Continuously Less and Less
—The New American Reality

The fundamental enabler of our industrialized American way of life is continuous access to enormous quantities of inexpensive nonrenewable natural resources (NNRs)—energy resources, metals, and minerals. Unfortunately, future NNR supplies will be insufficient to perpetuate our American way of life, for both geological reasons and geopolitical reasons.

Geologically, an ever-increasing number of NNRs are near, at, or past their peak production levels; NNR supplies available to the US are or will soon be in terminal decline.

Geopolitically, our foreign NNR suppliers, who are also our competitors for remaining global NNR supplies, are becoming less willing to export their increasingly scarce NNRs to the US in exchange for our continuously devaluing US dollars and our unrepayable US debt.

Since our continuously declining domestic NNR supplies are woefully inadequate to enable our American way of life, and our imported NNR supplies will decline continuously going forward, we will experience permanent NNR supply shortfalls in the not-too-distant future that will cause American society to collapse.

The following paper presents quantified evidence to support this contention.

The paper provides a comprehensive analysis of 58 nonrenewable natural resources for which the US Geological Survey and US Energy Information Administration keep current and historic production, pricing, and utilization data. Specifically, the paper assesses the extent to which nonrenewable natural resource (NNR) supplies available to America are becoming increasingly scarce, and the extent to which America is vulnerable to an imminent and permanent NNR supply shortfall associated with each of the 58 analyzed NNRs.

Finally, the paper discusses the implications associated with NNR scarcity and NNR supply shortfalls on our American way of life and American society.

Supporting data tables, NNR myths, and possible sources of error associated with the paper's analyses and findings are provided in the appendixes.

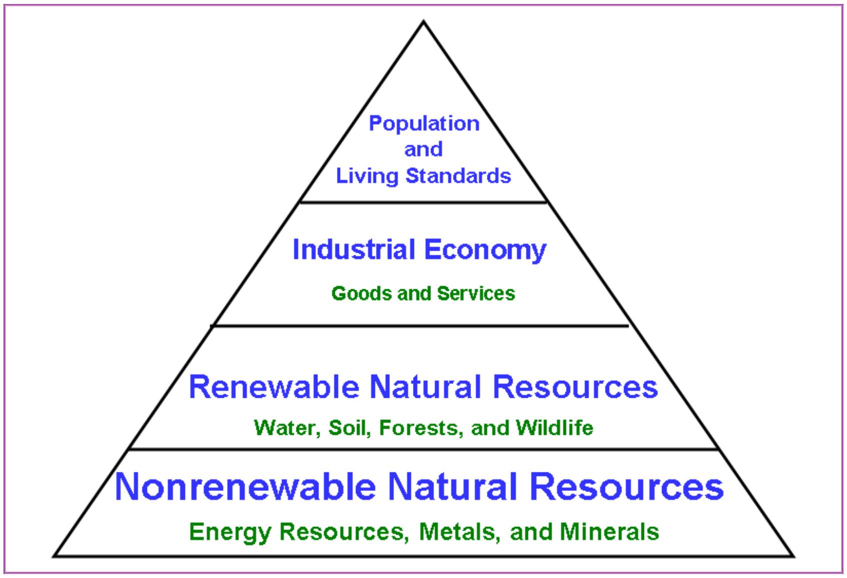
Contents

It's All About Natural Resources

Natural Resources as "Life Enablers"

Renewable natural resources (RNR)—i.e., air, water, soil, forests, and wildlife—enable all life, including human life. RNRs provide the essentials—water, food, energy, clothing, and shelter—that support life in all human societies.

Industrialized Societal Model



Nonrenewable natural resources (NNR)—energy resources, metals, and minerals—enable industrialized life in countries such as America.

NNRs play two critical roles in enabling industrialized human existence:

- They enable RNRs to be utilized in ways and at levels that are necessary to support the extraordinary population levels and material living standards associated with industrialized societies; and
- They enable the production and provisioning of "modern" goods and services that differentiate industrialized societies from non-industrialized societies—e.g., airplanes, computers, skyscrapers, super-highways, refrigerators, light bulbs, synthetic fabrics, etc.—and that are not possible through the exclusive utilization of RNRs.

NNRs and America's Historically Unprecedented Success

As recently as the year 1800, our American way of life was still predominantly agrarian—over 90% of American workers were involved in agriculture. Today, the US is the largest and most highly developed industrialized nation in the world. Currently, less than 2% of our workforce is involved in agriculture.[1]

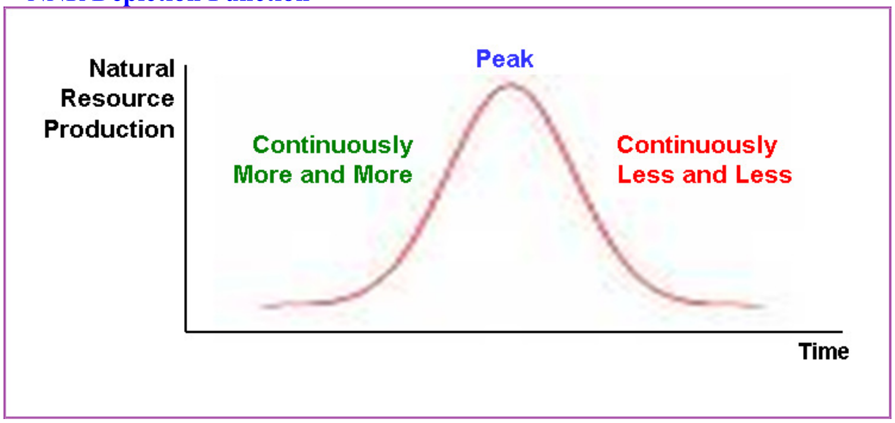
The key to our success—to the inception and perpetuation of our industrialized American way of life—has been continuous access to enormous quantities of affordable nonrenewable natural resources. Cheap and abundant NNRs have enabled the meteoric growth in our economic activity level, the extraordinary growth in our population level, and the continuous improvement in our material living standards.

Today, 95% of the natural resources that flow into the US economy are nonrenewable, compared with less than 10% NNRs in the year 1800.[2] We currently use approximately 6.5 billion tons of NNRs per year, which equates to nearly 43,000 pounds for each US citizen—compared with approximately 4 million tons of total NNR utilization, or 1500 pounds per capita, in the year 1800.[3]

NNR Depletion

Unfortunately, NNRs are finite—that is, the supply associated with every nonrenewable natural resource is fixed and limited. Since NNR supplies are not replenished within a timeframe that is relevant from the perspective of a human lifespan, any NNR use results in the "net depletion" of a finite resource—we are drawing against a one time inheritance.

NNR Depletion Function



In the absence of human-induced supply manipulation, the depletion function associated with an NNR typically approximates a normal distribution (bell curve).[4]

NNR supply initially experiences a period of "continuously more and more", as discoveries increase, exploration and production technologies improve, and the highest quality deposits are exploited. Assuming persistent and increasing production, NNR supply reaches its maximum level—its production peak;[5] which is followed by a period of "continuously less and less"—terminal supply decline, as NNR production activity is relegated to fewer, smaller, lower quality deposits.

Most of the NNRs that enable our American way of life have already reached their domestic US production peaks, and are near, at, or past their global production peaks. Available supplies associated with these NNRs have entered or will soon enter terminal decline, at a time when demand from existing industrialized nations and newly industrializing nations is rapidly increasing.

As "continuously more and more", to which we have become accustomed over the past several centuries, becomes "continuously less and less", historically abundant and inexpensive NNRs will continue to become increasingly scarce and expensive. The consequences associated with this Nature-imposed geological phenomenon, over which we have no control, will be devastating for industrialized nations such as America.

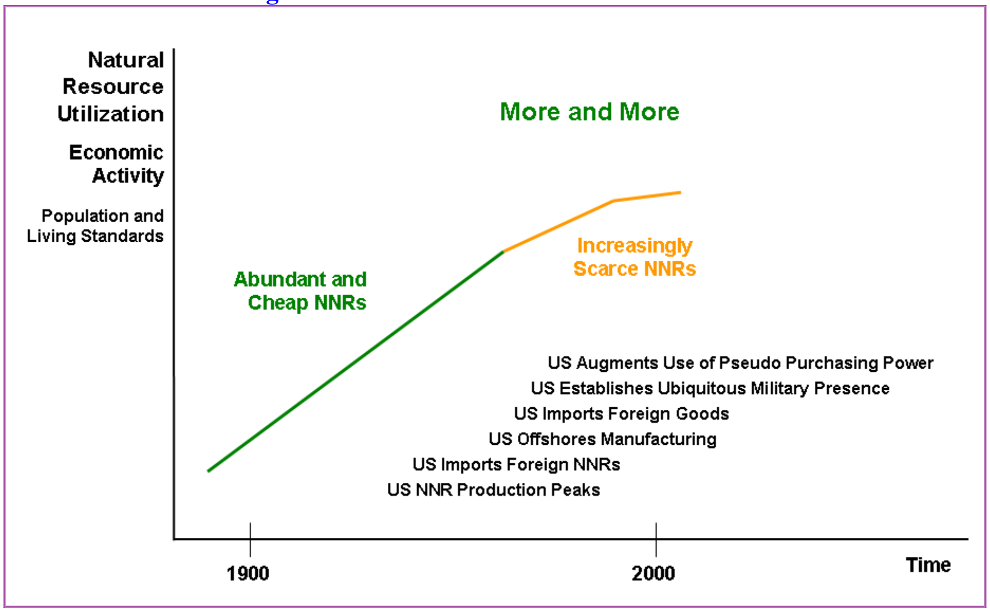
Ever-increasing NNR Scarcity

"Scarcity", as it pertains to natural resource availability, occurs when NNR supply is unable to keep pace with demand. NNR scarcity can result from geological factors and geopolitical factors.

America's Past—Continuously More and More

Our primary objective as "modern Americans" has been to obtain "continuously more and more"—to achieve ever-improving material living standards for our ever-increasing population—to achieve perpetual economic growth and prosperity—to continuously increase our level of societal wellbeing. Our credo has been "every American generation will have it better than the last".

US Societal Wellbeing—Industrial Past



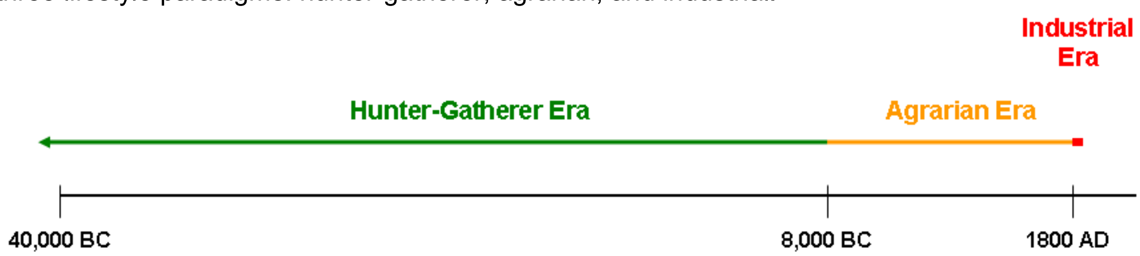
In order to accomplish this objective we have made ever-increasing use of abundant and cheap nonrenewable natural resources—initially from domestic sources, ultimately from foreign sources.

In the process, we established our American way of life—300+ million people enjoying historically unprecedented material living standards. We also substantially depleted the NNR reserves upon which our way of life and our very existence depend.

Pre-industrial America

The first human beings migrated to America over 40,000 years ago from Berengia, the "land-bridge" that spanned the Bering Sea between today's Northeast Siberia and Alaska at the time of the Wisconsin glaciation.[6] During the ensuing millennia, ancestors of these original Americans migrated to every habitable region in North, Central, and South America.

As was the case with human inhabitants in other regions of the world, Americans evolved through three lifestyle paradigms: hunter-gatherer, agrarian, and industrial.



The primary attributes associated with the industrial lifestyle paradigm are mechanized mass production facilities and processes, the division of labor, and the voracious consumption of nonrenewable natural resources.

American Industrialization

The Industrial Revolution commenced in the UK during the latter part of the 18th century. The "revolution" quickly spread to Western Europe, America, and Japan during the 19th century; and to the rest of Europe, Eastern Asia, and to several countries in Latin America and Africa by the end of the 20th century. Today, approximately 18% of the world's population can be considered "industrialized"[7], while an increasing number of countries in Africa, Latin America, and Asia are in the process of becoming industrialized.

The positive consequence associated with industrialization is a greater selection of higher quality goods and services at lower prices, which have enabled the historically unprecedented human population levels and material living standards associated with industrialized nations.

The negative consequence associated with industrialization is the unsustainable utilization of NNRs upon which the industrial lifestyle paradigm depends. It is our adoption of the industrialized lifestyle paradigm that is responsible for the ever-increasing NNR scarcity that we are experiencing today.

US as NNR Self-sufficient

By the early 20th century, the US industrial revolution was well underway. America, which was a veritable treasure trove of natural resources, was essentially self-sufficient with respect to NNR supplies, and with respect to the labor and the production facilities necessary to convert NNR inputs into finished goods and services outputs.

US wealth generated by our industrialized economy stayed "within the US system" for the most part; and, additional wealth "came into the US system" as a result of US exports of goods and services to foreign countries.

Following WWI, America became the de facto "production engine" for the world—the world's leading exporter of many NNRs and manmade goods and services. America's economic activity level, population level, and material living standards increased rapidly.

