would make wind, solar, and other forms of non-fossil fuel power generation competitive with coal, and would make investments in efficiency and electricity conservation far more profitable than expenditures on additional electricity produced from coal. (Epstein, et al., 2011).

III. IMPACT OF RISING CO_2 ON UTAH'S ECOLOGY

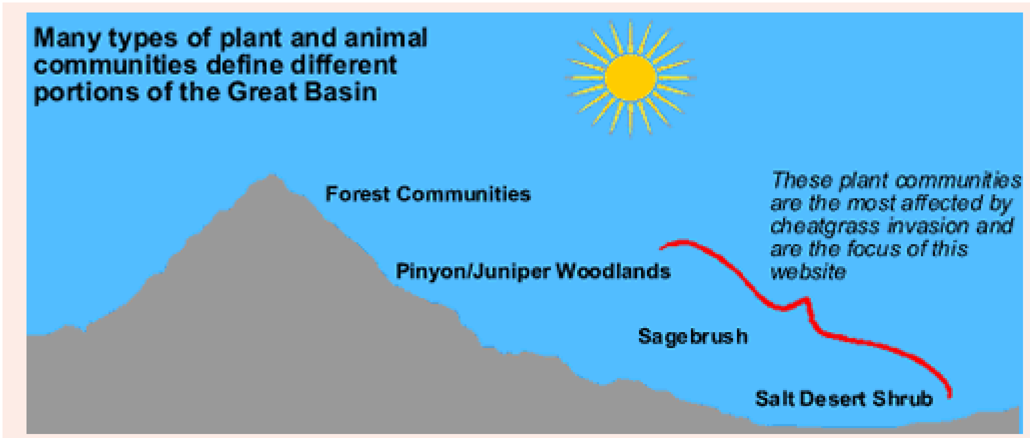
The subtropical jet stream and the storms that it brings to Utah in the winter and spring, is being weakened, and pulled north, away from Utah, by global warming. Studies of precipitation and runoff over the past several centuries and climate model projections for the next century indicate that ongoing greenhouse gas emissions at or above current levels will likely result in a long-run decline in Utah's mountain snowpack and an increased threat of severe and prolonged episodic drought in Utah, even though the possibility of occasional extreme precipitation and periodic flooding will remain. See http://www.deq.utah.gov/BRAC_Climate/docs/Final_Report/Sec1_SCIENCE_REPORT.pdf; http://robertscribbler.wordpress.com/tag/dr-jennifer-francis. What follows are just a few of the ways in which the long-run increase in heat and drought expected from climate change is likely to damage Utah's economy and the health of its citizens.

A. Impact on Sagebrush Ecosystems.

The Great Basin takes in portions of the states of Utah, Idaho, Nevada, Oregon, and California. The author Stephen Trimble memorialized the Great Basin as "the sagebrush ocean." In 1845, explorer John C. Fremont first recognized the uniqueness of the Great Basin's internal drainage and coined its name. The Great Basin covers 75 million acres. It is a series of dry, windswept valleys whose few rivers and streams never reach the sea. Instead, they flow inland to terminal lakes, marshes, and salt flats.

As Figure 2 shows, plant communities define different portions of the Great Basin. Forest communities occur at high elevations. Lower in elevation are the pinyon/juniper woodlands.

Figure 2



As elevation decreases further, the ecosystem is dominated by sagebrush, several perennial grasses, and forbs (such as clover). The lowest elevations are at the bottoms of valley basins. These areas often have very salty soils, and the only plants that can tolerate these conditions grow in salt-desert shrub communities.

Most of the native plants found in the Great Basin are relatively long-lived perennials that are slow to replace themselves when disturbed. Because of this, Great Basin rangelands have gone through cyclical vegetation changes. In sagebrush steppe communities, perennial grasses and forbs are faster growing and dominate first. Eventually, these herbaceous species give way to the longer-lived shrubs. The longer-lived shrubs persist until there is a disturbance (usually fire) which returns the rangeland to perennial grasses and forbs.

The disruptive effect that global warming is having on this cycle is summarized by the Bureau of Land Management and the National Forest Service. Rising temperatures associated with global warming have already altered the characteristics of a broad range of plant and animal species (80% of species from 143 studies). These changes include reduced species density, northward or range shifts, altered timing of organism growth and reproduction, and reductions in the diversity of species' gene pools.

There has been a rapid expansion of invasive species. This can be attributed primarily to the direct and indirect effects of climate change, including elevated CO_2 and N deposition. Changes in past and present land uses, such as intense grazing, have also contributed. Consequently, approximately 20% of the sagebrush ecosystem's native flora and fauna are considered imperiled, and the remaining components of the sagebrush-based ecosystem are in decline. (Miller and Tausch, 2000, pp. 15–30).

Prior to the 1860s, the Great Basin was dominated by a sagebrush ecosystem featuring an understory of perennial grasses (bunchgrasses). This ecosystem was resilient to drought and flood, and effective in holding the soil in place. Since 1860, much of the sagebrush ecosystem has been supplanted by pinyon and juniper woodland or by invasive annual grasses and a wide variety of thistles and other noxious weeds. (Id.)

Today, invasive annuals are displacing the native sagebrush ecosystem. This takeover is being carried out primarily by the ecologically deadly combination fire and cheatgrass.[63] In the last half of the 19th century, after the completion of the transcontinental railroad, the Great Basin saw a rapid influx of farmers and ranchers. They brought with them alfalfa seed from Europe that was contaminated with cheatgrass seed. Foreign cheatgrass thrived in the Great Basin climate, but had no natural enemies to keep it in check.

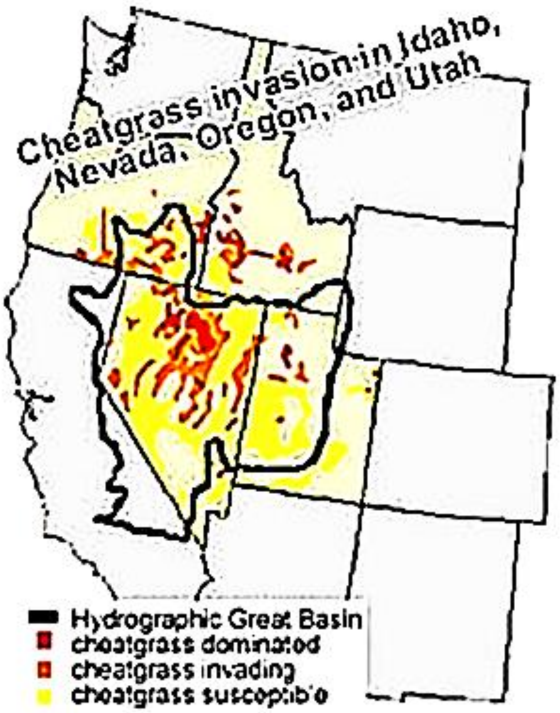
Cheatgrass is a short-rooted annual that moves in to a plant community when perennial grasses are destroyed by fire or overgrazing. Its success is based on its ability to respond with rapid growth to the brief spring wet period in the Great Basin. Once established, cheatgrass grows densely, pushing aside all competitors for moisture and nutrients. This results in unbroken swaths of short-rooted grass that dry out in mid-summer, providing a continuous source of fuel to sustain fires once they start. When fire comes, cheatgrass transforms what would have been occasional patchy burns into large-scale infernos that occur more often and earlier in the season.

Frequent, intense fires reduce the ability of many perennial plants to re-establish, furthering the dominance of cheatgrass. In this way, cheatgrass and fire perpetuate one another, and the problem magnifies itself with every reoccurring blaze. http://www.usu.edu/weeds/great_basin/ecology.html. Given the synergy between fire and cheatgrass, anything that promotes fire, including global warming, hastens the demise of the native sagebrush-dominant ecosystem of the Great Basin.

As Figure 3 shows, cheatgrass now dominates many landscapes once occupied by perennial shrubs, grasses, and forbs. The increased heat and episodes of drought associated with global warming also encourage the replacement of sagebrush ecosystems with stands of juniper and pinyon pine.

Figure 3

[63] Overgrazing of perennial grasses by cattle and sheep is also an important contributor.



Because the juniper and pinyon ecosystem is not hospitable to perennial grasses, it is less able to protect the soil against the forces of wind and water. The juniper/pinyon ecosystem also promotes fire, especially where the stands are dense and their crowns merge. (Miller and Tausch, 2000, pp.15–30).

As discussed in more detail below, global warming is dramatically increasing the frequency and intensity of fire in the Great Basin. Increased wildfires in shrublands in the Great Basin that have been converted to cheatgrass have now transformed rangelands that were carbon sinks into carbon sources on a large scale (Bradley et al., 2006). The combined effects of increased burn area and overgrazing mean that, by the end of the century, almost 59% of sagebrush-bunchgrass communities throughout the western U.S. could be replaced by communities of annual grasses and noxious weeds, or juniper and pinyon pines.

The consequences for mule deer, pronghorn and other species that depend on the sagebrush ecosystem will be devastating. (Glick, 2006). The consequences for the Great Basin's soils will be equally grim. Juniper, pinyon, annual grasses, and noxious weeds do little to prevent fluvial erosion, and do not facilitate infiltration of moisture into soil and ground water recharge. The decline in the sagebrush-bunchgrass ecosystem in the Great Basin will expose those soils to erosion by wind, rain, and flood. Although overgrazing, road building, and urban construction all contributing to demise of the sagebrush ecosystem, global warming is the main forcing mechanism, largely through its facilitation of fire. (Humboldt-Toiyabe Report, p. 9).

Global warming threatens the integrity of the soils of the American West in another important way. In the drier parts of the Great Basin, as well as the lower elevations of the Colorado Plateau in eastern and southern Utah, vegetation is sparse or absent. The open ground, however, is not bare, but is covered with a thin layer of biological soil crusts.