US as an NNR Importer

By the middle of the 20th century, many domestic US NNRs were near, at, or past their peak production levels, and we were forced to import increasing quantities of NNRs from foreign countries in order to supply the American production engine. US wealth began to flow "out of the US system", in order to pay for imported NNRs.

While America retained its status as the world's production engine, our declining domestic NNR supplies in combination with our ever-increasing labor and manufacturing costs began to erode our competitive position with respect to rapidly industrializing nations such as Japan and Germany, which had lower cost manufacturing operations and ready access to affordable NNRs.

In order to compensate for these competitive disadvantages, we established and continuously expanded our global military presence to insure continuous access to foreign NNR supplies at "favorable" prices. As a result of our "expansive" foreign policy, our economic activity level, population level, and material living standards continued to increase.

US as an Offshore Outsourcer

As an increasing number of NNRs reached their domestic US peak production levels during the latter part of the 20th century, our position as the world's leading producer of commodity goods, and ultimately of many high-end goods, continued to erode.

Our response was to outsource our corporate manufacturing operations through US-owned multinational corporations, to production facilities located in foreign countries that had low labor costs and access to affordable NNRs. US wealth now flowed "outside the US system" for foreign wages and production facilities, in addition to foreign NNRs.

While offshore outsourcing enabled us to further increase our economic activity level, population level, and material living standards, it did so at the expense of an increasing number of high-paying US manufacturing jobs, which were lost to lower-paid foreign workers in the process.

US as a Finished Goods Importer

As America transitioned from the 20th century to the 21st century, our domestically available NNR supplies continued to decline—even as our demand for manufactured goods and services continued to increase unabated. In order to satisfy this demand, we have resorted increasingly to importing finished goods and services that are produced and provisioned entirely by foreign-owned companies.

The inevitable consequence is that our control and ownership of the resource inputs, production, and provisioning associated with the goods and services that enable our American way of life have declined continuously. US wealth now flows "outside the US system" for the entire suite of product provisioning elements—raw materials (NNRs), marketing, engineering, production, distribution, service, administration, and profit.

To a disturbing degree, the US is becoming nothing more than a distribution outlet for foreign manufacturers. Our value-added contribution to the product provisioning process has continued to decline, as has our pool of "real wealth" available to procure the NNRs and derived goods and services that enable our American way of life.

As a result, we have resorted increasingly to pseudo purchasing power to procure our lifestyle perpetuating essentials. Pseudo purchasing power enables us to increase our "current" procurement level of natural resources and of the manmade goods and services derived from those resources, through fiscal imprudence—that is, by:

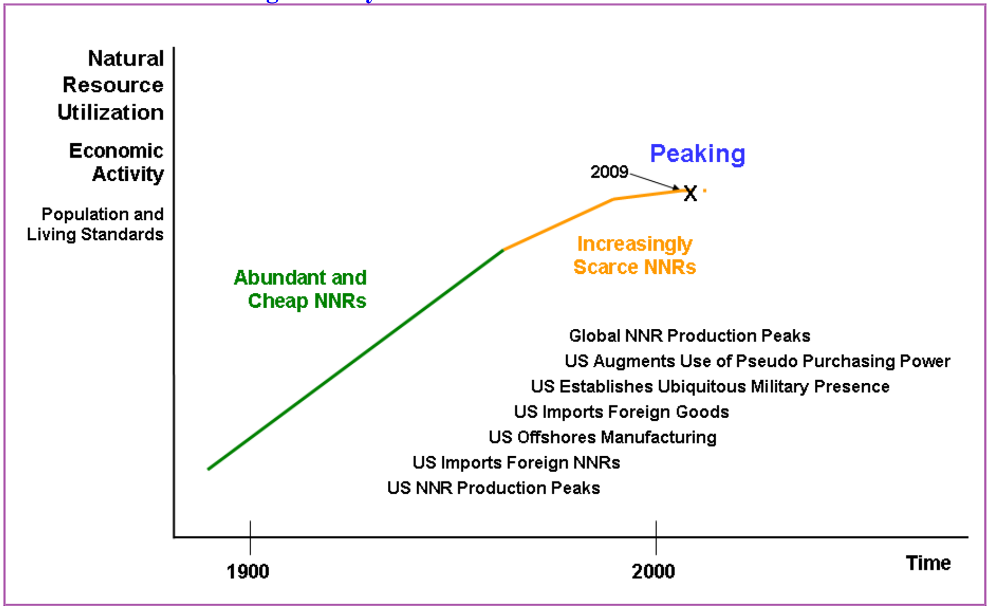
- Liquidating our previously accumulated economic asset reserves,
- Incurring ever-increasing levels of unrepayable intergenerational debt, and
- Underfunding investments critical to our future wellbeing.[8]

Increases in our economic activity level, population level, and material living standards over the past several decades are attributable almost exclusively to our ever-increasing reliance on pseudo purchasing power. In the year 2007, over two thirds of America's total consumption of goods and services was enabled by pseudo purchasing power.[9]

America Today—"Peak Societal Wellbeing"

Our American Dream is failing in realtime; we are near or at the peak of our attainable societal wellbeing level.

US Societal Wellbeing—Today



Our capacity to obtain "continuously more and more", thereby enabling ever-improving material living standards for our ever-increasing population, is near or at its peak for both geopolitical and geological reasons.

America retained its status as a manufacturing powerhouse so long as we also remained essentially self-sufficient with respect to our NNR supplies. Continuous access to abundant and inexpensive domestic NNRs enabled us to build our tremendous industrial base during the early stages of our industrial revolution, and to pay ourselves ever-increasing wages in the process.

As our domestic NNR supplies have become increasingly scarce, the foundation for our economic strength—and our American way of life—has eroded continuously. Countries in Eastern Asia, Central Asia, South America, and Africa have filled the void over the past several decades. To an increasing extent, they have enabled our American way of life by purchasing our debt and by accepting our US dollars in exchange for their NNRs, goods, and services.

They are becoming unwilling and/or unable to continue to do so.

Signs of Peaking US Societal Wellbeing

Signs of America's imminent peak in societal wellbeing first appeared decades ago, and are becoming increasingly numerous and evident as we approach the end to our era of "continuously more and more".

Continuously Devaluing US Dollar – using the year 1950 as a baseline, each US dollar provided $1 worth of purchasing power in 1950. By the year 1975, the purchasing power associated with a US dollar had declined to 43.6 cents—less than half of a dollar's value in 1950. By 2008, the purchasing power of a US dollar had further declined to 13.5 cents—only slightly more than 10% of a dollar's value in 1950.[10]

US Transition to a Service Economy – 1957 was the last year in which the "goods" sector of the US economy was larger than the "services" sector; by 2008 the "goods" sector comprised only 26% of the total US economy (GDP).[11]

US Foreign Oil Dependence – domestic US oil production peaked in 1970, and has declined at an average annual rate of 1.7% since that time; 1995 was the last year in which domestic oil production exceeded imports; we currently import approximately 2/3 of our oil.[12]

US Dollar Becomes a Fiat Currency – Richard Nixon "closed the gold window" in 1971, thereby reneging on America's pledge to exchange gold for US dollars among our international trading partners, and relegating US currency to intrinsically valueless pieces of paper.[13]

US Transition to a Net Importer – 1975 was the last year in which the value of US exports exceeded the value of US imports; our annual foreign trade deficit in 2008 was $669 billion.[14]

US Transition to a Debtor Nation – 1981 was the last year in which the amount of money owed by the rest of the world to the US exceeded the amount of money owed by the US to the rest of the world; by the end of 2008, the US, now the world's largest debtor nation by far, owed the rest of the world over $6 trillion more than the world owed us.[15]

US Net Asset Depletion – 1985 was the last year in which US ownership of foreign assets exceed foreign ownership of US assets; by the end of 2008, foreigners owned $3.5 trillion more US assets than we owned of foreign assets.[16]

Declining US Real Median Family Income – real (inflation adjusted) US median family income peaked at $61,000 in the year 2000, despite the economic boom that occurred between the year 2000 and the 2008 recession.[17]

Unfunded US "Social Entitlement" Programs – the amount by which projected future cash outflows associated with Social Security, Medicare, and Medicaid exceeded projected future cash inflows, expressed in today's dollars, exceeded $70 trillion at the end of 2008; this unfunded liability is increasing by nearly $3 trillion per year.[18]

Unrepayable US Debt – US debt totaled $ 52.8 trillion at the end of June 2009, which was 3.7 times the size of the US economy (GDP); US debt was "only" 2.6 times the size of US GDP in 1929, at the beginning of the Great Depression.[19]

Increasingly Costly US Military Presence – the US currently maintains a foreign military presence of 290,000+ personnel, located in 158 countries, on 820 installations; prior to WWII, America was an "isolationist" nation.[20]

Post-peak US NNRs – 50 out of the 58 NNRs examined in the following analyses—including bauxite, copper, iron ore, magnesium, manganese, oil, phosphate rock, potassium, tin, and zinc—have reached their US peak production levels and are in terminal decline domestically.

America's Last Hurrah

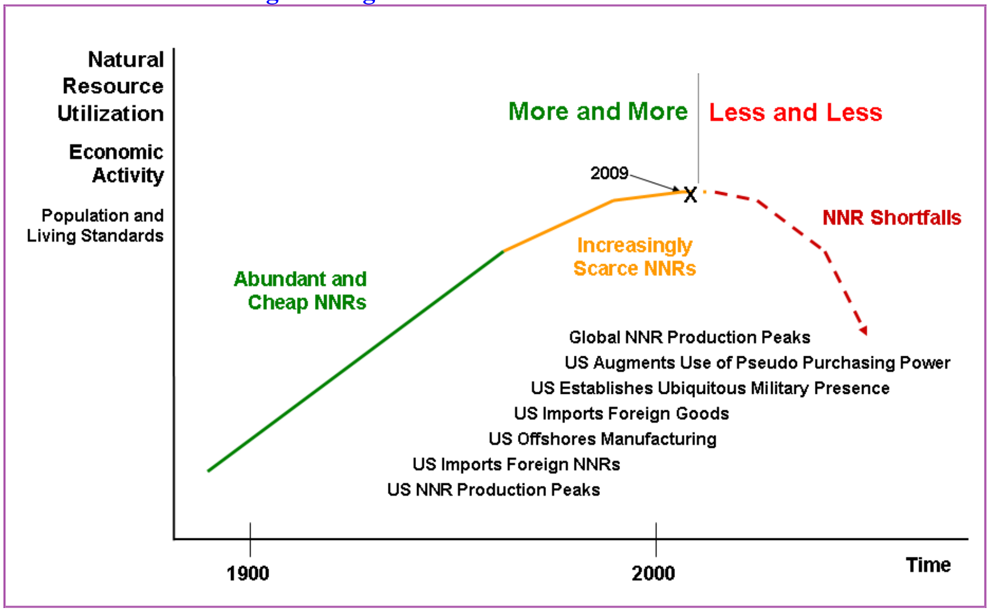
We are currently experiencing our last hurrah—our last-gasp attempt to perpetuate our American way of life at the world's expense—by appropriating dwindling global NNR supplies through pseudo purchasing power and our ubiquitous military presence, as we continue to deplete our remaining domestic NNR reserves toward exhaustion.

Our foreign benefactors are becoming increasingly unwilling to support our profligacy however, as they are also our competitors for remaining global NNR supplies—NNR supplies that will enable them to maintain or achieve industrialized status.

Unfortunately, insufficient NNRs exist to accomplish either objective. Our NNR "safety valve" has been foreign suppliers, who have temporarily enabled us to offset our declining domestic NNR supplies with imported NNRs, outsourced manufacturing, and imported finished goods. As global NNR supplies become increasingly scarce, there is no "higher level" safety valve—there is only one earth.

America’s Future—Continuously Less and Less

US Societal Wellbeing—Going Forward



The US is a microcosm of the world—“continuously more and more” will soon become “continuously less and less” with respect to global NNR supplies, as it has for domestic US NNR supplies.

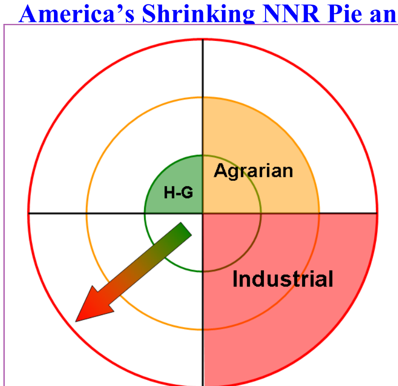
America is simply a few decades ahead of the rest of the world in terms of NNR depletion.

Yet global NNR demand continues unabated—interrupted unintentionally and only briefly by our latest global recession—fueled by industrializing nations such as China, India, Russia, Brazil, the Eastern European nations, the Persian Gulf states, the Caspian Sea countries, the resource-rich African nations, and others aspiring to the “American way of life”.

The inevitable consequence associated with this industrialization free-for-all will be ever-increasing NNR scarcity—continuously declining NNR supplies that will be unable to keep pace with ever-increasing demand.

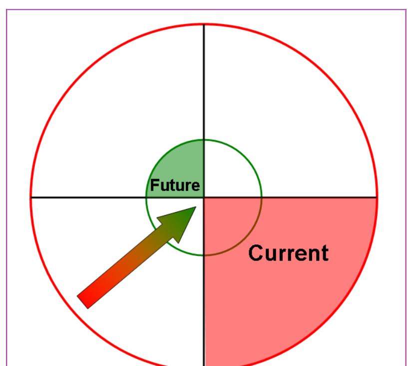
America’s “Shrinking NNR Pie and Slice” Double Whammy

America’s Shrinking NNR Pie and Slice Double Whammy



America’s Expanding NNR Pie and Slice

From the US perspective, both the NNR “pie”—global NNR supplies—and our NNR “slice”—NNR supplies available to the US specifically—which have expanded continuously, especially since the inception of our industrial revolution, are peaking and will shrink continuously going forward: our “shrinking NNR pie and slice” double whammy.



America’s Shrinking NNR Pie and Slice

Globally, supplies associated with an ever-increasing number of NNRs are near, at, or past their peak production levels—and are or will soon be in terminal decline.

Domestically, most NNR production levels are in post-peak decline; and an increasing number of our traditional foreign NNR suppliers:

- Are retaining more of their NNRs for internal use,
- Are diverting some or all of their NNR exports to new customers,
- Are restricting the flows of NNR exports through various forms of “resource nationalism” and “protectionism”,
- Are politically unstable,
- Have underinvested in new NNR development, and/or
- Are unwilling to accept our ever-devaluing US dollars and our unrepayable US debt in exchange for their finite and dwindling NNR stocks.

The End of Our American Way of Life

Imported NNRs, outsourced offshore manufacturing, and imported goods and services—all enabled by pseudo purchasing power and our ubiquitous military presence—have enabled America to continue to increase our economic activity level, our population level, and our material living standards from the late 20th century into the 21st century.

Our fairy tale is about to end, however, as “continuously more and more” becomes “continuously less and less”. ”Continuously less and less” will bring an end to our industrialized American way of life through a decline in our level of societal wellbeing that will quickly degenerate into a freefall.

More broadly speaking, the fate awaiting America, societal collapse, awaits all industrialized nations, irrespective of their political and economic orientations. All industrialized nations are dependent upon increasingly scarce NNRs to enable their historically unprecedented—and unsustainable—economic activity levels, population levels, and material living standards; all must and will collapse as a result.

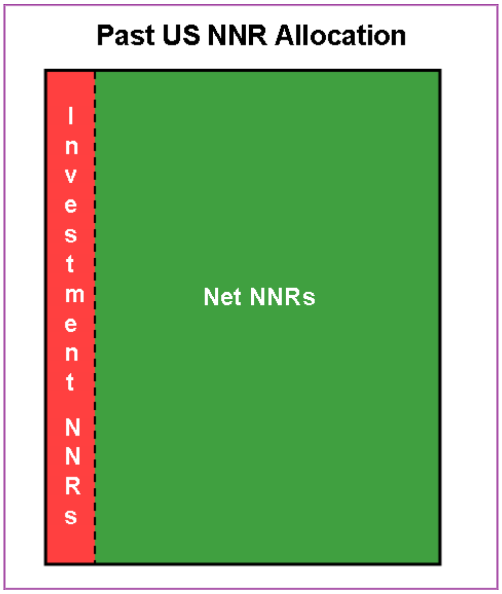
The Role of NNRs in America’s Success—and Failure

America’s rise as an industrialized superpower was a direct consequence of NNR abundance; our decline and collapse will be a direct consequence of NNR insufficiency.

America’s Past—Abundant NNRs

At the inception of America’s industrial revolution and during the early years of the 20th century, NNR supplies available to the US were abundant and inexpensive; and NNR demand was very low relative to supply. Domestic US NNR deposits were plentiful and of high quality; the investments in terms of dollars, energy, and other natural resources required to discover and produce new NNRs were relatively low.

Abundant "Net NNRs"



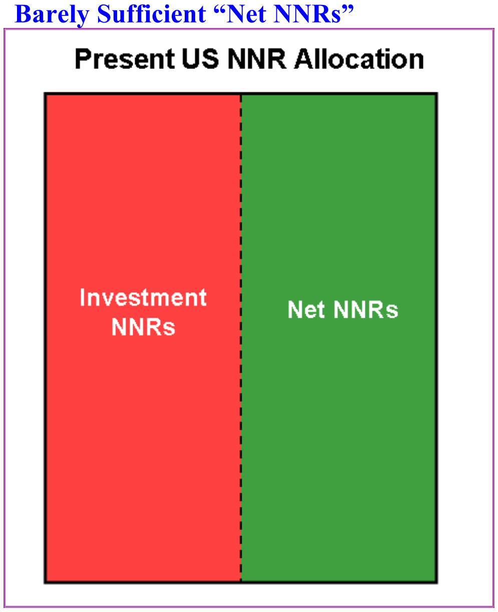
"Net NNR" levels—NNRs remaining after subtracting the quantities invested in exploration and production—were high; ample surplus NNRs existed to build a growing industrialized society. Both economic investment returns and natural resource investment returns were high; the American "can do" attitude was pervasive.

America's Present—Barely Sufficient NNRs

During the middle of the 20th century, domestically produced NNRs began to reach their peaks; by the early 21st century available NNR supplies were becoming increasingly scarce and expensive, as our historically high demand levels continued to increase.

Today, remaining global NNR deposits are less plentiful, smaller, and of lower quality; while the investments in terms of dollars, energy, and other natural resources required to discover and produce new NNRs are increasing continuously.

Barely Sufficient "Net NNRs"

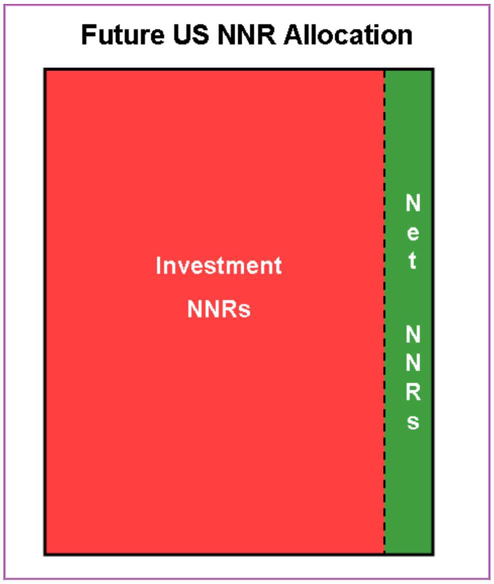


US "Net NNR" levels continue to decline. Today's surplus NNR supplies are barely sufficient to support our current economic activity level, much less to enable future economic growth. Economic investment returns and natural resource investment returns are declining continuously; the strain on the American economy and on the American public is becoming increasingly evident.

America's Future—Insufficient NNRs

Going forward, NNR supplies available to the US will continue to peak and go into terminal decline, as demand increases unabated. NNR prices will increase dramatically, as lower quality and less plentiful NNR deposits become increasingly difficult and costly to discover and exploit in terms of dollars, energy, and other natural resources.

Insufficient "Net NNRs"



"Net NNR" levels will decline continuously, until they become insufficient to enable our American way of life[21]—in the not-too-distant future. Our industrialized society, which is enabled almost exclusively through our rapacious NNR utilization, will collapse.

America's "Decreasing NNR ROI" Double Whammy

The return on investment (ROI) calculation is straightforward:

$$\text{ROI} = \frac{\text{Investment Proceeds}}{\text{Investment Costs}}$$

Investment proceeds and investment costs can be measured in terms of dollars or in terms of natural resources; in either case, a positive ROI is achieved when investment proceeds exceed investment costs.

In the case of America's NNR investments, our investment proceeds are decreasing while our investment costs are increasing:

$$\text{US NNR ROI} = \frac{\text{Decreasing Proceeds}}{\text{Increasing Costs}}$$

We are investing more and more dollars and natural resources which are yielding less and less in terms of both dollars and natural resources. Our NNR investment returns are shrinking due to both a decreasing numerator and an increasing denominator—our "decreasing NNR ROI" double whammy.[22]

US NNR Scarcity Analysis

The US NNR Scarcity Analysis (Scarcity Analysis), which follows, offers quantified evidence of ever-increasing domestic and global NNR scarcity, with the primary emphasis on increasing US NNR scarcity. The Scarcity Analysis is based on US Geological Survey (USGS) and US Energy Information Administration (EIA) data related to domestic and global production, pricing, and utilization associated with fifty eight (58) NNRs—energy resources, metals, and minerals.[23]

Scarcity Analysis Method

Scarcity Analysis NNRs

Primary Metals
- Aluminum
- Alumina/Bauxite
- Copper
- Iron Ore
- Lead
- Nickel
- Tin
- Zinc

Precious Metals
- Gold
- Silver
- PGM (Platinum Group Metals)

Industrial/Construction Minerals
- Bromine
- Cement
- Diamond
- Fluorspar
- Garnet (Industrial)
- Graphite
- Gypsum
- Lime
- Nitrogen (fixed—ammonia)
- Phosphate Rock
- Potash
- Quartz
- Salt
- Selenium
- Silicon
- Soda Ash
- Sulfur

Energy Minerals
- Coal
- Natural Gas
- Oil

Specialty Metals/Metalloids
- Antimony
- Arsenic
- Barite
- Beryllium
- Cadmium
- Chromium
- Cobalt
- Gallium
- Germanium
- Hafnium
- Indium
- Lithium
- Magnesium
- Manganese
- Mercury
- Molybdenum
- Niobium
- REM (Rare Earth Metals)
- Rhenium
- Strontium
- Tantalum
- Tellurium
- Thallium
- Titanium
- Tungsten
- Vanadium
- Zirconium

Scarcity Analysis Indicators

US Peak NNR Production Year
US NNR Import Percentage
Global Peak NNR Production Year
Remaining Global NNR Reserves
Global NNR Production Trends

NNR Price Trends
US NNR Utilization Trends
Geopolitical NNR Supply Constraints
NNR Substitutability

NNR Scarcity in the US

As the following indicators demonstrate, supplies associated with many of the NNRs that currently enable our industrialized American way of life are failing to keep pace with demand—for both geological and geopolitical reasons. (See Appendix A for the NNR Scarcity Analysis Metrics Summary.)

US Peak NNR Production

US Peak NNR Production Year

Fifty (50) of the 58 analyzed NNRs have reached their domestic US peak production (mine extraction) levels—including bauxite in 1943, copper in 1998, iron ore in 1951, magnesium in 1966, oil in 1970, phosphate rock in 1980, potash in 1967, rare earth metals in 1984, tin in 1945, titanium in 1964, and zinc in 1969.

Available supplies associated with these and dozens of other "post-peak" NNRs are in terminal decline domestically; scarcity will increase going forward.

US NNR Production Peak Incidence

Year of US Peak NNR Production	NNR #	US Post-peak NNRs
1900-1933	3	Graphite, Manganese, Silver
1934-1966	17	Antimony, Arsenic, Bauxite, Chromium, Cobalt, Fluorspar, Indium, Iron Ore, Lithium, Magnesium, Mercury, Niobium, Strontium, Tin, Tantalum, Titanium, Tungsten
1967-2000	28	Aluminum, Barite, Beryllium, Bismuth, Boron, Cadmium, Copper, Gallium, Garnet, Germanium, Gold, Hafnium, Lead, Molybdenum, Nickel, Nitrogen, Oil, Phosphate Rock, Potash, REM, Rhenium, Selenium, Silicon, Sulfur, Thallium, Vanadium, Zinc, Zirconium
2001-2005	2	Cement, PGM
US Post-peak NNR Total	**50**	

Analyzed NNRs that have yet to reach their domestic US peak production levels are bromine, coal, industrial diamond, gypsum, lime, natural gas, salt, and soda ash. Bromine, gypsum, lime, salt, and soda ash are "practically inexhaustible" industrial minerals, for which domestic peak production levels may never be reached. Natural gas and coal are primary energy sources that are critical to the perpetuation of our American way of life, and that will reach their peak production levels in the not-too-distant future.

Domestic US conventional natural gas production has peaked, as has that of North America overall.[24, 25] Expected to offset declining North American conventional natural gas production are unconventional natural gas sources such as coal bed methane, tight sands, gas shales, and offshore fields.

Natural gas from unconventional sources is more difficult and expensive to produce than is conventional natural gas; and the volume of ultimately recoverable resource in each case is less certain than is the case with conventional natural gas sources.

Under the most optimistic circumstances, our current domestic US natural gas production plateau might be maintained for another decade, if unconventional sources produce sufficiently to offset continuous declines from conventional wells. It is likely, however, that US natural gas supplies will be in terminal decline by the year 2020, if not before.[26]

While the US ranks first in terms of coal reserves worldwide, our remaining reserves must be understood in terms of their quality as well as their quantity. US anthracite production peaked in 1914; US bituminous production peaked in 1990; and US coal production peaked with respect to “energy content” in 1998.

And while we will certainly extract larger volumes of domestic coal over the coming decades, the mix will shift increasingly toward lower quality subbituminous and lignite. We must, therefore, be able to extract increasingly greater amounts of coal in order to obtain the same amount of usable energy.

It is likely that US peak volumetric coal production will occur between 2030 and 2040; it is questionable whether the heat content associated with the mix of coal available at that time will be sufficient to meet our requirements.[27]

US Post-peak NNR Decline Rates

Post-peak annual decline rates associated with NNR production vary widely, depending on factors such as the number and size of remaining deposits, the quality of the deposits, accessibility of the deposits, and the production/extraction methods employed.

Post-peak annual decline rates associated with US produced NNRs range from 1.4% for iron ore, 1.7% for oil, 2.0% for potash, and 0.7% for silver on the low end; to 2.9% for magnesium, 4.3% for vanadium, 5.6% for copper, 7.2% for tin, and 5.3% for zinc in the mid-range; to 16.8% for chromium, 12.7% for cobalt, and 29.1% for indium on the high end.