Biological soil crusts are formed by interactions between soil particles and cyanobacteria, algae, microfungi, lichens, and bryophytes (in different proportions) which live within, or immediately on top of, the uppermost millimeters of soil. The presence and activity of these biota knit the soil particles together. The resultant living crust covers the surface of the ground as a coherent, protective layer.

Biological crusts are a vital part of the Utah's two major ecological zones—the lower elevations of the Colorado Plateau and of the Great Basin. These crusts are fragile and easily damaged. These are the hottest and driest portions of the Plateau and Basin, where there is little vegetation to anchor the soil against wind and rain. In such places, soil is only held in place by the thin, dark crust formed on the surface by cyanobacteria. These tiny organisms, along with soil particles held together by materials they produce, provide the foundation for many biological processes. In addition to protecting the soil from erosion, they fix nitrogen and carbon to the soil, facilitating seed germination and plant growth. (Belnap and Lange, 2003, p. 503.)

Because of the harsh conditions of their environment, such crust can take centuries to form. When it is crushed by cattle hoofs, road grading, recreational off-road vehicle traffic, traffic associated with mining and oil and gas exploration, or urban construction, it can take centuries to re-form.[64]

They are also vulnerable to the higher air temperatures and more frequent droughts associated with global warming. Heat and drought shorten the time that these crusts can remain biologically active before they dry out. When dry, they are unable to produce or repair chlorophyll and/or pigments that would provide protection from solar radiation. (Belnap, et al., 2004, pp. 306-316.)

The damage to these crusts caused by changes to the climate, combined with the mechanical damage from human activity, has increased erosion of

---

[64] In southern Utah one can find places where a lone wagon cut into bioactive crusts more than 150 years ago and the wagon's ruts remain as clear and sharply defined as if they had been laid down yesterday.

Utah's desert soils. One ominous impact of this increased erosion is a substantial increase in the amount of dust that coats the snowpack of the Rocky Mountains. Dust on snow causes it to absorb rather than reflect solar radiation. It is estimated that increases in the dust that coats the mountain snowpack has reduced the flow of the Colorado River by 6%. http://www.colorado.edu/news/releases/2013/11/14/new-study-dust-warming-portend-dry-future-colorado-river. Since the population centers of Arizona, Southern Nevada, and Southern California are utterly dependent on the Colorado River, an ongoing reduction in its flow will have a major impact on those desert cities.

B. Impact on Forests.

Changes in temperature and precipitation associated with climate change are causing widespread deforestation across the globe. (Bonan, et al., 2008.) Deforestation, in turn, is responsible for 20% of the "greenhouse effect."

In the Great Basin, climate change is expected to continue to produce hotter, drier conditions at high elevations, drought-weakened trees, broader insect infestations, more frequent and more intense wildfires, and impaired forest ecosystems. White Pine and Aspen are in special peril. http://www.deq.utah.gov/BRAC_Climate/docs/Final_Report/Sec-A-1_SCIENCE_REPORT.pdf.

Of particular concern are the greatly expanded burn acreage caused by a warming climate and the effects of extreme wildfire events on ecosystems. It is estimated that increases in temperature will cause annual mean area burned in the western United States to increase by 54% by the 2050s relative to the present-day. The forests of the Pacific Northwest and Rocky Mountains will experience the greatest increases--78% and 175% respectively. The increase in the area burned is expected to cause a near doubling of wildfire carbonaceous aerosol emissions by mid-century. (Spraklen et al., DOI:10.1029.) In 2004, researchers at the U.S. Forest Service's Pacific Wildland Fire Lab looked at past fires in the West to create a statistical model of how future climate change may affect wildfires. They found that by the year 2100, the area annually burned in Montana, New Mexico, Washington, Utah, and Wyoming could be five times greater than at present. (McKenzie, et al., 2004, pp. 890-902.)

Although wildfire activity in the forests of the western United States has increased in recent decades, neither the extent of recent changes, nor the degree to which climate may be driving regional changes in wildfire, has been systematically documented. Much of the earlier research has laid the majority of the blame on the effects of 19th- and 20th-century land-use history.

A study published in *Science* magazine in 2006 corrects this misassumption. It compiled a comprehensive database of large wildfires in western United States forests since 1970 and compared it with hydroclimatic and land-surface data. It shows that large wildfire activity increased suddenly and markedly in the mid-1980s, with higher large-wildfire frequency, longer wildfire durations, and longer wildfire seasons. It found that the greatest increases in burn areas occurred in mid-elevation, Northern Rockies forests. It noted that land-use histories have had relatively little effect on fire risks in these zones. Instead, it demonstrates, those risks are driven by increased spring and summer temperatures and an earlier spring snowmelt associated with climate change. (Westerling, et al., 2006, pp. 940-943.)

Global warming gives the various species of bark beetle an overwhelming advantage in their assaults on host spruce and pine trees. Higher temperatures benefit every aspect of the bark beetle's life cycle, from the number of eggs laid by a single female beetle, to the beetles' ability to disperse to new host trees, to individuals' over-winter survival. Higher temperatures associated with climate change speed up reproductive cycles, particularly when there are consecutive warm years. Warmer winters make it easy for spruce and pine beetles to survive even at the highest elevations. Drought-weakened trees have few defenses against the newly robust beetle populations. www.fs.fed.us/ccrc/topics/bark-beetles.shtml. As a result, bark beetle infestations destroyed 9 million acres of forest in the Western US in 2009 alone. http://www.scientificamerican.com/article/mountain-pine-beetle-damage-declines/.

In the Western U.S., as noted above, the forest fire season is 79 days longer than 25 years ago. The severity of these fires is greatly enhanced by the unchecked depredations of bark beetles. The dead tree litter caused by bark beetle infestations creates ideal conditions for catastrophic forest fires. Northern latitude forests on other continents have been similarly affected.

The impact of the loss of forests to bark beetle infestations is magnified by the fact that dead trees not only cease to absorb carbon from the atmosphere but release it back into the atmosphere as they decay.

C. Impact on Species Extinction

Current trends suggest that the fastest and most wide spread mass extinction of species in the Earth's history is very likely underway. In the tropics alone, we may now be losing 27,000 species per year to extinction. http://www.pbs.org/wgbh/evolution/library/03/2/l_032_04.html. By the year 2050, it is estimated that 15–37% of land plants and animals will become extinct as a result of climate change. (Thomas, C. et al., 2004.) Many species will die because they will not be able to migrate to places where the climate remains suitable. Others will die because suitable habitat will no longer exist. http://www.nature.com/nature/links/040108/040108-1.html.

When viewed on an evolutionary time scale, the current pace of climate change is essentially instantaneous. For example, studies of the fossil record indicate that for tree species to adapt to the current pace of climate change, they would have to migrate to suitable habitats ten times faster than most species were able to respond to climates shifts in the past two million years. Few tree species have this ability. (Davis and Shaw, 2001.)

Species mortality has serious consequences. In plant communities, reduced diversity leads to lower productivity, less nutrient retention in ecosystems and ecosystem instability. An average plot containing one plant species is less than half as productive as an average plot containing 24–32 species. As plant diversity is lost, leaching of nutrients from the soil increases, reducing its fertility. (Tilman, D., 2000).

It is helpful to consider that the species presently inhabiting the earth are the result of over 3 billion years of natural selection that fostered efficiency, productivity, and specialization. These organisms are the agents that capture and transform energy and materials, producing, among other things, food, fuel, fiber, and medicines. These species recycle wastes, create pure drinking water, drive global biogeochemical cycles that created and maintain an aerobic atmosphere, regulate global climate by absorbing greenhouse gases, regulate local climate through plant evapotranspiration, make soils fertile, and provide other natural “goods and services.”

In addition, the Earth's biodiversity is the source of all crops and all pollinators of crops, of all livestock, and of many pharmaceuticals and pesticides. Just three crops--corn, rice and wheat--provide about 60% of the human food supply. To remain viable, these crops must remain genetically diverse. Among other things, genetic diversity ensures that strains are available that are resistant to emerging and evolving diseases and pests. In the long term, food stability will require development of new crops from what are now wild plants, because disease or pesticide-resistant pests will cause the loss of current crops, just as disease eliminated chestnuts, elms, and other tree species from North American forests.

Ours is a society that is accustomed to the availability of natural resources. We think of them as free and take them for granted. But, a decade ago, the World Resources Institute estimated an annual global price tag of $33 trillion dollars for the array of services that natural systems provide. These natural systems cannot provide these services unless they are healthy, functioning ecosystems. All of these natural systems are threatened by climate disruption.

Utah is where the Great Basin's ecosystems and those of the Colorado Plateau meet. It is where four, major, unique ecosystems intersect. As a result, despite being a predominantly desert state, Utah is ranked fifth in the nation for biodiversity. A large portion of the State is covered by the Great Salt Lake. Of all the wetlands in the United States, the Great Salt Lake may be one of the most vulnerable to climate change. The diversity of Utah's ecosystems can be expected to suffer more than the diversity of ecosystems generally as a result of climate change because its water-constrained ecological systems already exist at the margin of viability.

IV. IMPACT OF RISING CO_2 ON PUBLIC HEALTH IN UTAH.

Climate change can be expected to impact the health of Utah residents in the following ways.

A. Impaired Respiratory Function from Increased Ground-Level Ozone.

The chemical reaction that forms ozone is, in part, heat driven. Hotter temperatures will create higher ozone concentrations. The incidence of forest fires is also heat driven. Forest fires are a major source of ground-level ozone. As forest fires become more frequent and intense, exposures to ground-level ozone will increase. The significance of forest fires as sources of ozone can be appreciated by considering that smoke plumes from forest fires in Alaska have been shown to significantly increase ground-level ozone concentrations as far away as Europe. (Real E., et al., 2007).

Ozone creates a positive feedback mechanism for global warming because ozone itself is a greenhouse gas. In yet another feedback mechanism, higher ozone concentrations retard the growth of trees, which reduces the ability of forests to absorb CO_2.