US Post-peak Annual NNR Production Decline Rates

Annual Decline Rate	NNR #	US Post-peak NNRs
0+%-2%	11	Boron, Cement, Iron Ore, Molybdenum, Nitrogen, Oil, Potash, Selenium, Silver, Sulfur, Titanium
2+%-5%	16	Aluminum, Antimony, Beryllium, Garnet, Gold, Graphite, Hafnium, Lead, Magnesium, Phosphate Rock, PGM, Rhenium, Silicon, Strontium, Vanadium, Zirconium
5+%-10%	13	Arsenic, Barite, Bauxite, Cadmium, Copper, Fluorspar, Germanium, Manganese, Mercury, REM, Tin, Tungsten, Zinc
10+%	5	Chromium, Cobalt, Gallium, Indium, Nickel

As the term implies, the post-peak production decline rate is applied annually to a continuously shrinking NNR reserve [quantity]. A relatively small annual decline rate can therefore reduce annual NNR production levels significantly within a very short period of time.

For example, an annual decline rate of only 2% results in a 17% reduction in annual NNR production within 10 years; a 5% annual decline rate results in a 37% reduction in annual NNR production within 10 years; and a 10% annual decline rate results in a 61% reduction in annual NNR production within 10 years.

Available NNR supplies can become scarce very quickly once peak production levels have been reached.

US Post-peak NNR Production Levels

In 25 cases—including bauxite, chromium, indium, manganese, nickel, tin, and vanadium—newly mined NNRs are no longer being produced in America, because it is economically impractical or physically impossible to do so.

Current domestic production levels associated with other post-peak NNRs vary according to their peak dates and post-peak depletion rates. Zinc is currently being produced domestically at only 13% of its US peak production level; iron ore at 44%, potash at 39%, aluminum at 55%, copper at 60%, phosphate rock at 55%, and platinum group metals at 87%.

Current US NNR Production Level as a Percentage of US Peak Production Level

Current/Peak Percentage	NNR #	US Post-Peak NNRs
0%	25	Antimony, Arsenic, Bauxite, Bismuth, Chromium, Cobalt, Fluorspar, Gallium, Graphite, Hafnium, Indium, Lithium, Manganese, Mercury, Nickel, Niobium, REM, Selenium, Strontium, Tantalum, Thallium, Tin, Tungsten, Vanadium, Zirconium
1%-25%	5	Barite, Cadmium, Germanium, Lead, Zinc
26%-50%	5	Iron Ore, Magnesium, Potash, Rhenium, Silicon
51%-75%	10	Aluminum, Beryllium, Copper, Gold, Nitrogen, Oil, Phosphate Rock, Silver, Sulfur, Titanium
76%-99%	5	Boron, Cement, Garnet, Molybdenum, PGM

America is not even close to being NNR self-sufficient, given our domestically available NNR supplies. Our American way of life—300+ million people enjoying historically unprecedented material living standards—would be physically impossible in the absence of enormous quantities of imported NNRs and imported goods and services enabled by foreign NNRs.

US NNR Import Percentage

US Reliance on NNR Imports over Time

Because domestic US NNR supplies are becoming increasingly scarce, we are becoming increasingly reliant upon foreign NNRs to fill the void. We are importing a greater number of NNRs than we did only 13 years ago; and we are importing higher percentages of the NNRs that we import.

US NNR Import Reliance

US NNR Import Percentage	1995 NNR #	2008 NNR #
100%	8	18
50%-99%	16	26
1%-49%	23	17
Total Imported NNRs*	**47**	**61**

*Based on data from USGS Annual Mineral Summaries; totals differ from the 58 analyzed NNRs.

Current US NNR Import Reliance[28]

The US currently imports some quantity of 46 of the 58 analyzed NNRs—including 100% of our bauxite, 32% of our copper, 100% of our manganese, 33% of our nickel, 62% of our oil, 91% of our platinum group metals, 81% of our potash, 100% of our rare earth metals, 80% of our tin, and 73% of our zinc.

2008 US NNR Import Reliance

US Import Percentage	NNR #	NNRs Imported by the US
1%-20%	5	Cement, Lime, Natural Gas, Phosphate Rock, Salt
21%-40%	6	Bromine, Copper, Garnet, Gypsum, Nickel, Sulfur
41%-60%	6	Chromium, Lithium, Magnesium, Nitrogen, Silicon Silver
61%-80%	6	Barite, Oil, Tin, Titanium, Tungsten, Zinc
81%-100%	21	Antimony, Arsenic, Bauxite, Bismuth, Cobalt, Diamond, Fluorspar, Gallium, Germanium, Graphite, Indium, Manganese, Niobium, PGM, Potash, REM, Rhenium, Strontium, Tantalum, Thallium, Vanadium
N/A (Insufficient USGS data)*	2	Hafnium, Selenium
Total Imported NNRs	**46**	

*The US produced no Hafnium or Selenium in 2008; some quantities of each must have been imported.

The bottom line: if we had to rely exclusively upon domestic NNRs to enable our way of life, our attainable population level and material living standards would be only small fractions of their current levels—and they would be declining continuously.

Global Peak NNR Production Year

Seven (7) of the 58 analyzed NNRs reached their global peak production levels during the 20th century—beryllium in 1961, cadmium in 1988, germanium in 1981, hafnium in 1962, mercury in 1971, selenium in 1996, and thallium in 1989. Production levels associated with an additional 7 NNRs peaked globally between the years 2001 and 2005—although it is quite possible that the "peak-to-date" peak production levels associated with some of these NNRs will be exceeded in the future, due to their relatively recent "apparent" peak years.

Global NNR Production Peak Incidence

Year of Global Peak NNR Production	NNR #	Global Post-peak NNRs
1900-1933	0	
1934-1966	2	Beryllium, Hafnium
1967-2000	5	Cadmium, Germanium, Mercury, Selenium, Thallium
2001-2005	7	Arsenic, Barite, Boron, Diamond, Gold, Tantalum, Tungsten
Past Global Peak NNR Total	**14**	

America is simply a microcosm of the world; our domestic NNR peak production scenario is now unfolding on a global basis—in realtime and rapidly. The difference between the two scenarios is that as our domestic NNR supplies peaked, we turned to foreign NNR sources to supplement our declining supplies. The world has no similar "safety valve"; there is only one earth.

And, because the US and other industrialized nations have been "appropriating" NNRs from the rest of the world for generations, global NNR reserves are already significantly depleted in many cases.

The global NNR "peak production barrage" is in process—a trend that will intensify as developing nations seeking to achieve industrialized status compete increasingly with industrialized nations for remaining NNR supplies.

Of special significance in this regard is oil, which is probably at or near its global production peak at the time of this writing (2009).[29] "Peak oil" will cause the most far reaching and devastating impacts on human population levels and living standards, both domestically and globally, of all NNRs.

Remaining Global NNR Reserves

"Years to Exhaustion" is the period of time over which proven global reserves associated with an NNR will last assuming continued annual production growth at the 21st century rate.[30] While no NNR will ever deplete completely to exhaustion, much less at a constant annual growth rate, this indicator is a convenient benchmark for assessing the adequacy associated with remaining global NNR reserves.

If 21st century annual NNR production growth rates are maintained going forward, proven global reserves associated with 31 of the 58 analyzed NNRs will exhaust within the next 40 years—including bauxite in 40 years, coal in 35 years, copper in 26 years, iron ore in 22 years, molybdenum in 21 years, natural gas in 36 years, nickel in 28 years, oil in 32 years, tin in 15 years, and zinc in 14 years.

Remaining Global NNR Reserves

Years Until Exhaustion*	NNR #	NNRs
1-10 Years	1	Lithium
11-25 Years	17	Antimony, Arsenic, Barite, Cadmium, Fluorspar, Gold, Iron Ore, Lead, Manganese, Molybdenum, Niobium, Rhenium, Silver, Strontium, Tin, Zinc, Zirconium
26-40 Years	13	Bauxite, Bismuth, Coal, Cobalt, Copper, Garnet, Graphite, Natural Gas, Nickel, Oil Thallium, Titanium, Tungsten
41-60 Years	7	Boron, Magnesium, Mercury, Phosphate Rock, PGM, Selenium, Vanadium
60+ Years	8	Bromine, Cement, Lime, Potash, REM, Salt, Soda Ash
N/A (Insufficient USGS data)	12	Aluminum, Beryllium, Chromium, Diamond, Gallium, Germanium, Hafnium, Indium, Nitrogen, Silicon, Sulfur, Tantalum

* Reserve to production ratio (R/P) data used for "negative growth rate" NNRs: thallium, mercury, and boron.

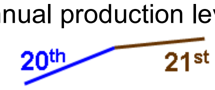
Barring significant new NNR discoveries and/or technological advances that greatly increase the recoverable percentages associated with NNR deposits, available supplies associated with many NNRs will be insufficient in the not-too-distant future to enable existing global economic activity levels, much less continuously robust economic growth. Annual NNR production levels at pre-recession 21st century growth rates, upon which our thriving global enterprise depends, are clearly unsustainable.

It is therefore impossible that industrialized nations such as America will perpetuate our existing way of life going forward, as it is impossible that developing nations currently seeking industrialized status will achieve it.

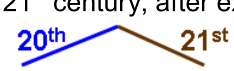
Global NNR Production Trends

The global production growth rates associated most analyzed NNRs have contracted during the 21st century—that is, annual growth rates associated with 21st century NNR production have either slowed or turned negative when compared with 20th century growth rates.

Twenty-seven (27) NNRs—including aluminum, copper, magnesium, molybdenum, natural gas, oil, phosphate rock, potash, and sulfur—experienced slower growth in annual production levels so far in the 21st century than had been the case during the 20th century.



An additional six (6) NNRs—including gold, mercury, tantalum, and thallium—experienced declining annual production levels in the 21st century, after experiencing increasing annual production levels during the 20th century.



Global NNR Production Trend

Global NNR Production Level	NNR #	NNRs
Positive Annual Growth Rate in the 20th Century followed by a Lower Positive Annual Growth Rate in the 21st Century	27	Aluminum, Arsenic, Barite, Bauxite, Cadmium, Cement, Chromium, Copper, Diamond, Fluorspar, Gallium, Garnet, Magnesium, Molybdenum, Natural Gas, Nickel, Nitrogen, Oil, Phosphate Rock, Potash, REM, Rhenium, Selenium, Strontium, Sulfur, Titanium, Tungsten
Positive Annual Growth Rate in the 20th Century followed by a Negative Annual Growth Rate in the 21st Century	6	Boron, Bromine, Gold, Mercury, Tantalum, Thallium
N/A (Insufficient USGS Data)	1	Hafnium
Contracting NNR Production Growth	**33**	

It seems likely that contracting 21st century growth rates in NNR production levels are attributable to geological supply-side factors in most cases—an increasing number of NNRs near, at, or past their global peak production levels.

Generally declining NNR demand, which could also explain the contracting growth rates associated with NNR production levels during the 21st century, seems unlikely, given the rapid global economic growth that occurred prior to the recession. Global GDP grew at a compound annual rate of 5.6% between the years 2000 and 2008, which is nearly double the 3.1% compound annual growth rate achieved during the 20th century.[31]

Global NNR demand during the early years of the 21st century remained extremely robust until the onset of our latest recession. Tightening NNR supplies simply failed to keep pace with demand, thereby choking off global economic growth and causing the 2008 recession.

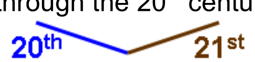
The primary issues of concern going forward, as global economies attempt to recover from the recession:

- Are remaining NNR supplies sufficiently abundant (and affordable) to enable a broad-based global economic recovery? Or, are ultimately recoverable NNR reserves depleted to levels that will render a global economic recovery impossible?
- Assuming sufficient NNR supplies remain available to enable "this" economic recovery, what about the "next" recovery?

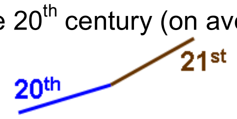
NNR Price Trends

Inflation adjusted price levels associated with 50 of the 58 analyzed NNRs experienced increases during the 21st century when compared with 20th century price levels.

In the case of 38 NNRs—including aluminum, bauxite, coal, iron ore, nickel, nitrogen, phosphate rock, potash, sulfur, tin, and zinc—the pricing trend actually inverted from century to century: annual price levels declined through the 20th century (on average), then increased during the early part of the 21st century.



Annual price levels associated with an additional 12 NNRs—including copper, magnesium, natural gas, and oil—increased through the 20th century (on average), then increased at an even greater annual rate during the 21st century.



Global NNR Price Trend

Global NNR Price Level	NNR #	NNRs
Negative Annual Growth Rate in the 20th Century followed by a Positive Annual Growth Rate in the 21st Century	38	Aluminum, Antimony Bauxite, Beryllium, Bismuth, Bromine, Cadmium, Cement, Chromium, Coal, Cobalt, Germanium, Gold, Graphite, Hafnium, Indium, Iron Ore, Lead, Lime, Mercury, Molybdenum, Nickel, Nitrogen, Phosphate Rock, Potash, REM, Rhenium, Salt, Selenium, Silver, Soda Ash, Sulfur, Tantalum, Tin, Tungsten, Vanadium, Zinc, Zirconium
Positive Annual Growth Rate in the 20th Century followed by a Higher Positive Annual Growth Rate in the 21st Century *	12	Boron, Copper, Fluorspar, Gallium, Gypsum, Magnesium, Manganese, Natural Gas, Oil, Silicon, Strontium, Thallium
N/A (Insufficient USGS Data)	1	Titanium
Accelerating Global Prices	**50**	

*Or a negative 20th century growth rate followed by a "less negative" 21st century growth rate

Continuously increasing prices associated with any commodity or product typically indicate increasing scarcity—i.e., supply is failing to keep pace with demand. The compound annual growth rates in price levels associated with 51 of the 58 analyzed NNRs increased between the years 2000 and 2008, dramatically in some cases—cadmium (41%), chromium (18%), copper (18%), phosphate rock (17%), potash (18%), selenium (33%), sulfur (16%), tungsten (16%), and vanadium (18%).

This nearly universal NNR pricing uptrend, combined with the fact that NNR price levels declined only when the world entered one of the most severe economic recessions in history, clearly demonstrate that most NNR supplies could not physically keep pace with demand during the recent "economic boom".

Although bringing on incremental NNR capacity requires considerable time and expense, it seems reasonable that NNR supplies could have caught up with demand between the years 2000 and 2008, had additional readily accessible NNR deposits been available. Instead, insufficient NNR supplies caused the global economy to crash.

Geopolitical NNR Supply Constraints

Geopolitical factors also have the potential to constrain future NNR supplies to the US.

In the case of 32 NNRs—including cobalt, gallium, indium, magnesium, nitrogen, oil, phosphate rock, potash, titanium, and zinc—the potential for geologically oriented NNR supply constraints is significant. That is, at least 40% of US imports are supplied by adversarial or potentially adversarial nations; or, at least 50% of US imports are supplied by only one or two countries, and remaining US reserves are limited.

For an additional seventeen (17) NNRs—including aluminum, bauxite, copper, natural gas, sulfur, and tin—the potential for geologically oriented NNR supply constraints is moderate. That is, either remaining US reserves are limited, or at least 50% of US imports are supplied by only one or two countries.

Geopolitical NNR Supply Constraints

NNR Supply Constraint Potential	NNR #	Potentially Supply-constrained NNRs
Significant Supply Constraint Potential	32	Antimony, Arsenic, Barite, Beryllium, Bismuth, Cobalt, Diamond, Fluorspar, Gallium, Graphite, Indium, Lead, Lithium, Magnesium, Manganese, Niobium, Nitrogen, Oil, Phosphate Rock, PGM, Potash, REM, Rhenium, Silicon, Silver, Strontium, Tantalum, Thallium, Titanium, Tungsten, Vanadium, Zinc
Moderate Supply Constraint Potential	17	Aluminum, Bauxite, Boron, Bromine, Chromium, Copper, Garnet, Germanium, Gold, Gypsum, Hafnium, Lime, Mercury, Natural Gas, Sulfur, Tin, Zirconium
NNRs with Potential Constraints	**49**	

As both domestic and global NNR supplies decline going forward due to geological factors, the threat of NNR scarcity due to geopolitical factors will become increasingly severe for the US.

NNR Substitutability

For 50 of the 58 analyzed NNRs, viable substitutes are limited or nonexistent.

In the case of 25 NNRs—including bauxite, chromium, molybdenum, niobium, oil, phosphate rock, potash, rare earth minerals, sulfur, and titanium—no viable substitutes exist. For an additional 27 NNRs—including aluminum, coal, copper, iron ore, magnesium, natural gas, platinum group metals, and zinc—effective substitutes exist only in a limited number of applications.

NNR Substitutability

Available NNR Substitutes	NNR #	NNRs
No Viable Substitutes	25	Barite, Bauxite, Beryllium, Chromium, Cobalt, Gallium, Garnet, Germanium, Gold, Graphite, Indium, Molybdenum, Niobium, Nitrogen, Oil, Phosphate Rock, Potash, REM, Salt, Strontium, Sulfur, Tantalum, Thallium, Titanium, Tungsten
Substitutes In Some Cases	27	Aluminum, Antimony, Arsenic, Bismuth, Boron, Bromine, Cadmium, Coal, Copper, Diamond, Fluorspar, Gypsum, Hafnium, Iron Ore, Lead, Lithium, Magnesium, Manganese, Natural Gas, Nickel, PGM, Rhenium, Silicon, Silver, Vanadium, Zinc, Zirconium
NNRs with Limited or No Substitutes	**50**	

Conventional wisdom holds that NNR substitutes exist in all cases, and that when price/scarcity signals warrant, NNR “B” will seamlessly displace NNR “A”.

The problem with this line of reasoning is that it is precisely because we utilize our existing NNR mix and levels that we are able to enjoy our historically unprecedented American way of life. Conversely, failure to utilize our existing NNR mix and levels will result in lifestyle disruptions—we will experience population level reductions and/or material living standard degradation.

“Forced” NNR substitution, which results from NNR scarcity, always involves some level of price/performance degradation in one or more NNR applications—forced NNR substitution therefore causes some level of lifestyle disruption. This is the case because if the substitute NNR was price/performance superior to the incumbent NNR, we would be using the substitute NNR currently—but we are not.

So, while NNR substitution might be technically feasible in most cases, forced NNR substitution resulting from NNR scarcity will always compromise our American way of life—the only questions are “how” and “by how much”?

US NNR Utilization Trends

Domestic US NNR Utilization[32]

Domestic US NNR utilization levels associated with 50 of the 58 analyzed NNRs are either declining absolutely or are increasing at lower rates in the first few years of the 21st century than was the case during the 20th century.

In the case of 31 NNRs—including aluminum, bauxite, coal, copper, iron ore, magnesium, oil, phosphate rock, rare earth minerals, titanium, and zinc—the US utilization trend actually inverted from century to century: annual US utilization levels increased through the 20th century (on average), then decreased so far during the 21st century.

Annual US utilization levels associated with an additional 19 NNRs—including indium, molybdenum, natural gas, platinum group metals, potash, and sulfur—increased through the 20th century (on average), then increased at lower rates during the 21st century.

Domestic US NNR Utilization Trends

US NNR Utilization	NNR #	NNRs
Positive Annual Growth Rate in the 20th Century followed by a Negative Annual Growth Rate in the 21st Century	31	Aluminum, Antimony, Arsenic, Bauxite, Beryllium, Cadmium Cement, Chromium, Coal, Cobalt, Copper, Fluorspar, Gallium, Gold, Gypsum, Iron Ore, Lead, Lithium, Magnesium, Nickel, Oil, Phosphate Rock, REM, Silicon, Soda Ash, Strontium, Tantalum, Titanium, Tungsten, Vanadium, Zinc
Positive Annual Growth Rate in the 20th Century followed by a Lower Positive Annual Growth Rate in the 21st Century	19	Barite, Bromine, Diamond, Graphite, Hafnium, Indium, Lime, Molybdenum, Natural Gas, Nitrogen, PGM, Potash, Rhenium, Salt, Selenium, Silver, Sulfur, Thallium, Zirconium
N/A (Insufficient USGS Data)	1	Mercury
Contracting US Utilization Growth	**51**	

Declining domestic US NNR utilization levels are attributable primarily to geological factors; 50 of the 58 analyzed NNRs have reached US peak production and are in terminal decline domestically. Domestic NNR production declines are being only partially offset by foreign NNR imports.

Total US NNR Utilization

While our “direct” NNR utilization levels are certainly declining in a majority of the cases, our “real” NNR utilization levels are still increasing in almost every case. We are simply supplementing our declining direct NNR utilization levels by:

1. Outsourcing US manufacturing operations to foreign offshore locations, thereby utilizing foreign NNRs, which are not reflected in USGS US NNR utilization data; and
2. Becoming a net importer of foreign goods and services, thereby utilizing foreign NNRs throughout the product/service production and provisioning processes that are likewise not reflected in the USGS US NNR utilization data.

Available USGS and EIA NNR utilization data might create the impression that we are weaning ourselves from nonrenewable natural resources as we become a "service economy"—nothing could be further from the truth! If US NNR utilization quantities associated with offshore outsourcing and net imports were included in the USGS and EIA data, the trend would show steady, if not dramatic, increases in US NNR utilization levels—at least until the onset of the 2008 recession.

Our dependence upon nonrenewable natural resources, increasingly from foreign sources, is greater than ever, even as global NNR supplies peak and decline, and as foreign competition for remaining NNR supplies becomes increasingly intense.

Scarcity Analysis Findings

At the end of the day, we are not about to "run out" of any NNR, we are about to "run critically short" of many…

Available NNR supplies are becoming increasingly scarce, both domestically and globally. The NNR "peak-decline" scenario that occurred in the US is now unfolding on a worldwide basis.

From America's perspective, the underlying cause associated with ever-increasing NNR scarcity is straightforward: both global NNR supplies (the NNR pie) and NNR supplies available to America specifically (America's NNR slice), which have expanded continuously for centuries, are peaking and will shrink continuously going forward—our "shrinking NNR pie and slice" double whammy.

The tangible manifestations associated with ever-increasing NNR scarcity are readily evident: we are investing more and more dollars and natural resources while obtaining less and less of both—our "decreasing NNR ROI" double whammy.

Within this context of ever-increasing NNR scarcity, our current solution for obtaining NNR supplies sufficient to perpetuate our American way of life—our ever-increasing reliance on pseudo purchasing power and our ubiquitous military presence—will soon fail. Our foreign NNR suppliers are losing faith in our continuously devaluing US dollar and our unrepayable US debt.

The inevitable consequences associated with America's "predicament" are imminent and permanent US NNR shortfalls—increasingly scarce NNR supplies will no longer be able to keep pace with demand, and will ultimately become insufficient to perpetuate our American way of life.

US NNR Supply Shortfall Analysis

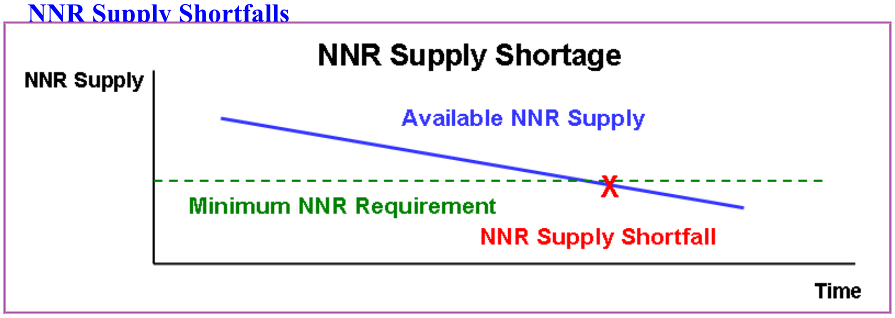
The US NNR Supply Shortfall Analysis (Shortfall Analysis), which follows, assesses the probability of a permanent US supply shortfall associated with each of the 58 analyzed NNRs within the following time window: 5 years possibly, 15 years probably, and 25 years almost certainly (from 2009).

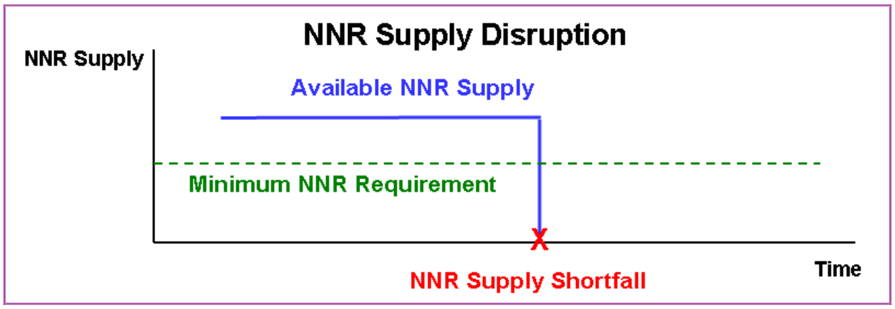
US NNR supply shortfall probability estimates are based on USGS and EIA data related to domestic and global production, pricing, and utilization associated with each of the 58 analyzed NNRs.[33]

US Vulnerability to NNR Supply Shortfalls

The inevitable consequences associated with increasingly scarce NNRs are NNR supply shortfalls—NNR supply shortages and NNR supply disruptions.

NNR Supply Shortfalls





During an NNR shortfall, the available NNR supply becomes insufficient to meet minimum societal requirements; that is, to enable the production and provisioning of societal essentials—water, food, energy, clothing, shelter, and other infrastructure—to the society's population.

Lifestyle disruptions—population level reductions and/or material living standard degradation—result. Permanent NNR supply shortfalls associated with one or more NNRs, especially critical NNRs, can cause societal collapse.

As is the case with peak NNR production timing, NNR supply shortfall timing is impossible to know with certainty in advance. However, both peak NNR production and NNR supply shortfalls are inevitable, assuming persistent NNR utilization.

At issue: which NNRs are most likely to experience permanent supply shortfalls in the US, and when?

Shortfall Analysis Method

Shortfall Analysis Indicators

US Peak NNR Production
- Peak Production Year
- "Current-to-Peak" Production Percentage
- Post-peak Annual Production Decline Rate

US NNR Import Percentage

Global Peak NNR Production
- Peak Production Year
- "Current-to-Peak" Production Percentage
- Post-peak Annual Production Decline Rate

Remaining Global NNR Reserves

Global NNR Production Trend

NNR Price Trend

US NNR Utilization
- US NNR Utilization Trend
- Geopolitical NNR Supply Constraints
- NNR Substitutability

Shortfall Analysis Rating Scheme

A rating was assigned to each of the shortfall vulnerability indicators for which sufficient USGS or EIA data were available, based on the following rating scheme. The individual ratings for each NNR were then summed to yield the “Composite Vulnerability Rating”. (See Appendix B for Scarcity Analysis Ratings Detail.)