The American Lung Association estimates that at least one-third of Utah is vulnerable to the impacts of air pollution. Of a population of 2.8 million, more than 1 million are under 19 or over 64. About 230,000 have asthma, and nearly 494,000 have cardiovascular disease. The effect of ground-level ozone pollution on the delicate lining of the lungs is analogous to the effects of sunburn on the skin. It aggravates respiratory diseases like asthma, and impairs lung function in the population generally.

Until recently, high concentrations of ground-level ozone in the Mountain West had been observed only in the summer in population centers, as auto and industrial emissions reacted in the presence of sunlight and heat. Now high concentrations of ground-level ozone are appearing in the Mountain West's remote areas as well, especially in areas where oil and gas producers have recently drilled thousands of wells. Oil and gas drilling, as presently practiced, releases large quantities of ozone precursors, such as nitrogen oxide (NOx), volatile organic compounds (VOCs), and formaldehyde. http://rd.usu.edu/files/uploads/ubos_2011-12_final_report.pdf. Recently, for the first time, concentrated ozone has appeared in the winter in the remote energy development areas of Wyoming and Colorado and Utah's Uinta Basin.

Utah's Uinta Basin covers nearly 6 million acres. In winter, emissions from energy production collect in the lower atmosphere where they are transformed into ozone by interacting with sunlight and snow. Air pollution monitors installed in the Uintah Basin measured ozone concentrations exceeding federal health standards more than 68 times in the first three months of 2010. http://www.nytimes.com/gwire/2010/10/01/01greenwire-air-quality-concerns-may-dictate-uintah-basins-30342.html?pagewanted=all. Maximum 8-hour average ozone concentrations at the Ouray air monitoring station during 2013 reached 142 ppb. This exceeds federal air quality standards by 89%. http://www.deq.utah.gov/envrpt/Planning/s12.htm. For long periods of time, ground-level ozone concentrations in the Uinta Basin now exceed those of Los Angeles County, where the nation's highest ozone concentrations traditionally occur.[65]

Atmospheric currents are capable of transporting ozone and particulate matter thousands of miles away from their original sources. Ozone is showing up now in high concentrations in the air over the middle of the Atlantic Ocean. This raises the prospect that the rapidly growing supply of ozone precursors in the Uinta Basin, combined with the higher temperatures that global warming will

---

[65] The Uinta Basin's average ozone concentration for 2010-2011 was 116.5 ppb (based on the NAAQS-created measurement of the fourth-highest value averaged over the two years). In comparison, Los Angeles County averaged 108 ppb over the same two years. http://www.blm.gov/pgdata/etc/medialib/blm/ut/lands_and_minerals/oil_and_gas/november_2011.Par.75557.File.dat/Email%20July%2015%202011%20Garbett%20-%20SUWA%20Comments%20Nov%202011.

bring, will increase ground-level ozone both there and in adjacent regions, such as the mountain valleys of the heavily populated Wasatch Front.

Another source of ozone adjacent to the Wasatch Front is the ultraviolet light that reflects off of the surface of the Great Salt Lake and interacts with the chemical soup produced by the refinery emissions and the vehicle exhaust emitted near the shore of the lake. This adds to the concentration of ozone along the Wasatch Front, and makes the Wasatch Front all the more vulnerable to the ozone-promoting effects of global warming.

A recent study of ozone by Utah's Division of Air Quality reports annual concentrations of ozone in the Salt Lake City of 0.079 ppb, violating the National Ambient Air Quality Standard of 0.075 ppb (based on the 4th highest annual 8-hour maximum). Furthermore, the study shows, ozone is expanding far beyond the areas traditionally affected by photochemical reaction. It reports ozone levels virtually as high in the parks of Southern Utah as in the urbanized North. http://www.airquality.utah.gov/Public-Interest/Current-Issues/Ozone/2012_Utah_Ozone_Study.pdf. Utah's air quality is already being affected by events and policies in other parts of the world, this trend will intensify.

A recent, landmark study led by Brigham Young University's Arden Pope has enhanced our understanding of the impact of ozone on public health. It clearly demonstrates that ozone exposure increases rates of respiratory death. Along the Wasatch Front, the study concludes, exposure to ground-level ozone increases the rate of respiratory death by about 25%. Other studies establish that ground-level ozone negatively impacts lung function across all segments of the population, including young, healthy adults, even at levels below current national air quality standards.

B. Impaired respiratory and cardiac function due to excessive heat events.

Models from climate researchers indicate that climate change will not just warm the average climate, but will also increase extreme climate events, such as heat waves. Studies show a correlation between temperature and hospital admissions for respiratory failure and for cardiac death. For example, a study published in The American Journal of Respiratory and Critical Care Medicine examined populations in 12 different European cities. For each city they found a temperature/humidity threshold beyond which each degree of increase resulted in a 4% increase in respiratory admissions for all ages, but especially those over 75.

In the summer of 2003, a heat wave in Europe killed 70,000 people within a few weeks. The similar heat wave struck Russia in 2010. In the Russian event, monthly temperatures were more than 5 degrees Celsius above average, and daily temperatures peaked at up to 12 degrees above average, reaching over 40 degrees Celsius (104F). These conditions caused an estimated 55,000 deaths, a 25% drop in annual crop production, and a total economic loss of more than $15 billion.

An Oxford University study published in 2012 estimates that the risk of a heat wave of the magnitude of the Russian event has approximately tripled due to the warming of the globe that has occurred since the 1960s, caused mostly by increases in greenhouse gas emissions. The study concluded that this kind of extreme weather event can be "mostly natural" in terms of magnitude, but "mostly human-induced" in terms of the probability of incurrence. By modeling these distinct aspects of this event, the study was able to calculate how much human-induced climate change cost the Russian economy in the summer of 2010. http://phys.org/news/2012-02-russian-manmade-natural.html#jCp.

A study published in the Proceedings of the National Academy of Science in 2012 concluded that the global distribution of temperature anomalies has shifted toward higher temperatures, and that the range of such anomalies has increased. This has created a category of extreme summertime outliers, more than three standard deviations (3σ) warmer than the climate in the 1951–1980 base period. The distribution of such heat extremes covered much less than 1% of Earth’s surface during the base period. Now, such heat extremes typically cover about 10% of the land area. The study concludes that it is extremely unlikely that the heat waves that struck Moscow in 2010, and those that struck Texas and Oklahoma in 2011, would have occurred absent global warming. http://www.pnas.org/content/early/2012/07/30/1205276109.

Global warming also increases the severity of heat waves indirectly. Using broad measurements taken in southeastern Europe, a study demonstrates that the moisture contained in soils acts as a heat sink, absorbing heat until the moisture in the soil is exhausted. The study concludes that compared to wet summers, the frequency of very hot days increases tenfold in summers with dry soils. Soils dried out by heat and drought associated with global warming cannot function as a heat sink to moderate regional heat waves when they occur. http://www.ethlife.ethz.ch/archive_articles/101213_hitzewellen_paper_ga/index_EN. As the climate warms, Utah can expect to experience extreme summertime “heat wave” events similar to recent heat waves in Europe, Russia, Texas, and Oklahoma. It cannot expect to have moist soils to mitigate these events.

C. Hazardous substances distributed by dust pollution.

As described earlier, hotter temperatures and reduced precipitation expected in the Great Basin as a result of climate change is likely to result in widespread loss of native vegetation in the already water-stressed Great Basin. This can be expected to expand the sources of dust, or particulate matter pollution, to which Utah residents are exposed. Particulates that are likely to increase as a result of global warming, and the additional threats that they pose to the health of Utah's residents, are discussed below.

Erionite exposure

Erionite is a mineral that forms long fibers that have an effect on the lungs similar to asbestos, producing Malignant Mesothelioma (MM). Before discussing the hazards associated with exposure to erionite, it would be useful to review several key technical facts about MM. MM is a rare and unusually deadly form of cancer that develops from cells of the mesothelium, the protective lining that covers many of the internal organs of the body.

Most often MM develops in the pleura (the outer lining of the lungs and internal chest wall), but it can also develop in the peritoneum (the lining of the abdominal cavity), the pericardium (the sac that surrounds the heart), or the tunica vaginalis (a sac that surrounds the testis). MM has a latency period of from 30 to 60 years. This tends to obscure both its sources, and its prevalence. Despite the various forms of treatment available (chemotherapy, radiation therapy, sometimes surgery), MM carries a poor prognosis once contracted.

MM is most commonly caused by exposure to asbestos, but exposure to erionite is a far more potent cause. Erionite is a fibrous mineral with properties similar to asbestos. Animal studies, however, have shown it to be 300 to 800 times more carcinogenic than asbestos. (Wagner, et al.,1985, pp. 727-730). It is the most toxic naturally occurring fibrous mineral known. (Pass, et al., 2005).

Erionite was first recognized as a serious health hazard in the 1980s and found to cause the same types of cancer and interstitial fibrosis as asbestos. In villages in Turkey contaminated with naturally occurring erionite, the rate of cancer is about 1000 times the normal rate. Three villages there are known locally as "cancer villages" because MM was the cause of 40 percent to 50 percent of all deaths. (Baris, et al.,1978, pp. 181-192). Epidemiological studies linked these high concentrations of MM to exposure to erionite released into the air from the soil and rock formed from the local volcanic tuff. (Int. J. Cancer 39, 1987, pp.10-17); Proceedings of the National Academy of Sciences, (June, 2011) www.pnas.org/cgi/goi/10.1073/pnas.1105887108.

The ambient fiber concentrations that produced this extraordinarily high incidence of MM were very low. This, together with the prevalence of erionite in other parts of the world, indicated an urgent need to develop animal models to investigate the relationship between erionite and MM.

Erionite is one of a group of silicate minerals called zeolites. It is usually found in volcanic ash that has been altered by weathering or exposure to alkaline ground water. Like naturally occurring asbestos, zeolite beds containing erionite are present in many Western states. Figure 4 shows that Utah lies in the center of an arc of erionite that sweeps from Arizona through Nevada and Oregon to Montana and North Dakota.

Figure 4

The Great Basin is uniquely suited to the formation of erionite in that a great deal of volcanic ash has accumulated in the valley basins. The permanent saline, alkaline lakes and playas provide ideal circumstances for the volcanic ash to transform into zeolites. When eronite is disturbed, it can release fibers into the air that cause MM. An environmental survey confirmed that erionite was the main component of the fibers in the airborne dust in the “cancer villages” of Turkey. It also confirmed that the source of the erionite fibers was poorly consolidated, incompletely formed rock. (Wagner, J. et al., pp. 727-730)

A systematic survey of the characteristics of the many erionite deposits in Oregon, Nevada, and California that are generally upwind of Utah has yet to be made. Therefore, it is not known how many of them consist of poorly consolidated rock that was characteristic of erionite outcroppings in Turkey, which is prone to weathering and release into the air.

It is known that erionite-containing gravel has been mined and used for road building in locations in eastern Oregon and western North Dakota, and these roads are now sources of windborn erionte-laden dust. Erionite-contaminated gravel in North Dakota has resulted in levels of exposure similar to what was found in Turkish villages ravaged by mesothelioma cancer. (Carbone, et al., 2011, pp. 13618–13623). The first North American with erionite-related lung disease was recognized in Utah and reported in 1981. (Weissman and Keifer, 2011). The patient was a road construction worker who lived in an area rich in zeolite deposits. He had extensive parenchymal and pleural fibrosis and had a lung biopsy revealing the presence of both fibrous particles which were found to be consistent with erionite.

The toxicity of even small amounts of erionite is established. The facts described above also demonstrate a risk that Utah's residents are being exposed to erionite-laden dust from the many desposits that are upwind of the State. What is needed now is a systematic study of levels of exposure in the western United States and any correlation between levels of exposure and the incidence of MM. Outside of North Dakota, however, such studies have yet to be funded. Seeing this need, Dr. William N. Rom, currently director of the pulmonary division at the New York University School of Medicine, and Dr. Kenneth R. Casey, now at the University of the Cincinnati College of Medicine, requested a grant from NIH to conduct such studies. Their request was rejected.

The people of Utah are at risk from the failure to conduct such studies. As noted, erionite deposits are prevalent in the parts of the Great Basin that are upwind of Utah. It is entirely possible that erionite occurs in loose, weathered outcrops that are susceptible to natural dispersion by dust storms. In addition, roads, mines, pipelines, power lines, wind and solar farms, and recreation sites, are proliferating in those areas, making it likely that such activity will unwittingly disturb erionite and release it into the air. Because exposure to erionite is not regulated, there are no applicable Federal standards to enforce. Federal agencies have failed to alert land-use officials, developers and residents of affected areas to look for erionite outcrops or to avoid disturbing them by their development activity. For these reasons, there is a compelling need to inventory erionite deposits and assess their susceptibility to both man-made and natural dispersion.

If there are weathered erionite outcrops or artificially disturbed erionite beds upwind of Utah, they place Utahns at risk of inhaling erionite fibers and contracting MM. It is probable that climate change, by damaging the vegetation and biological crusts that now hold the soil of these regions in place, will increase Utahn's exposure to dust-borne erionite. The risk that dust containing erionite (and a wide range of other hazardous substances that contaminate Nevada's soil) will be carried to Utah's population centers will be much greater if Las Vegas goes ahead with its plans to dewater central Nevada and Western Utah.

Radionuclide exposure

In 2006, the Federal government announced plans for a non-nuclear bomb test in Nevada dubbed "Divine Strake." Utahns sent ten thousand letters to the Federal government opposing "Divine Strake," most of them citing the risk that radioactive contaminated dust would drift into Utah. Divine Strake was cancelled due to public opposition and pressure from Utah's Governor Jon Huntsman. Increased desertification from climate change, made worse by Las Vegas's plan to drain nearby acquirers, would increase the risk that radionuclides will be dispersed downwind from the radioactive test sites.

Over 900 above-ground nuclear bomb tests occurred at the Nevada test site in the mid-20th century. The Department of Energy (DOE) also conducted numerous "safety tests" in which it blew up mock nuclear war heads. While not nuclear explosions, safety tests caused significant contamination of the surface with plutonium. Nuclear "rocket tests" added additional radioactive contamination.

In terms of cumulative effects, the contamination from above-ground testing, along with the safety shots, and cratering events, left an estimated 27,000 acres (42 square miles) of surface soils contaminated at levels in excess of 40 pico curies per gram (20). (Walker, et al., 1998). Underground tests, which continued until 1992, also released significant radioactivity into the atmosphere.

DOE has stated that it is not possible to fully define the level of residual contamination that remains from the atmospheric testing program, but admits that radioactive isotopes that are still in Great Basin soil include americium, plutonium, uranium, cobalt, cesium, strontium, and europium. (Id.)

Some of these radioactive elements are alpha-emitters, some of the most carcinogenic substances known. To illustrate this point: since 1943, the military has been aware of the extreme toxicity of uranium as a gas. In a document dated October 30, 1943 and declassified June 5, 1974, three major scientists from the Manhattan Project, Drs. James Conant, A. H. Compton, and H. C. Urey wrote to Brigadier General Leslie R. Groves, who was the head of the atom bomb project, concerning "Radioactive Materials as a Military Weapon." In that document they stated:

> As a gas warfare instrument the material (uranium) would be ground into particles of microscopic size to form dust and smoke and distributed by a ground-fired projectile, land vehicles, or aerial bombs. In this form it would be inhaled by personnel. The amount necessary to cause death to a person inhaling the material is extremely small. It has been estimated that one millionth of a gram accumulating in a person's body would be fatal. There are no known methods of treatment for such a casualty.

Uranium was also recommended as a permanent terrain contaminant which could be used to destroy populations by contaminating water supplies and agricultural land with radioactive dust. http://www.mindfully.org/Nucs/Groves-Memo Manhattan30oct43.htm. One millionth of a gram of uranium yields 1,000 alpha particles per day, each alpha particle carries over 4 million electron volts, and it takes only 6-10 electron volts to break a DNA strand.

The longer-lived radioactive elements, including plutonium, Cesium 137, and Strontium 90, bioconcentrate as they rise up the food chain, reaching concentrations as much as thousands of times higher in meat and milk, including human breast milk. Humans reside at the top of the food chain, especially human embryos.

Once ingested, these radioactive elements continue to bioconcentrate, accounting for their distinctive carcinogenic patterns and enhancing the toxicity of low dose exposures. Strontium concentrates in bone, bone marrow and teeth, resulting in bone cancers and leukemia. Cesium resembles potassium, which is ubiquitous in every cell. It concentrates in brain, muscle, ovary and testicles, leading to brain cancer, muscle cancers (rhabdomyosarcomas), ovarian and testicular cancer. Most importantly, Cesium 137 can mutate genes in eggs and sperm, causing genetic diseases in future generations.

The Nevada Test Site and other nuclear test areas are shown in Figure 1. Figure 5, taken from a 1997 National Cancer Institute study, shows the pattern of deposition of all of the Plutonium dust released from those sites.

Figure 5

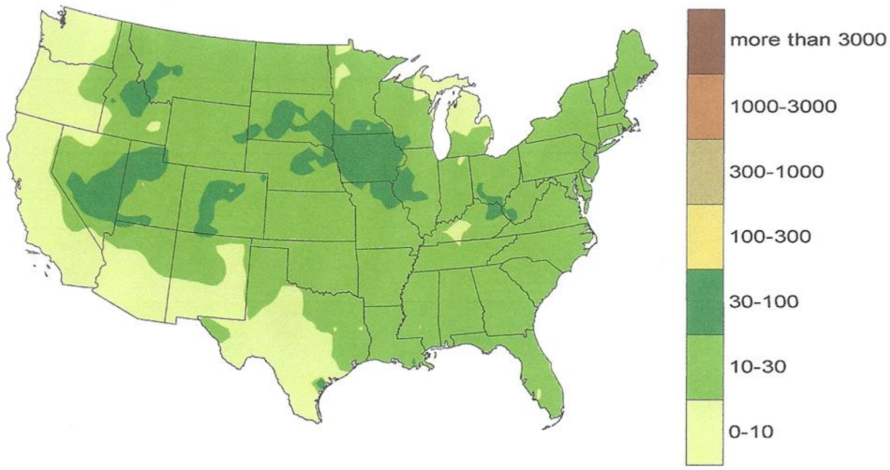


Figure 3.4. Plutonium (239+240) deposition density (Bq/m^2) due to all NTS tests.

The six test main series which took place in 1951, 1952, 1953, 1955, 1957, and 1962, deposited different amounts of fallout within the United States. For example, the 1957 Plumbbob series deposited 35% of the total cesium followed by the 1953 Upshot-Knothole series that contributed 23%. These proportions are shown in Figure 3.5.

Of all the alpha emitters, Plutonium is the most deadly. If inhaled, it is transported from the lung to thoracic lymph nodes where it can induce Hodgkins disease or lymphoma. Because it is an iron analogue, it combines with the iron transporting protein and concentrates in the liver, causing liver cancer, and the bone marrow causing bone cancer, leukemia, or multiple myeloma. It also concentrates in the testicles and ovaries where it can induce testicular or ovarian cancer, and/or mutate genes to induce genetic disease in future generations.

Plutonium can cross the placental barrier which protects the embryo. Once lodged within the embryo, one alpha particle could kill the cell that would eventually have formed the left side of the brain, or the right arm, as thalidomide did years ago. The half-life of plutonium is 24,400 years, so it can cause harm for 500,000 years; inducing cancers, congenital deformities, and genetic diseases for the rest of time, not only in humans, but in all life forms.