US Peak NNR Production

- Peak Production Year
  - **2006-2008: 0**
  - **2000-2005: 1**
  - **1980-1999: 2**
  - **1950-1979: 3**
  - **Pre 1950: 4**
- “Current Production” to “Peak Production” Percentage
  - **100%: 0**
  - **80%-99%: 1**
  - **50%-79%: 2**
  - **20%-49%: 3**
  - **< 20%: 4**
- Post-peak Annual Production Decline Rate
  - **Not Yet Peaked: 0**
  - **0+%-2%: 1**
  - **2+%-5%: 2 (also used for N/A—insufficient USGS data)**
  - **5+%-10%: 3**
  - **10+%: 4**

US NNR Import Percentage

  - **0%: 0**
  - **1%- 19%: 1**
  - **20%-49%: 2 (also used for N/A—insufficient USGS data)**
  - **50%-79%: 3**
  - **80%-100%: 4**

Global Peak NNR Production

- Peak Production Year
  - **2006-2008: 0**
  - **2000-2005: 1**
  - **1980-1999: 2**
  - **1950-1979: 3**
  - **Before 1950: 4**
- “Current Production” to “Peak Production” Percentage
  - **100%: 0**
  - **80%-99%: 1**
  - **50%-79%: 2**
  - **20%-49%: 3**
  - **< 20%: 4**
- Post-peak Annual Production Decline Rate
  - **Not Yet Peaked: 0**
  - **0+%-2%: 1**
  - **2+%-5%: 2**
  - **5+%-10%: 3**
  - **10+%: 4**

Remaining Global NNR Reserves

- **> 60 years: 0**
- **40 years – 60 years: 1**
- **25 years – 39 years: 2 (also used for N/A—insufficient USGS data)**
- **10 years – 24 years: 3**
- **< 10 years: 4**

Global NNR Production Trend

- **Continuously Increasing Growth: 0**
- **Slowing Growth: 1 (also used for N/A—insufficient USGS data)**
- **Change from Growth to Decline: 2**

NNR Price Trend

- **Continuously Declining Price: 0**
- **Increasing Growth: 1 (also used for N/A—insufficient USGS data)**
- **Change from Decline to Growth: 2**

US NNR Utilization

- US NNR Utilization Trend
  - **Continuously Increasing Growth: 0**
  - **Slowing Growth: : 1 (also used for N/A—insufficient USGS data)**
  - **Change from Growth to Decline: 2**
- Geopolitical NNR Supply Constraints
  - **None Currently: 0**
  - **"Moderate": 1**
  - **"Significant": 2**
- NNR Substitutability
  - **Generally Available Substitutes: 0**
  - **Viable Substitutes in Some Cases: 1**
  - **No Viable Substitutes: 2**

The Shortfall Analysis rating scheme is heavily weighted toward geologically oriented factors such as peak production timing, post-peak decline rates and production levels, US import dependence, and remaining global reserves. Geopolitically oriented factors such as pricing levels, US utilization levels, and geopolitical supply constraints, are weighted less heavily.

Shortfall Analysis Composite Vulnerability Ratings

Composite Vulnerability Rating Scale

The Shortfall Analysis rating scheme produces a forty-four (44) point rating scale: a rating of 0 indicates no probability of a permanent US NNR supply shortfall within the specified 25 year time window; while a rating of 44 indicates a 100% probability of a permanent US NNR supply shortfall within the 25 year time window.

For purposes of the analysis, NNR Composite Vulnerability Ratings were segmented as follows:

- NNRs rated between 1 and 11 have a "low" probability of experiencing a permanent supply shortfall within the 25 year time window;
- NNRs rated between 12 and 22 have a "medium" probability of experiencing a permanent supply shortfall within the 25 year time window;
- NNRs rated between 23 and 33 have a "high" probability of experiencing a permanent supply shortfall within the 25 year time window; and
- NNRs rated between 34 and 44 have a "very high" probability of experiencing a permanent supply shortfall within the 25 year time window.

Composite Vulnerability Ratings

The actual range of Composite Vulnerability Ratings extends from 4 (soda ash) to 35 (tantalum), with tantalum receiving the only “very high” probability rating.

Probability of an Imminent and Permanent US NNR Shortfall

Shortfall Probability	NNR #	NNRs
Low Probability	8	Bromine, Cement, Coal, Gypsum, Lime, Natural Gas, Salt, Soda Ash
Medium Probability	31	Aluminum, Bismuth, Boron, Copper, Diamond, Garnet, Gold, Graphite, Hafnium, Iron Ore, Lead, Lithium, Magnesium, Molybdenum, Nickel, Niobium, Nitrogen, Oil, Phosphate Rock, PGM, Potash, REM, Rhenium, Selenium, Silicon, Silver, Sulfur, Tin, Titanium, Vanadium, Zirconium
High Probability	18	Antimony, Arsenic, Barite, Bauxite, Beryllium, Cadmium, Chromium, Cobalt, Fluorspar, Gallium, Germanium, Indium, Manganese, Mercury, Strontium, Thallium, Tungsten, Zinc
Very High Probability	1	Tantalum

Highly Vulnerable NNRs

Nineteen NNRs—including bauxite, chromium, cobalt, manganese, tungsten, and zinc—have a “high” or “very high” probability of experiencing a permanent US supply shortfall within the specified 25 year time window.

Highly Vulnerable NNRs

NNR	Composite Vulnerability Rating	Key Vulnerability Factors	Applications
Tantalum	35	No US production since 1959; global production peaked in 2004 (to date); US imports 100% of total usage; 98+% of proven reserves are in Brazil and Australia; no effective substitutes.	Capacitors (electronics); super alloys used in jet engines, nuclear reactors, and missiles; substitutes for platinum in some applications.
Arsenic	30	US production peaked in 1944; no current US production; global production peaked in 2003 (to date); US imports 100% of total usage; 17 years until exhaustion; 86% of US imported metallic arsenic comes from China.	Batteries, specialty semiconductors, solar cells; pesticides, insecticides, herbicides, and alloys; wood preservative.
Thallium	29	US production peaked in 1977; no current US production; global production peaked in 1989; US imports 100% of usage; 38 years until exhaustion; 72% of US imports come from Russia; no effective substitutes.	Photocells and medical imaging; high temperature superconductivity applications.
Mercury	28	US production peaked in 1943; no current US production; global production peaked in 1971; 48 years of proven reserves remain; 59% of US imports come from Chile and Peru.	Batteries, florescent lights, thermometers; use is declining due to health concerns.
Tungsten	28	US production peaked in 1955; no current US production; global production peaked in 2004 (to date); US imports 61% of total usage; 34 years until exhaustion; 43% of US imports come from China; no effective substitutes.	Light bulbs and x-ray tubes; super alloys in aerospace, armament, and other high-temperature applications; high performance cutting and wear resistant materials.

NNR	Composite Vulnerability Rating	Key Vulnerability Factors	Applications
Cobalt	25	US production peaked in 1958; no current US production; US imports 81% of total usage; 26 years until exhaustion; 48% of proven reserves are in the Congo; no effective substitutes.	Magnetic, wear-resistant, and high strength alloys for gas turbine blades and jet engines; batteries; catalyst in petroleum production.
Gallium	25	US production peaked in 1978; no current US production; US imports 99% of total usage; China, Kazakhstan, and Ukraine are major producers; no effective substitutes.	High speed semiconductors, laser diodes, solar cells, and light emitting diodes; high temperature, high stability metal alloys.
Strontium	25	US production peaked in 1943; no current US production; US imports 100% of usage; 12 years until exhaustion; 100% of US strontium mineral imports come from Mexico.	Pyrotechnics, signals, magnets, master alloys, ceramics, glass, and CRT glass.
Antimony	24	US production peaked in 1943; no current US production; US imports 86% of total usage; 11 years until exhaustion; 51% of US imports come from China.	Flame retardants, ceramics, alloy (hardens lead in batteries), and semiconductors (diodes and infrared detectors).
Barite	24	US production peaked in 1981; current US production is 18% of US peak level; global production peaked in 2005 (to date); US imports 79% of total usage; 19 years until exhaustion; 92% of US imports come from China; no effective substitutes.	CRT faceplate glass, x-ray shield, ceramics, and oil and natural gas well drilling mud (weighting agent).
Bauxite	24	US production peaked in 1943; no current US production; US imports 100% of usage; 40 years until exhaustion; no effective substitutes.	Primary feedstock for aluminum; also abrasives, chemicals, and refractories applications.
Chromium	24	US production peaked in 1956; no current US production; US imports 54% of total usage; 54% of US imports come from South Africa and Kazakhstan; no effective substitutes.	Super alloy, stainless steel component, catalyst, and electroplating.
Fluorspar	24	US production peaked in 1944; no current US production; US imports 100% of total usage; 25 years until exhaustion; 58% of US imports come from China.	Fluorine bearing chemicals; flux in aluminum, uranium, and steel processing; ceramics; precision optics (high end lenses).
Germanium	24	Both US and global production peaked in 1981; current US production is 16% of US peak level; US imports 85% of total usage; a majority of known reserves are in China; no effective substitutes.	Fiber optics, infrared optics, solar electronics, and high performance semiconductors.
Indium	24	US production peaked in 1966; no current US production; US imports 100% of total usage; 43% of US imports come from China; no effective substitutes.	Semiconductors, LCDs (thin film displays), solar cells, and low melting point alloys.
Beryllium	23	US production peaked in 1980; global production peaked in 1961; current US production is 56% of US peak level; 58% of US imports come from Kazakhstan; no effective substitutes.	X-ray tubes; master copper alloy; components of high-speed aircraft, missiles, and space craft; microwave telecom applications.

NNR	Composite Vulnerability Rating	Key Vulnerability Factors	Applications
Cadmium	23	US production peaked in 1969; global production peaked in 1988; current US production is 13% of US peak level; 22 years until exhaustion.	Batteries, coatings, metal alloys, and photovoltaics.
Manganese	23	US production peaked in 1918; no current US production; US imports 100% of total usage; 16 years until exhaustion; 55% of imports come from Africa; no effective substitutes.	Myriad construction, machinery, and transportation applications; iron and steel alloy applications.
Zinc	23	US production peaked in 1969; current US production is 13% of US peak level; US imports 73% of total usage; 14 years until exhaustion; 69% of US ore and concentrate imports come from Peru.	Galvanizing (coating iron and steel), alloy, brass and bronze; multiple industrial uses.

While some of above listed NNRs are unfamiliar to most people, all but four—thallium, tungsten, strontium, and fluorspar—are essential components in the manufacture of computers,[34] in the absence of which today's industrialized societies could not function. America's vulnerability to imminent and permanent supply shortfalls associated with these "secondary" NNRs is therefore significant for several reasons:

- Cascading supply shortfalls associated with multiple secondary NNRs are sufficient to cause significant lifestyle disruptions or societal collapse.
- Supply shortfalls associated with secondary NNRs can trigger or amplify shortfalls associated with more critical NNRs.
- The above listed NNRs are merely precursors of things to come; the number of NNRs highly vulnerable to an imminent and permanent US supply shortfall will certainly increase dramatically in the near future.

Critical NNRs

The following twelve NNRs are critical to the perpetuation of our American way of life; that is, they are indispensible in providing/enabling some or all of our societal essentials—water, food, energy, clothing, shelter, and other infrastructure. While their Composite Vulnerability Ratings indicate that they are not as susceptible to imminent and permanent supply shortfalls as the highly vulnerable NNRs, these critical NNRs merit close attention.

As the following profiles demonstrate, some of the critical NNRs nearly missed a highly vulnerable rating, while others could experience near term US supply shortfalls if the geological and/or geopolitical factors that govern their availability change only slightly.

Critical NNRs

NNR	Composite Vulnerability Rating	Key Vulnerability Factors	US Shortfall Vulnerability Assessment
REM	22	US production peaked in 1984; no current US production; US imports 100% of total usage; myriad critical high tech applications; 87% of US imports come from China; no effective substitutes exist.	China is restricting REM exports, and they control 97% of current global REM production.
Tin	21	US production peaked in 1945; no current US production; US imports 80% of total usage; myriad electrical, construction, and industrial applications; 60% of US imports come from Peru and Bolivia; substitutes exist, but scalability and cost are issues.	Tin just missed a "high probability of an imminent and permanent shortfall" rating.
Magnesium	19	US production peaked in 1966; current US production is 30% of US peak level; myriad critical refractory, agricultural, construction, and industrial applications; 78% of US imports come from China.	China, Russia, and North Korea own 67% of the world's proven magnesium reserves; we own less than 5%.
Oil	19	US production peaked in 1970; current US production is 53% of US peak level; US imports 62% of total usage; 32 years until exhaustion; ubiquitous critical applications; some import sources (e.g., Venezuela, Nigeria, and Angola) are potentially unstable; no effective substitutes exist.	Global peak oil production, which could occur at any time, will be devastating to industrialized nations, especially the US.
Potash	18	US production peaked in 1967; current US production is 39% of US peak level; US imports 81% of total usage; 62 years until exhaustion; irreplaceable in agricultural fertilizers; 90% of US imports come from Canada; no (potassium) substitutes exist.	Canada owns 53% of the world's proven potash reserves (the US owns 1%); a favorable trade relationship with Canada will suffice until peak production occurs.
Copper	17	US production peaked in 1998; current US production is 60% of US peak level; US imports 32% of total usage; 26 years until exhaustion; myriad electronics and construction applications; 53% of US imports come from Chile and Peru; substitutes exist, but scalability and cost are issues.	Unless world copper reserves are drastically understated or significant new discoveries are made realtime, shortages could develop within the next 10-15 years.
Nitrogen (fixed)	17	US (ammonia) production peaked in 1980; current US production is 60% of US peak level; US imports 48% of total usage; irreplaceable in agricultural fertilizers; 56% of US imports come from Trinidad and Tobago; no substitutes exist.	The primary feedstock for fixed nitrogen (ammonia) production is natural gas; future nitrogen availability is therefore tied to future natural gas availability.
Phosphate Rock	17	US production peaked in 1980; current US production is 55% of US peak level; US imports 9% of total usage; 44 years until exhaustion; irreplaceable in agricultural fertilizers and feed supplements; 65+% of proven reserves are in China and Morocco—100% of US imports come from Morocco; no (phosphorous) substitutes exist.	Morocco owns 38% of the world's proven phosphate rock reserves (the US owns 8%); a favorable trade relationship with Morocco should suffice until peak production occurs.