The Nevada Test Site has a "Soils Program" to determine the extent of surface contamination and develop mitigation plans for these areas, which may involve soil removal. Prior to 2006, there was an estimated 20-25 million cubic feet of plutonium-contaminated soil at the NTS and the adjacent Tonopah Test Range. How much of that remains is unclear.

It is estimated by the National Nuclear Security Administration that about 3,000 acres are contaminated with plutonium at levels in excess of 40 pCi/g (with some areas in excess of 12,000 pCi/g) left by the "safety tests." In a 2003 document, all of the safety test areas were to have been cleaned up by 2006 to a "target level" of 200 picograms plutonium per gram of soil (a picogram is one-trillionth of a gram). While this level seems very small it is still 4 times the clean-up level for Rocky Flats. Over time some of the longer-lived radioactive particles have been taken up by plants in the area or concentrated in drainage gullies. The Site Wide Draft Environmental Impact statement for the NTS does not say whether these sites have been cleaned up. It does say that there is a target date of 2022 for all the soils sites to be "closed." Unfortunately, DOE does not say what level of clean-up will be achieved at a "closed site" in its public documents. Nevada Test Site Public Information Brief - March 2012. http://www.h-o-m-e.org/nts-vision-project/nts-briefing-paper.html.

An article published in 1979 in the Washington Post quoted Utah scientists stating that in the 1950s, plutonium was spread across the most densely populated part of Utah (the Salt Lake City area) that produced levels of plutonium as much as 3.8 times higher than concentrations elsewhere. These scientists were surprised that plutonium was found in such large quantities. The scientists attributed it to the safety tests in which mock warheads were blown up. A study conducted in the 1990s by a Nevada graduate student found plutonium dust in the attics of homes in Las Vegas and other towns in Nevada and Utah. He also attributed this contamination to the safety tests.

The dirtiest of all the safety tests was 'Project 57,' which contaminated Nevada Test Site's Area 13 with four times more Curies of radioactivity than the average at nine other safety test sites. At Area 13, hundreds of acres of soils are contaminated at the level of 46 Curies – a level immensely higher than that which would provide a fatal dose to humans. The plume cloud from Project 57 went north-northeast and deposited just over 200 Curies of plutonium over a large area extending towards Ely, Nevada, and into Utah, and possibly Salt Lake City.

Since plutonium concentrations greater than 10 picoCuries (10 trillionths of a Curie) per gram are fatal for humans, there are a lot of 'hot' areas at Area 13, and downwind of that area in Nevada and Utah, that still contain dangerous levels of plutonium.[66] The danger will remain for the next 240,000 years. Ninety-nine percent of the plutonium particulates at Area 13 (and possibly elsewhere) are small enough to be picked up by wind. Area 13 has yet to cleaned up and the plutonium there keeps on getting resuspended into other areas that don't have radiation monitoring equipment. The current monitoring network run by DOE cannot detect alpha or beta radiation (e.g., plutonium 239). (Wilshire, et al., 2008, pp. 395-398).

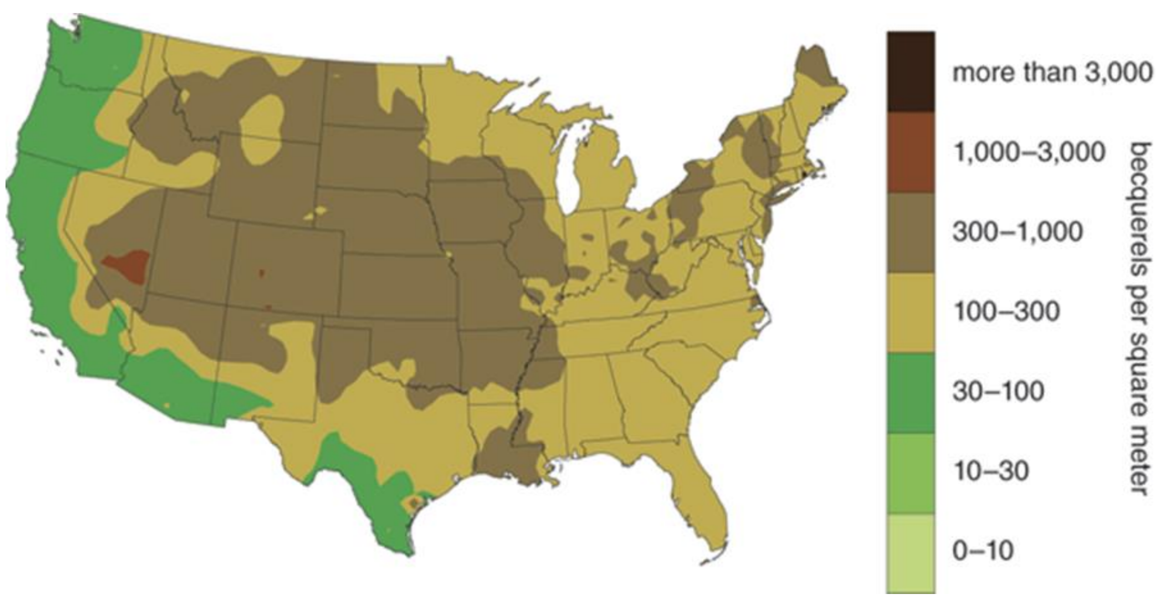
Utahns, both in the Southern and the more heavily-populated Northern end of the State, were, and still are, "downwinders." Many residents of the St. George and the Salt Lake City areas were heavily exposed at the time of the tests. Some are still dying from that exposure. The lack of data and fallout maps regarding these safety tests has prevented the public from appreciating the seriousness of ongoing risks of radiation-induced illness that lingers from the atomic tests that were conducted upwind of the State. The Department of Energy has yet to provide comprehensive data that would allow the risk to be quantified. The DOE's environmental analysis of Area 13 remains incomplete and its environmental cleanup of the area has stalled. The DOE should complete a new, full-blown EIS for the Nevada test sites to address these lingering radiation hotspots, the dangers of resuspension, and the lack of adequate airborne radiation monitoring in and around downwind communities.

[66] Figure 4 shows that the region of highest Plutonium soil deposition covers the region that Las Vegas plans to dewater with its groundwater pumping project. With the predictable die off of the vegetation cover of this region, its Plutonium-contaminated soils can be expected to become airborne during periods of high wind.

It is almost certain that dust storms from the Great Basin still deliver radioactive isotopes to the environment where millions of Utah's residents live. While the risk of radionuclide contamination has not been quantified, we do know that the risk that contaminated soil will be resuspended in the atmosphere and exported beyond the original deposition site rises dramatically where the size of the particles of contaminated soil are small, the soil has been mechanically disturbed (by grazing animals' hooves, road cuts, etc.), or the surface has been subjected to fire. (Gilbert, et al., 1988, pp. 869-87). DOE should conduct a survey of the deposition region that collects data on all of these characteristics to inform future land use plans.

Figure 6, taken from a 1997 National Cancer Institute study, shows the pattern of soil deposition of cesium-137, a radionuclide traditionally used for reference, resulting from all NTS tests in the entire United States.

Figure 6

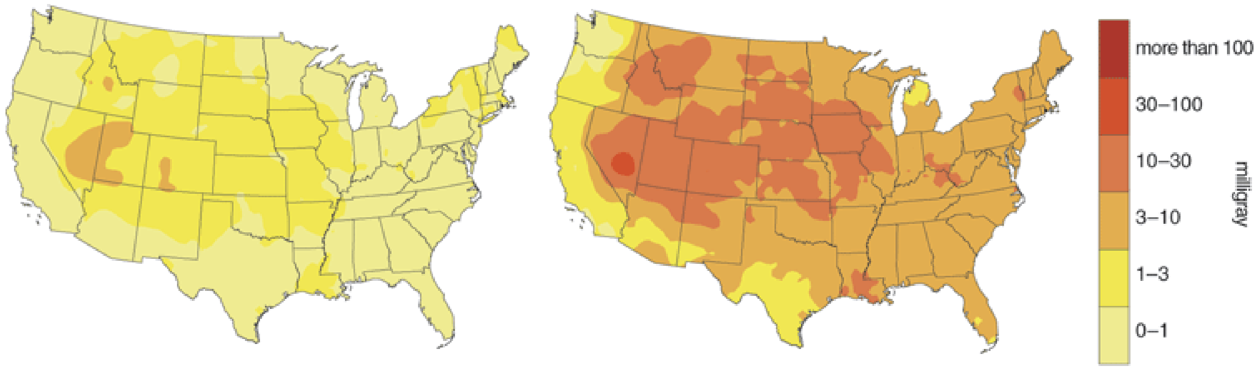


Cesium-137 deposition density resulting from the cumulative effect of the Nevada tests. Data from 1997 National Cancer Institute study.

Fallout decreased with distance from the NTS along the prevailing wind direction, which was from west to east. Very little fallout was observed along the Pacific coast, which was usually upwind from the NTS. The soil deposition of Strontium 90, another long-lived radionuclide, is virtually identical to that of Cesium 137. (Dept. of Health and Human Services, 2005).

Estimated internal doses of Cesium 137 absorbed by bone-marrow and the thyroid gland are illustrated in Figure 7 on the left. External doses are illustrated on the right. The internal doses present the greatest health risk. The fact that both external and internal doses were roughly proportional to the deposition density is reflected in similarities between the two figures.

Figure 7



Total external and internal dose to the red bone marrow of persons born on January 1, 1951, from all Nevada tests is shown at left. Data from NCI 1997.

In a 2009 masters thesis, a study was conducted using soil samples from Utah's Washington County to determine how much Cesium 137 still exists there. Over a hundred soil samples were collected and analyzed. Only one did not have detectable amounts of Cesium. The author noted that several of the samples contained levels substantially higher than earlier estimates would have predicted, which led him to conclude that doses to the public from the testing could also have been higher than had previously been estimated. http://ir.library.oregonstate.edu/xmlui/handle/1957/9293.

If Cesium 137 is still that prevalent in soil in Washington County, Utah, one can assume that it, and other long-lived radioactive isotopes, would be all the more prevalent in soil in the area of the State where aquifers would be drained, parts of which are closer to the Nevada Nuclear Testing Site. The combined effects of global warming and aquifer draining could well destroy the vegetative cover that keeps those soils in place. Windstorms could then carry that radioactive dust to the Wasatch Front, as air currents did during the bomb testing of the 1950s.

Science has established that there is no safe level of radioactivity exposure. The National Academy of Sciences Biological Effects of Ionizing Radiation (BEIR) Report VII from 2005 states,

> [a] comprehensive review of available biological and biophysical data supports a “linear-no-threshold” (LNT) risk model, that the risk of cancer proceeds in a linear fashion at lower doses without a threshold and that the smallest dose has the potential to cause a small increase in risk to humans.

Radiation damage is cumulative and each successive dose builds upon the cellular mutation caused by the last. One mutation, in one gene, in a single cell, if unrepaired, can result in a fatal cancer. Many cancers, especially solid tumors, and other genetic diseases have a latency period of many decades. Utah residents are still contracting new cancers from the original nuclear testing program conducted more than 50 years ago.

Even small increases in risk per person become significant public health hazards in the aggregate, when large numbers of people are exposed. In other words, when millions of people are exposed to slightly increased risks, there will be thousands of new victims.

It should be emphasized that cancer is not the only health risk of radiation exposure. Cardiovascular disease causing heart attacks, strokes and diseases consequent to immunosuppression are all correlated to radiation exposure, as are any diseases related to chromosomal dysfunction, such as birth defects. Children are much more susceptible to radiation-caused health effects and human embryos, especially during early gestation, are perhaps thousands of times more at risk for genetic mutations from radiation exposure than are adults. There are over 2,600 diseases described in the medical literature caused by genetic mutations. Once they occur, mutations are, in a sense, immortal. They are passed down from generation to generation in perpetuity, impacting the health of future generations.

The radioactive contamination from nuclear testing still present in Great Basin soil and dust has medical ramifications that will never cease. It will affect the health and viability of future generations forever; inducing epidemics of cancer, leukemia and genetic disease. There is a critical need for a systematic survey of concentrations of residual radioactive isotopes in the surface soil of the Nevada nuclear test sites and adjacent contaminated areas so that modeling could be done to assess potential public exposure to radioactive dust from those sites should future climate change and aquifer draining combine to destroy the vegetation that now holds those soils in place.

Mercury exposure

On a per-weight basis, mercury is considered the most toxic substance on earth, after plutonium, and the most toxic natural heavy metal. The exposure of Utah's residents to mercury can be expected to increase as a result of the effects of climate change in all parts of the globe. Mercury has become a ubiquitous contaminant of the global environment primarily because of industrial emissions from coal power plants and cement production plants. As the arctic thaws, mercury from those sources that is now trapped in ice will be released into the global atmosphere.

Forest fires release mercury as well. As the forest fire season becomes longer and more severe, mercury contamination will increase. New studies also suggest that the particulate matter component of forest fire pollution may be as much as ten times more toxic than industrial or vehicle pollution--due, in large part, to its mercury content. A potential source of additional exposure to mercury is windblown dust from the surface soils of central Nevada which have been contaminated by mercury released during the smelting phase of the numerous gold mine operations in the region.

Mercury is a potent neurotoxin. In one out of six U.S. women of child bearing age, it is already in high enough concentrations that any child conceived would be at risk for some loss of intellectual function. Mercury contamination of fish is already ubiquitous throughout the US. A recent US Geological Survey demonstrated mercury contamination of every fish that was sampled from over 300 streams and rivers in the country. Utah already has a serious problem with environmental mercury contamination. The fish in most of its lakes and streams have so much mercury that they are unsafe for human consumption.

The Great Salt Lake has the highest level of mercury of any inland body of water measured in the United States. Because of toxic mercury levels found in ducks along the Great Salt Lake ecosystem, Utah has the nation's only advisories against eating waterfowl. http://articles.latimes.com/2008/aug/10/news/adme-saltlake10. As Utah's climate becomes hotter and dryer, the level of the lake will inevitably drop, exposing more of the contaminated lake bed to windstorms, increasing the mercury exposure of the people that inhabit the Wasatch Front. As noted below, the Great Salt Lake Minerals Corporation plans to triple the size of its evaporating ponds. If that plan is implemented, it will lower the level of the lake still further, exposing more contaminated lake bed, further increasing the public's exposure to windblown heavy metals, including mercury and selenium.

Particulate exposure

As described above, climate change can be expected to lead to further desertification of the Great Basin, threatening to turn it into a dust bowl. This is especially true of central Nevada, which lies upwind of the Wasatch Front, and faces the prospect of disastrous drying out and ground cover die off due to Las Vegas's plans to drain those aquifers.

The Southern Nevada Water Authority (SNWA) is aggressively pursuing permission to build pipelines to drain the aquifers of central Nevada and western Utah and transfer the water to Las Vegas. The proposed pipeline would cost more than $15 billion. It would run from Las Vegas 285 miles to the northeast to Spring Valley with three primary laterals connecting Spring, Snake, and Cave Valleys to the pipeline. It would pump up to 180,000 acre feet from valley wells. It would be the biggest groundwater pumping project ever built in the United States. It would have devastating ecological impacts across vast areas of central Nevada and Western Utah.

The basic premise of the project is to mine water from valleys that receive 6 inches of rain a year, to supply a region that gets 4 inches of rain a year. There is no surplus water in these valleys. This is evident from the effect that pumping much smaller amounts to water livestock and crops currently has. This amount of pumping is trivial compared to what SNWA proposes, and it already has caused springs and marshes to dry up. The Snake Valley is known for its fierce winds that can blow as much as 70 miles an hour for anywhere from several hours to several days. According to Snake Valley rancher Dean Baker:

> Virtually any level of pump irrigation here leaves nearby springs dry, and the vegetation dies. And once the vegetation goes, the dust will really start blowing around. If the pipeline dries this county up, and I'm certain the water just isn't there, then what happens?"

(PLAN Report, 2006, at 40). These valleys already live on the margin of viability. Every acre-foot of water taken can be expected to cause plants or animals currently living in these ecosystems to die.

Groundwater is the source of seeps and springs. It can be a major source of marshes, streams, and lakes, as well, which is why these often dry up when groundwater wells are pumped. The aquifers under these valleys are a connected system, so that draining the groundwater under one valley can dry up another. Seventy percent of the 100-mile-long Snake Valley lies in Utah, so this project would dewater a substantial portion of Utah as well. The balance of aquifer systems is delicate, and the balance of desert areas is often extremely delicate. It doesn't take much disruption to wreak havoc, as the history of similar dewatering projects in the United States and elsewhere shows.

If this $15 billion project is built, it will become a beast that must be fed. Rather than be allowed to sit empty, it will be put to work mining water, regardless of the ecological damage that such mining might do. This will accelerate the decline of central Nevada's sagebrush-bunchgrass ecosystems that is already underway due to climate change, and is likely to convert a large portion of central Nevada and western Utah into a dust bowl.

There is also an application before the Army Corps of Engineers by the Great Salt Lake Minerals Corporation for permission to greatly increase the amount of Great Salt Lake water they are allowed to divert to settling ponds for mineral extraction. If that is allowed, the water level will drop and thousands of acres of dry beach will be exposed. This will create an additional source of new dust pollution contaminating the air shed of the Wasatch Front whenever a storm front moves through.

When evaluating the likely effects of climate change on the health of the people of Utah, it is prudent to consider how the Dust Bowl formed in the Great Plains in the 1930s. It is also essential to consider why projects of the kind proposed by SNWA have already turned the Owens Valley and the Aral Sea to dust.

In his book, "The Worst Hard Time", Pulitzer Prize winner Timothy Egan chronicles the nightmare of the 1930s Dust Bowl, arguably the world's worst environmental disaster. For nine years tsunamis of dust pounded the Great Plains. Sometimes they lasted for weeks at a time, reached 10,000 feet high and blew as far east as the middle of the Atlantic Ocean. Because dirt coated every indoor surface, house cleaning began with a shovel. People and animals trapped outside in the storms risked blindness or suffocation.

Woody Guthrie wrote a song about the chronic "dust pneumonia", a lung disease that sickened or killed thousands of Midwesterners, especially children. In some counties one third of all deaths were due to "dust pneumonia." Heat waves led to plagues of insects. For mile after mile not a single green leaf survived as waves of grasshoppers devoured any plants that survived the weather.

The Dust Bowl of the 1930s had three ingredients: unusual heat and drought, coupled with land use mismanagement. With roots 18 feet deep, native prairie grasses had kept the soil in place for centuries. But, encouraged by ignorant government agencies and greedy real estate speculators, settlers were duped into plowing under native grasses to plant winter wheat that had no chance to survive extreme conditions.

The same three ingredients that led to the formation of the Dust Bowl are now coming together in the Great Basin. Scientists expect that climate change, if unchecked, will bring heat and drought worse than 1930s. If SNWA's groundwater mining project is implemented, it will supply the third ingredient that led to the Dust Bowl--land-use mismanagement and the loss of native vegetation that for centuries anchored the soil.

In the 1930s the ecological disaster of the Dust Bowl got very little attention in Washington, D.C., until the dust started filling the skies and affecting the air quality of the Nation’s capital. But despite reform of Federal land use policies, the Dust Bowl of the 1930s did not end until rain finally returned to the Great Plains. The Great Basin is not likely to see rain reverse the environmental damage that draining its aquifers will cause.

The dessicated bed of Owens Lake has become the largest source of particulate air pollution in the United States. It has set the record for particulate concentrations measured in the U.S. Keeler, California is the nearest town, 60 miles away. It experiences particulate pollution that violates the NAAQS about 25 days per year. Dr. Bruce Parker, one of the emergency room physicians at Ridgrecrest Community Hospital made this statement:

> When we see the white cloud headed down through the pass, the ER and doctors' offices fill up with people who suddenly got worse. It's pretty straightforward cause and effect. http://geochange.er.usgs.gov/sw/impacts/geology/owens/.