NNR	Composite Vulnerability Rating	Key Vulnerability Factors	US Shortfall Vulnerability Assessment
Sulfur	16	US production peaked in 1981; current US production is 75% of US peak level; US imports 28% of total usage; critical in agricultural fertilizers; 73% of US imports come from Canada; no effective substitutes exist.	Most sulfur production is a byproduct of fossil fuel processing; future sulfur availability is therefore tied to future oil, natural gas, and coal availability.
Iron Ore	15	US production peaked in 1951; current US production is 44% of US peak level; 22 years until exhaustion; ubiquitous critical applications; substitutes exist for iron/steel, but scalability and cost are issues.	China and the FSU own 56% of the world's proven iron ore reserves (the US owns less than 5%); however, the US currently produces more than it uses domestically.
Natural Gas	8	Production has yet to peak domestically or globally; US imports 12% of total usage; 36 years until exhaustion; critical applications include home heating and electricity generation; possible substitutes (oil and coal) face similar supply constraints.	Assuming US natural gas production peaks within the next 10 years, shortages could develop any time thereafter.
Coal	7	Volumetric production has yet to peak domestically or globally—although US production peaked with respect to "energy content" in 1998; 35 years until exhaustion; primary critical application is electricity generation; possible substitutes (oil and natural gas) face similar supply constraints.	Assuming volumetric US coal production peaks within the next 25 years, shortages could develop any time thereafter—although coal "energy content" shortages could develop well before that time.

Given that global NNR demand will remain strong among both industrialized and industrializing nations; and that an ever-increasing number of additional NNRs will reach their global peak production levels going forward; and that geopolitical NNR supply constraints will become increasingly prevalent; and that the US will continue to rely heavily on pseudo purchasing power and military intervention to secure access to critical NNRs—these and many other NNRs could easily experience permanent US supply shortfalls within the next 25 years.

Shortfall Analysis Findings

Each peaking NNR is like another crack in the foundation of our industrialized American society; at issue is which crack or combination of cracks will cause the structure to fall…

The US is currently vulnerable to a large number of imminent and permanent NNR supply shortfalls; this number will increase going forward. Supplies associated with seven NNRs—including cadmium, germanium, and mercury—have reached their global peak production levels and are in terminal decline. Global supplies associated with an additional 18 NNRs—including bauxite, coal, copper, iron ore, manganese, natural gas, oil, tin, and zinc—are also likely to enter terminal decline within 25 years.

Supply shortfalls associated with a single critical NNR or a small number of secondary NNRs can cause significant lifestyle disruptions—or societal collapse.

A permanent shortfall in the supply of oil alone would be sufficient to collapse American society; as would permanent shortfalls associated with 2-3 critical NNRs such as potassium, phosphate rock, and (fixed) nitrogen; as would concurrent or cascading permanent shortfalls associated with 4-5 secondary NNRs such as the alloys, catalysts, and reagents that enable the effective use of critical NNRs.[35]

Given America's vulnerability to an ever-increasing number of imminent and permanent NNR supply shortfalls, American societal collapse is not a question of "if", but "when".

Implications of NNR Scarcity and NNR Supply Shortfalls

Both uncertainty and certainty exist going forward. Uncertainty exists regarding the specific timing and circumstances associated with impending US NNR supply shortfalls, and regarding the specific sequence in which NNR supply shortfalls will occur.

Complete certainty exists however, regarding the inevitability associated with imminent and permanent US NNR supply shortfalls, and regarding the inevitable consequence for America—societal collapse, soon.

Future NNR Demand, Supply, and Utilization

NNR Demand/Supply/Utilization Paradigm Shift

We are witnessing a fundamental shift in NNR demand/supply/utilization dynamics, both domestically and globally. We are evolving from a "demand driven" paradigm in which NNR utilization levels are determined by ever-increasing NNR demand, which is always met with ever-increasing supplies; to a "supply constrained" paradigm in which NNR utilization levels will be determined by continuously declining NNR supplies, which will fail increasingly to keep pace with demand.

NNR Demand, Supply, and Utilization

NNR Demand

Assuming that we recover from our current economic recession, global NNR demand will quickly surpass pre-recession levels, driven by an ever-increasing global population aspiring to ever-improving material living standards.

Post recession domestic US NNR demand will continue to increase as well—if only at levels commensurate with our ever-increasing population level—so long as pseudo purchasing power and our ubiquitous military presence permit.

NNR Supplies

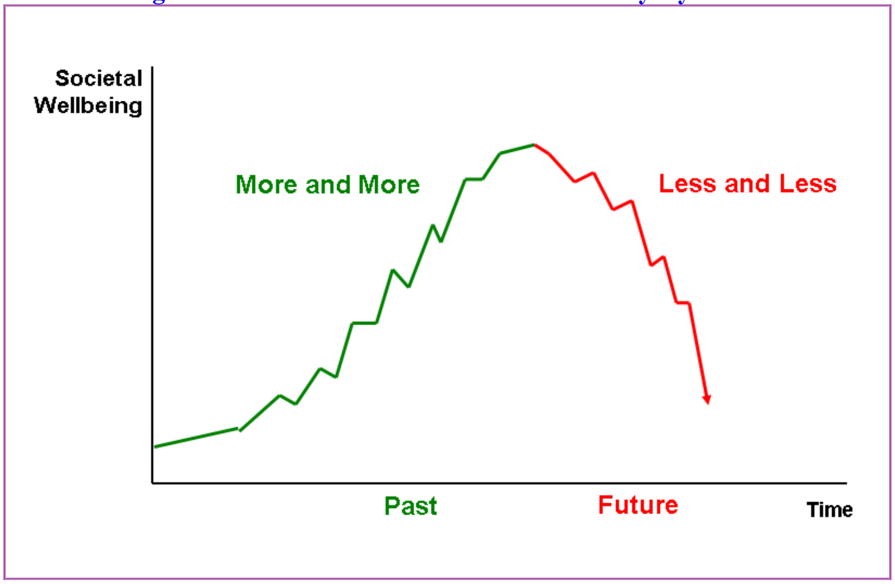
Global NNR supplies will continue to peak and decline, as they have in the US, due to geological factors beyond our control. Remaining global NNRs will go to those who own them, to those who can afford to buy them with real purchasing power, and to those who can take them by force.

In addition to contending with geologically imposed NNR supply constraints, the US will face increasing geopolitical NNR supply constraints as well. Our traditional foreign suppliers will become increasingly unable and unwilling to export critical NNRs and essential goods and services to the US.

Demand/Supply Imbalances

Today's NNR demand/supply imbalances will intensify going forward. Post recession NNR demand will increase until it again exceeds NNR supplies sufficiently to drive prices to levels that choke off economic growth. At that time, we will experience our next economic recession.

“Ratcheting Down” Economic Recession and Recovery Cycles



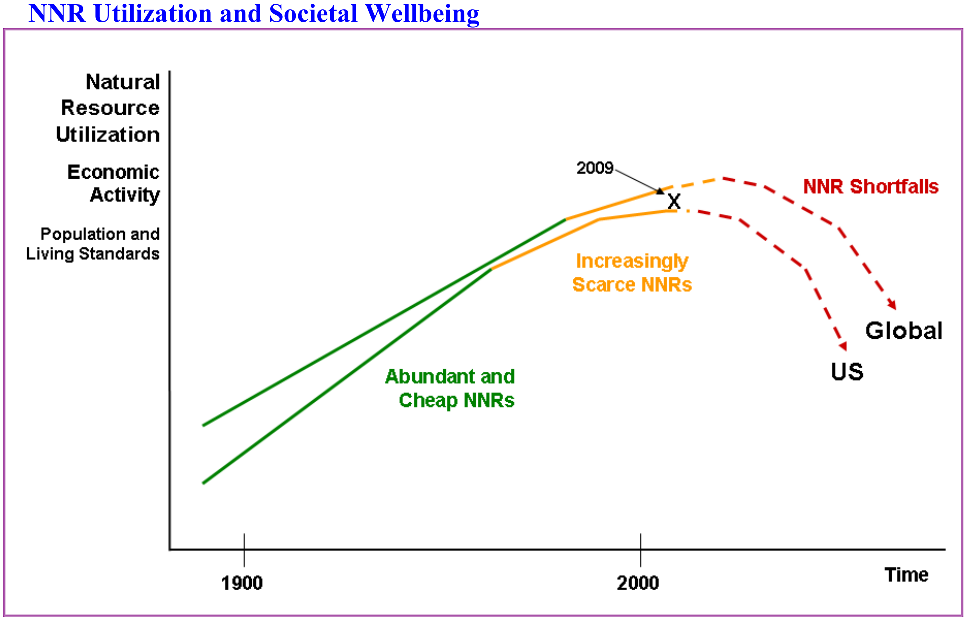
A downward trending recession and recovery scenario will unfold, both domestically and globally, through a series of increasingly frequent, severe, and protracted economic recessions punctuated by increasingly brief and anemic economic recoveries.

This “ratcheting down” economic cycle will continue until geological and geopolitical NNR supply-side constraints preclude further recovery.

NNR Utilization

Global and domestic NNR utilization levels will increase at decreasing rates as NNR supplies struggle to keep pace with demand. NNR utilization will peak—soon—then decline remorselessly as post-peak supplies will no longer be able to keep pace with demand.

NNR Utilization and Societal Wellbeing



US NNR utilization will peak in the very near term—ahead of the global peak—as US-specific geopolitical factors and geological factors combine to permanently reduce NNR supplies available to America.

The inevitable consequence associated with declining global and domestic NNR utilization is declining global and domestic societal wellbeing: continuously declining economic activity levels, population levels, and material living standards.

America's Destiny

We are blind to our predicament because we believe without thinking or questioning that the NNRs that enable our American way of life—and our very existence—will be available at sufficient levels going forward to perpetuate our lifestyle forever. This will not be the case.

America's Fallacy

In order to perpetuate our American way of life going forward, we require:

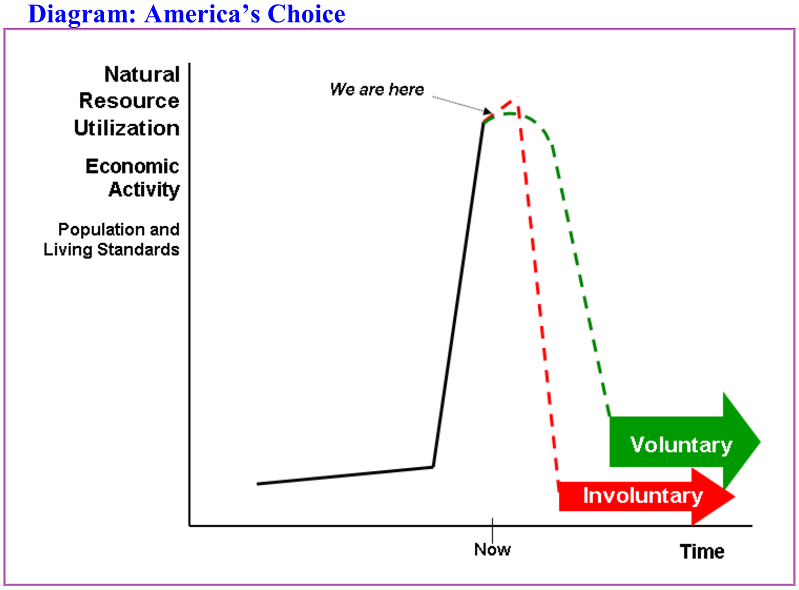
- Continuous discoveries of "high ROI" NNR deposits of all types—despite the fact that such discoveries have long since peaked in most cases.[36]
- Continuous development of new technologies that will enable us to produce ever-increasing NNR quantities from NNR deposits of ever-lower quality—despite the fact that such technological development is experiencing diminishing returns;[37]
- Continuous supplies of inexpensive imported NNRs—despite ever-increasing global NNR scarcity and competition; and
- Continuous access to inexpensive imported goods and services—despite our suppliers' ever-increasing misgivings regarding the viability of our currency the levels of our debt.

While it is critical to American societal stability that we maintain the illusion that the above described scenario will come to pass and that our American way of life will flourish for centuries to come, the above described scenario is, in fact, physically impossible. Remaining NNR supplies are NOT sufficient to perpetuate our American way of life going forward; our American way of life is NOT sustainable—it must and will end, soon.

America's Conundrum

Our only rational course of action is an impossible course of action…

Diagram: America's Choice



Our only solution for averting societal collapse, and thereby mitigating to some degree the devastating lifestyle disruptions that await us, is to transition voluntarily to a sustainable lifestyle paradigm—within which we would choose to utilize renewable natural resources exclusively.[38]

Unfortunately, we will not take this course of action because we are "culturally incapable" of doing so.

Our cornucopian worldview—our unquestioned belief that we will achieve perpetual population growth, living standard improvement, and economic prosperity through our ever-increasing utilization of the earth's "unlimited" natural resources—does not permit us to acknowledge our current predicament, much less to take meaningful action to mitigate its catastrophic consequences.