An additional health hazard presented by the particulate pollution generated in the Owens Valley is arsenic and other trace metals carried by the dust. These appear in concentrations as high as 400 ng/m3. http://geochange.er.usgs.gov/sw/impacts/geology/owens/.

The history of Kazakhstan’s diversion of the inlet waters to the Aral Sea must also be considered when examining the consequences of climate change coupled with the planned draining of central Nevada’s aquifers. Called one of the world's worst environmental disasters by the UN's Secretary General Ban Ki-Moon, the Aral Sea is now 10% of its original size. Due to increased dust storms generated in the now-dry lake bed, respiratory illnesses, including drug resistant tuberculosis, brucellosis, cancer, digestive disorders, anemia, and infectious diseases are now common ailments in the region. Liver, kidney and eye problems can also be attributed to the toxic dust storms. There is an unusually high fatality rate amongst vulnerable parts of the population. The child mortality rate is 75 in every 1,000 newborns, and the maternity death rate is 12 in every 1,000 women.

In 2002 the UN estimated that winds carried an average of 200,000 tons of salt and toxic dust every day throughout the Aral Sea region and thousands of miles beyond, as far as Russia's arctic north. The dust is heavily polluted with herbicides, heavy metals, and salt. http://www.columbia.edu/~tmt2120/impacts%20to%20life%20in%20the%20region.htm; http://www.reuters.com/article/2008/06/24/idUSL23248577.

Average life expectancy in the Aral Sea region has declined from 64 to 51 years. Reproductive pathologies and adverse pregnancy outcomes are much higher than the rest of the former USSR and present-day Russia. Eighty-seven percent of newborn babies are anemic and 5% have birth defects. Ataniyazova, O., 2003). Health authorities in the area are largely in agreement that the newly formed dust bowl and the toxic chemicals contained in the dust is the primary cause of these disturbing public health trends.

Some skepticism is natural that dust originating in central Nevada could travel 200 miles downwind to be deposited on the Wasatch Front. PM10, however, can be transported more than 1,000 km even in light storms. (Tsoar and Pye, 1987, p. 139-153.) Researchers from the University of Washington found that dust from the Gobi and Taklimakan deserts in China is routinely present in the air over the western United States. http://www.sciencedaily.com/releases 2007/12/071213000427.htm. The National Weather Service has stated that dust generated in the Gobi Desert affects the air quality and sunsets visible in Utah. http://www.usatoday.com/weather/news/2001/2001-04-18-asiandust.htm. Researchers from the University of California at Davis, using a monitoring station at the top of Donner Summit, concluded that most of the particulate pollution measurable over Lake Tahoe originates in China and that one third of it is dust from drought and deforestation. http://www.sierrasun.com/article/20060731/NEWS/60731006. NASA has documented that forest fires in Russia and Canada have created a poisonous ring of particulate pollution around the entire planet. http://www.thehindu.com/news/internationalarticle566562.ece.

As noted above, dust from the Southwest has already been shown to hasten the melting of snow in the Rocky Mountains, reducing the amount of runoff into the upper Colorado River by 6%, ultimately causing a loss of 250 billion gallons of water a year.

http://latimesblogs.latimes.com/greenspace/2010/09/colorado-river-water-california-dust-grazing.html; (Painter T, et al., 2010, pp. 17125-17130. Dust from the Sahara Desert is regularly transported to Europe. In fact, a recent study demonstrated that Sahara Desert dust is frequently responsible for violating the European Union's standard for PM10. Furthermore, a study of over 80,000 residents in Rome, Italy, found increased death rates from cardiac, respiratory, cerebrovascular, and natural causes related to increases in PM10 from Saharan dust outbreaks. The relationship was present even at levels that would have been below the EPA's standards in the United States. http://www.thehindu.com/news/internationalarticle566562.ece.

The World Health Organization published a hundred-page document titled, The Health Risks of Particulate Matter From Long-Range Transboundary Air Pollution. It observes that PM in the size between 0.1 μm and 1 μm can stay in the atmosphere for days or weeks and thus can be transported over long distances in the atmosphere (up to thousands of kilometres). The coarse particles are more easily deposited and typically travel less than 10 km from their place of generation. However, dust storms may transport coarse mineral dust for over 1000 km.

Medical research of the last ten years has identified ultrafine particle pollution as the most dangerous because it travels deeper into body membranes when inhaled, can invade virtually any cell in the body, penetrate cell membranes, and create a chemical toxicity within organelles and the nucleus of the cell. (Geiser, et al., 2005, pp.:1555-1560). The WHO report goes on to state,

> Health effects are observed at all levels of exposure, indicating that within any large population there is a wide range of susceptibility and that some people are at risk even at the lowest end of the observed concentration range.

Medical research conducted since this 2006 report has significantly strengthened that contention.

These case studies demonstrate that climate change in the Great Basin, coupled with the planned dewatering much of the Great Basin that lies upwind from the Wasatch Front, has the potential to repeat the tragedies of the dust bowls created in the Great Plains, the Owens Valley, and the Aral Sea.

Pathogen exposure

Soils in the Western United States also harbor significant concentrations of microorganisms like *coccidiodomycosis*, the fungal spores that cause Valley Fever. Valley Fever is a disease with flu-like symptoms that is difficult to diagnose, and is sometimes fatal. It is spread by inhaling windblown coccidiodomycosis spores, known by the inhabitants of the Southwest as “Death Dust.” Valley Fever has quadrupled in the last ten years in the Southwest. The American Academy of Microbiology estimates that 200,000 people per year contract the disease, which is fatal in about one in 1,000 cases. People who are immunosuppressed, women who are pregnant, and diabetics, are particularly susceptible to serious courses of this disease.

Hotter temperatures associated with global warming will give the cocci a survival advantage over other microorganisms. More frequent and intense dust storms are the perfect delivery system for increasing this infectious disease among residents of the Western U.S. Dale Griffin, a USGS microbiologist, says that one gram of desert soil can contain as many as one billion microorganisms. Fungi can travel long distances because the spore “housing” acts like a cocoon, protecting the fungus from environmental stresses. More than 140 different organisms have been identified as "hitchhiking on to dust particulates.” These include SARS, meningitis, influenza and foot and mouth disease. http://wwwp.dailyclimate.org/tdc-newsroom/valley-fever/Valley-Fever-blowin2019-on-a-hotter-wind.

Climate change, through weather extremes, pollution, habitat fragmentation and destruction, and widespread extinction of species, is reducing the viability of world’s ecosystems. If allowed to continue, the collapse of these ecosystems is likely to be a major contributor to future pandemics of infectious disease.

V. SUMMARY

Sustaining life as we have known it in Utah presumes a future climate that is at least as favorable as it has been in the past 160 years. The science is very clear: we are headed into a hotter, drier climate that will threaten our forests, rivers, streams, lakes, pastures, and air quality, and virtually all of the resources we depend on for our quality of life. It will also threaten the continued viability of many of the industries that support our economy. The health of the public depends heavily on what happens to the community’s economy and quality of life. Climate change threatens everything that makes this desert we call Utah beautiful, unique, and life sustaining.

We join thousands of other scientists throughout the world who believe that prompt government action and international cooperation are necessary to avoid the multi-dimensional catastrophe that unchecked climate change will bring. No ideological tug-of-war should be allowed to obscure this message:

climate change is the greatest public health threat of the 21st century—in Utah, as in the rest of the planet. Falling to respond to this threat is the riskiest course of all, because climate change is a long-term problem that carries with it a huge procrastination penalty.

The Clean Power Plan's proposed state standards for reducing CO_2 emission-rates for existing power plants is too modest to meet America's obligation to keep global warming within the 2°C limit that was committed to in Copenhagen. The ratio of benefit to cost of curbing CO_2 and related emissions is so high, and the net economic impacts are so positive, that there is plenty of room to raise those standards, both for Utah and the nation.

Sincerely,

Brian Moench, MD

President, Utah Physicians for a Healthy Environment

REFERENCES

NOTE -- The References below are associated with Sections II through V of the comments submitted. Because Section I has been recently revised to reflect newly published research, references in that section are provided in internal footnotes.

Baris, Y., et al., An outbreak of pleural mesothelioma and chronic fibrosing pleurisy in the village of Karain/Urgup in Anatolia. Thorax 33: 181-192, 1978.

Belnap, J., and Lange, O. L., 2003, Biological Soil Crusts: Structure, Function, and Management, in Baldwin, I. T., Caldwell, M. M., Heldmaier, G., Lange, O. L., Mooney, H. A., Schulze, E.- D., and Sommer, U., eds., Ecological Studies Series 150, Volume 150: Berlin, Springer- Verlag, p. 503.

Belnap, Jane, Susan L. Phillips and Mark E. Miller. 2004. Response of desert biological soil crusts to alterations in precipitation frequency. Oecologia 141: 306-316.

Carbone M, Barisb Y, Bertinoa P, et al., 2011, Erionite exposure in North Dakota and Turkish villages with mesothelioma. PNAS August 16, 2011, vol. 108, no. 33, 13618–13623.

Chambers, Jeanne C. 2011. [document review] April 11. On file at U. S. Department of Agriculture, Forest Service, Humboldt-Toiyabe National Forest, Sparks, NV.

Chambers, Jeanne C. and Mike Pellant. 2008. Climate change impacts on Northwestern and Intermountain United States rangelands. Rangelands 30(3):29-33.

Climate Change: Evidence, Impacts, and Choices, National Research Council of the National Academies of Science Brochure, p. 7. http://nas-sites.org/americasclimatechoices/more-resources-on-climate-change/.

Davis, M., Shaw, R., Range Shifts and Adaptive Responses to Quaternary Climate Change, Science, Vol. 292, April 27, 2001.

Department of Health and Human Services, A Feasibility Study of the Health Consequences to the American Population from Nuclear Weapons Tests Conducted by the United States and Other Nations (2005), available at http://www.cdc.gov/nceh/radiation/fallout/default.htm.

Dr. Oral A. Ataniyazova, M.Sc., the Karakalpak Center for Reproductive Health. Health and Ecological Consequences of the Aral Sea Crisis and Environment, Uzbekistan. Prepared for the 3rd World Water Forum Regional Cooperation in Shared Water Resources in Central Asia, Kyoto, March 18, 2003.

Epidemiological and Environmental Evidence of the Health Effects of Exposure to Erionite Fibres: A four-year study in the Cappedocian region of Turkey, Int. J. Cancer 39, 10-17 (1987).

Epstein, et al., Full Cost Accounting for the Llife Cycle of CoalIssue: Ecological Economics Reviews; doi: 10.1111/j.1749-6632.2010.05890.x; Ann. N.Y. Acad. Sci. 1219 (2011) 73–98 c 2011.

Erionite Exposure and Mesotheliomas in Rats, J.C. Wagner, et al., Journal of Cancer (1985), 51, 727-730.

Erionite Exposure in North Dakota and Turkish villages with Mesothelioma. Carbone, et al.; Proceedings of the National Academy of Sciences, (June, 2011) www.pnas.org/cgi/goi/10.1073/pnas.1105887108.

Geiser M, et al., Ultrafine Particles Cross Cellular Membranes by Nonphagocytic Mechanisms in Lungs and in Cultured Cells, Environ. Health Perspect. (2005), 113:1555-1560, doi:10.1289/ehp.8006 (12).

Gilbert, R., et al., Radionuclide transport from soil to air, native vegetation, kangaroo rats and grazing cattle on the Nevada test site, Health Phys. 1988 Dec; 55(6):869-87. http://www.ncbi.nlm.nih.gov/pubmed/3198397.

Glick, P., Fueling the Fire: Global Warming, Fossil Fuels and the Fish and Wildlife of the American West (Reston, VA: National Wildlife Federation, 2006).

http://articles.latimes.com/2008/aug/10/news/adme-saltlake10.

http://droughtmonitor.unl.edu/.

http://e360.yale.edu/slideshow/loss_of_arctic_sea_ice_already_influencing_weather/74/4/.

http://geochange.er.usgs.gov/sw/impacts/geology/owens/.

http://ir.library.oregonstate.edu/xmlui/handle/1957/929.

http://latimesblogs.latimes.com/greenspace/2010/09/colorado-river-water-california-dust-grazing.html.

http://openchannel.msnbc.msn.com/_news 2011/10/07/8190110-health-concerns-grow-over-little-known-mineral; Nature 468, 884-885 (2010) | doi:10.1038/468884a. Published online 9 December 2010.

http://robertscribbler.wordpress.com/2013/07/16/dr-jennifer-francis-top-climatologists-explain-how-global-warming-wrecks-the-jet-stream-and-amps-up-hydrological-cycle-to-cause-dangerous-weather/;

http://robertscribbler.wordpress.com/2014/01/23/arctic-heat-wave-to-rip-polar-vortex-in-half-shatter-alaskas-all-time-record-high-for-january/.

http://robertscribbler.wordpress.com/tag/dr-jennifer-francis.

http://www.airquality.utah.gov/Public-Interest/Current-Issues/Ozone/2012_Utah_Ozone_Study.pdf.

http://www.cdc.gov/nceh/radiation/fallout/default.htm.

http://www.colorado.edu/news/releases/2013/11/14/new-study-dust-warming-portend-dry-future-colorado-river.

http://www.columbia.edu/~tmt2120/impacts%20to%20life%20in%20the%20region.htm; http://www.reuters.com/article/2008/06/24/idUSL23248577.

http://www.deq.utah.gov/BRAC_Climate/docs/Final_Report/Sec1_SCIENCE_REPORT.pdf;

http://www.deq.utah.gov/BRAC_Climate/docs/Final_Report/Sec-A-1_SCIENCE_REPORT.pdf.

http://www.deq.utah.gov/envrpt/Planning/s12.htm.

http://www.h-o-m-e.org/nts-vision-project/nts-briefing-paper.html.

http://www.mindfully.org/Nucs/Groves-Memo Manhattan30oct43.htm.

http://www.nature.com/nature/links/040108/040108-1.html.

http://www.nytimes.com/gwire/2010/10/01/01greenwire-air-quality-concerns-may-dictate-uintah-basins-30342.html?pagewanted=all.

http://www.pbs.org/wgbh/evolution/library/03/2/l_032_04.html.

http://www.sciencedaily.com/releases 2007/12/071213000427.htm.

http://www.sciencedaily.com/releases/2008/04/080416153558.htm.

http://www.scientificamerican.com/article/mountain-pine-beetle-damage-declines/.

http://www.sierrasun.com/article/20060731/NEWS/60731006.

http://www.thehindu.com/news/internationalarticle566562.ece.

http://www.usatoday.com/weather/news/2001/2001-04-18-asiandust.htm.

http://www.usatoday.com/weather/news/2001/2001-04-18-asiandust.htm.

http://www.usu.edu/weeds/great_basin/ecology.html.

http://wwwp.dailyclimate.org/tdc-newsroom/valley-fever/Valley-Fever-blowin2019-on-a-hotter-wind.

Humboldt-Toiyabe National Forest Climate Change Vulnerability Report, April 2011. http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5294901.pdf./

Las Vegas and the Groundwater Development Project: Where Will It Start, Where Will It End, A Progressive Leadership Alliance of Nevada (PLAN) Report, (2006), at 40,
http://greatbasinwaternetwork.org/pubs/PLAN_Report_Pipeline.pdf.

Loehman, R. 2010. Understanding the science of climate change: talking points - impacts to Arid Lands. Natural Resource Report NPS/NRPC/NRR—2010/209. National Park Service, Fort Collins, Colorado.

McCabe, Gregory J.; Wolock, David M. 2009. Recent declines in western U.S. snowpack in the context of twentieth-century climate variability. Earth Interactions V13, No.12 .

McKenzie, D., Z.M. Gedalof, D.L. Peterson, and P.W. Mote. 2004. Climatic change, wildfire, and conservation. Conservation Biology 18(4):890-902.

Miller, Richard F. and Robin J. Tausch. 2000. The role of fire in juniper and pinyon woodlands: a descriptive analysis. Pages 15–30 in K.E.M. Galley and T.P. Wilson (eds.). Proceedings of the Invasive Species Workshop: the Role of Fire in the Control and Spread of Invasive Species. Fire Conference 2000: the First National Congress on Fire Ecology, Prevention, and Management. Miscellaneous Publication No. 11, Tall Timbers Research Station, Tallahassee, FL.

Painter T, Deems J, Belnap J, Hamlet A, Landry C, Udall B., Response of Colorado River runoff to dust radiative forcing in snow. PNAS 2010 107 (40) 17125-17130; published ahead of print September 20, 2010, doi:10.1073/pnas.0913139107.

Pass H, Vogelzang N., Carbone, M., 2005. Malignant Mesothelioma: Advances in Pathogenesis, Diagnosis, and Translational Therapies.

Real E, Law K, Weinzier B, Fiebig B, et al. Processes influencing ozone levels in Alaskan forest fire plumes during long-range transport over the North Atlantic. Journal of Geophysical Research D: Atmospheres 112 (2007) D10S41.

Ryan, M.G., S.R. Archer, R. Birdsey, C. Dahm, L. Heath, J. Hicke, D. Hollinger, T. Huxman, G. Okin, R. Oren, J. Randerson, and W. Schlesinger, 2008. Land Resources. In The effects of climate change on agriculture, land resources, water resources, and biodiversity in the United States. A Report by the U.S. Climate Change Science Program and the Sub¬committee on Global Change Research. Washington, DC., USA, p. 362.

See, e.g., Gilbert, R., et al., Radionuclide transport from soil to air, native vegetation, kangaroo rats and grazing cattle on the Nevada test site, Health Phys. 1988 Dec; 55(6):869-87. http://www.ncbi.nlm.nih.gov/pubmed/3198397.

Spraklen et al., Impacts of climate change from 2000 to 2050 on wildfire activity and carbonaceous aerosol concentrations in the western United States, Journal of Geophysical Research, DOI:10.1029.

The American West at Risk: Science, Myth, and Politics of Land Abuse and Recovery, by Howard G. Wilshire, Jane E. Nielson and Richard W. Hazlett , Oxford University Press (2008), pp.395-398.

Thomas, C. et al., Extinction Risk from Climate Change, Nature, Vol. 427, January 8, 2004.

Tilman, D., 2000. Causes, Consequences and Ethics of Biodiversity, Insight and Overvierw, http://www.lter.umn.edu/biblio/fulltext/t1780.pdf.

Tsoar, H., and K. Pye, 1987, Dust transport and the question of desert loess formation: Sedimentology, v. 34, p. 139-153.

Wagner, J. et al., Erionite exposure and mesotheliomas in rats, Br. J. Cancer (1985), 51, 727-730. Weissman, D., Keifer, M., Erionite: An Emerging North American Hazard, CDC National Institute for Occupational Safety and Health blog, http://blogs.cdc.gov/niosh-science-blog/2011/11/22/erionite/.

Walker, J., et al., Nevada Division of Environmental Protection Bureau of Federal Facilities, Long-Term Stewardship at the Nevada Test Site, (1998).

Westerling, A, 2008, Climate and Wildfire in the Western United States, UC Merced, http://meteora.ucsd.edu/cap/pdffiles/westerling_fire08.pdf.

Westerling, A., et al., Warming and Earlier Spring Increase Western U.S. Forest Wildfire Activity, Science, August 18, 2006, Vol. 313 no. 5789 pp. 940-943.