We are unwilling to compromise, much less relinquish, the historically unprecedented material living standards associated with our industrialized American way of life, which we consider to be a birthright. Our vested interest in the continued success of our existing lifestyle paradigm is simply too great to permit us even to consider deviating from our current trajectory, despite the fact that our current trajectory leads to collapse.

America's Unraveling

Instead, we will continue to use the remaining NNRs available to us in futile attempts to perpetuate our American way of life—behavior that will become increasingly desperate as we encounter increasingly severe NNR supply shortages and disruptions.

We will continue to cling to the deluded belief that we can somehow substitute hope, faith, determination, ingenuity, technology, and pseudo purchasing power for the finite and dwindling NNRs that enable our unsustainable American way of life.

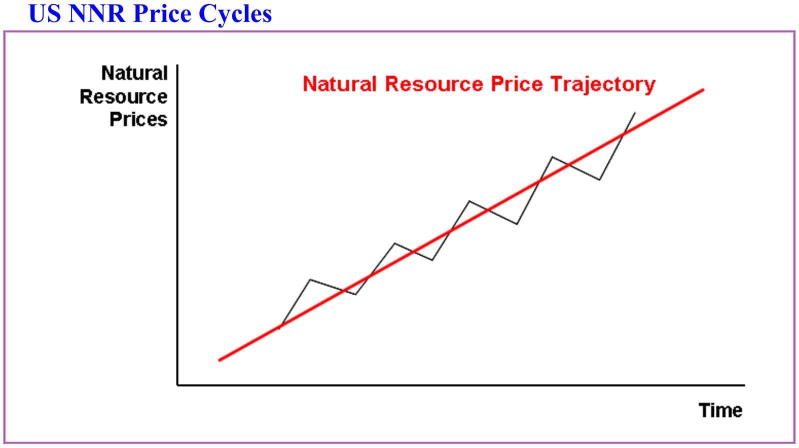
And we will continue to adhere blindly and steadfastly to our misguided perception that we are entitled to our unsustainable American way of life, until the instant that Nature intervenes to orchestrate our transition to sustainability for us, horrifically, through famine, disease, and pestilence—unless we annihilate ourselves in the meantime through domestic and international resource wars.

The ultimate irony is that the more quickly we recover from our increasingly frequent economic recessions and hasten our depletion of remaining NNR reserves through renewed economic growth, the sooner we will experience NNR shortfalls and trigger societal collapse.

America's Peak and Decline

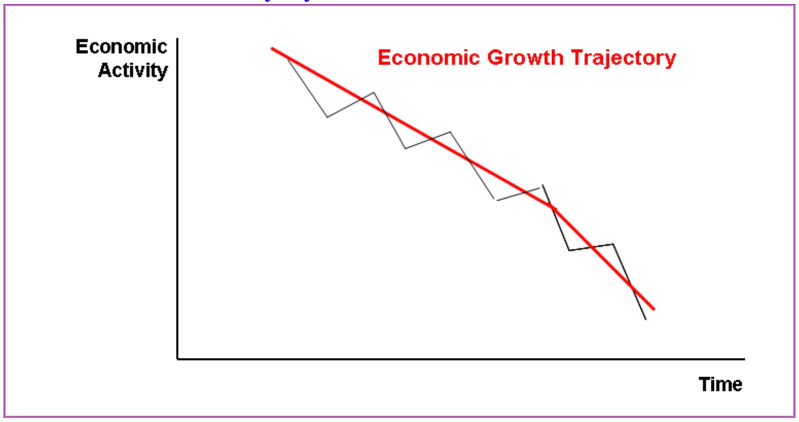
Going forward, our economic recession/recovery cycles will continue as they have since the inception of our industrial revolution, with one critical difference. The generally declining NNR price levels and generally increasing economic activity level that characterized our economic cycles during times of "continuously more and more", will give way to economic cycles characterized by a persistent upward trajectory in NNR prices and a persistent downward trajectory in our economic activity level.

US NNR Price Cycles



As available US NNR supplies become increasingly scarce, each successive NNR price cycle will be characterized by a higher "high point" and a higher "low point".

US Economic Activity Cycles



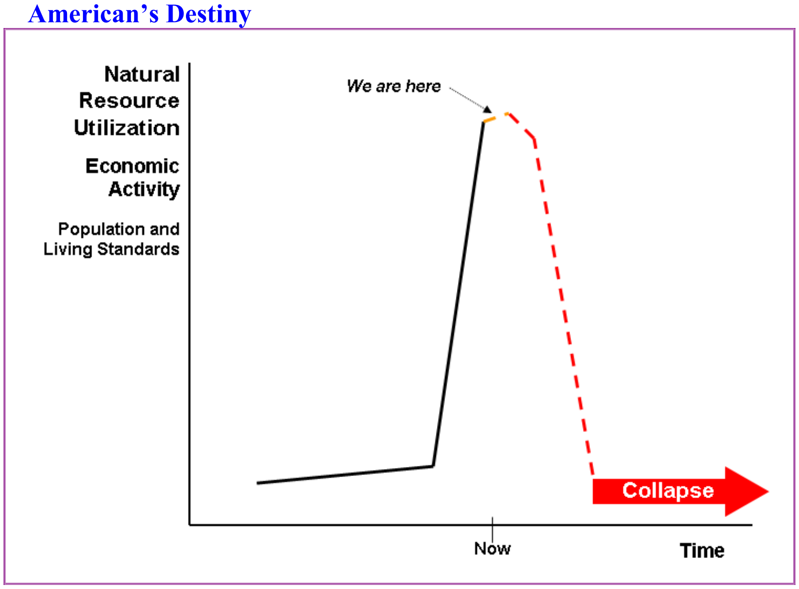
And each successive US economic cycle will be characterized by a longer, deeper recession followed by a shorter, less robust recovery.

America's Societal Collapse

As mainstream America comes to understand our new reality of "continuously less and less", ever-broadening segments of our population will succumb to the strain caused by continuous reductions in our material living standards. We will seek to maintain our American way of life in the only manner possible within a continuously contracting operating environment—by taking from each other.

Social unrest will become increasingly prevalent, which will steepen the trajectory associated with our economic decline.

American's Destiny



As NNR scarcity becomes increasingly acute, America will experience an escalating barrage of permanent NNR supply shortfalls—available NNR supplies will become insufficient to meet our minimum societal requirements; that is, to enable the production and provisioning of societal essentials—water, food, energy, clothing, shelter, and other infrastructure.

American society will collapse.

***Acknowledgements:* I wish to thank Andre Diederen, Peter Goodchild, and Dexter Graphic for their editorial review, comments, and suggestions for improvement.**

Appendix A: NNR Scarcity Analysis Metrics Summary

NNR	USA Peak Production			US Import %		Global Peak Production			WW Reserves		WW Production CAGR		US Price CAGR		US Utilization GAGR	
	Year	Cur/Peak	Yrly Decline	1995	2008	Year	Cur/Peak	Yrly Decline	R/P	Exhaust	20th	21st	20th	21st	20th	21st
Aluminum	1980	55%	-2.2%	25%	0%	2008				N/A	8.5%	6.3%	-2.2%	4.6%	8.3%	-7.5%
Antimony	1943	0%	-4.2%	60%	86%	2006			13	11	2.8%	4.3%	-1.1%	17.0%	2.0%	-6.0%
Arsenic	1944	0%	-5.7%	100%	100%	2003	77%	-5.2%	20	17	2.1%	1.5%	-1.1%	-3.0%	2.5%	-14.2%
Barite	1981	18%	-6.5%	65%	79%	2005	96%	-1.4%	24	19	4.0%	2.2%	-0.4%	-1.9%	4.6%	2.3%
Bauxite	1943	0%	-5.1%	100%	100%	2008			132	40	7.6%	5.3%	-1.2%	1.0%	6.0%	-1.4%
Beryllium	1980	56%	-2.1%	0%	0%	1961	38%	-2.0%		N/A	3.2%	5.2%	-4.4%	7.2%	6.0%	-8.9%
Bismuth	pre-1997			Negligible	97%	2007			55	26	1.9%	5.6%	-2.5%	12.9%	3.3%	4.4%
Boron	1995	84%	-1.7%	0%	0%	2004	77%	-8.2%	41	41	4.8%	-2.5%	-0.9%	-0.8%	3.7%	4.5%
Bromine	2006			0%	< 25%	2006				60+	4.6%	-3.8%	-2.6%	3.7%	7.2%	2.3%
Cadmium	1969	13%	-5.3%	21%	0%	1988	95%	-0.3%	24	22	7.6%	0.3%	-4.3%	40.6%	6.9%	-14.7%
Cement	2005	96%	-1.5%	17%	12%	2008				60+	14.8%	7.2%	-0.1%	1.1%	3.6%	-1.4%
Chromium	1956	0%	-16.8%	78%	54%	2007				N/A	5.8%	4.9%	-0.4%	17.8%	4.9%	-0.5%
Coal	2035 (e)			0%	0%	2030 (e)			118	35	1.8%	6.0%	-1.6%	3.1%	1.2%	-0.1%
Cobalt	1958	0%	-12.7%	82%	81%	2008			99	26	8.0%	9.0%	-1.3%	11.7%	6.6%	-1.7%
Copper	1998	60%	-5.6%	6%	32%	2008			35	26	3.3%	2.2%	1.7%	17.6%	3.0%	-4.8%
Diamond (Indus)	2007			36%	92%	2005	99%	-0.4%		N/A	6.5%	4.2%	-2.6%	-5.5%	8.8%	4.1%
Fluorspar	1944	0%	-7.1%	92%	100%	2008			39	25	3.8%	3.5%	0.0%	5.8%	6.1%	-3.5%
Gallium	1978	0%	-22.2%	Negligible	99%	2008				N/A	6.6%	0.7%	-2.7%	-1.7%	13.1%	-3.5%
Garnet (Indus)	1998	83%	-2.1%	0%	40%	2008			36	26	4.8%	2.4%	-1.2%	-1.8%	3.2%	5.6%
Germanium	1981	16%	-6.7%	Negligible	85%	1981	84%	-0.6%		N/A	1.3%	5.2%	-2.2%	0.5%	3.7%	8.8%
Gold	1998	65%	-4.7%	0%	0%	2001	90%	-1.6%	20	23	1.9%	-1.3%	-0.3%	13.9%	2.4%	-7.5%
Graphite	1907	0%	-3.3%	100%	100%	2008			81	40	2.4%	3.3%	-1.3%	0.8%	0.8%	0.0%
Gypsum	2006			30%	27%	2007				60+	3.2%	4.3%	0.2%	3.3%	3.9%	-2.2%
Hafnium	1983	0%	-2.3%	N/A	N/A	1962				N/A		N/A	-2.5%	1.7%	2.3%	0.5%
Indium	1966	0%	-29.1%	Negligible	100%	2008				N/A	5.8%	6.8%	-6.0%	14.4%	17.8%	11.4%
Iron Ore	1951	44%	-1.4%	18%	0%	2008			68	22	5.1%	9.4%	-0.6%	9.5%	0.9%	-3.7%
Lead	1970	20%	-4.3%	15%	0%	2008			21	17	1.5%	2.2%	-0.8%	11.7%	1.9%	-1.0%
Lime	2006			1%	1%	2008				60+	1.6%	11.5%	-0.3%	4.4%	2.1%	0.3%
Lithium	1954	0%	N/A	0%	> 50%	2006			11	8	5.5%	9.6%	-3.3%	-5.2%	5.8%	-4.0%
Mag Comp	1966	30%	-2.9%	50%	52%	2007			145	60	3.7%	2.6%	0.0%	1.3%	7.4%	-0.8%
Manganese	1918	0%	-8.2%	100%	100%	2008			36	16	2.5%	9.1%	0.2%	8.0%	1.3%	3.4%
Mercury	1943	0%	-6.6%	Negligible	0%	1971	9%	-6.3%	48	48	-0.8%	-4.4%	-1.9%	16.2%	-1.1%	N/A
Molybdenum	1980	83%	-0.7%	0%	0%	2008			41	21	10.0%	5.8%	-0.6%	0.6%	8.7%	5.4%
Natural Gas	2017 (e)			14%	12%	2020 (e)			61	36	5.1%	2.8%	4.3%	7.4%	4.7%	0.1%
Nickel	1997	0%	-73.2%	61%	33%	2007			43	28	5.1%	2.8%	-1.0%	9.1%	2.3%	-1.6%
Niobium	pre-1959			100%	100%	2007			45	16	6.6%	11.7%	0.8%	-6.7%	2.7%	11.0%
Nitrogen (fixed)	1980	60%	-1.9%	20%	48%	2008				N/A	7.3%	2.9%	-2.3%	12.9%	6.5%	0.7%
Oil	1970	53%	-1.7%	44%	62%	Now (e)			40	32	6.1%	1.4%	0.7%	14.0%	5.3%	-0.4%
Phosphate Rock	1980	55%	-2.2%	0%	9%	2008*			90	44	3.8%	3.0%	-1.2%	17.0%	3.9%	-1.7%
PGM	2002	87%	-2.6%	Negligible	91%	2006			141	43	4.0%	4.8%	1.5%	0.7%	4.5%	1.1%
Potash	1967	39%	-2.0%	74%	81%	2008			231	62	6.9%	3.7%	-2.1%	17.9%	4.4%	1.3%
REM	1984	0%	-9.6%	2%	100%	2008			710	86	4.6%	4.0%	-4.5%	1.1%	4.1%	-1.8%
Rhenium	1991	37%	-6.0%	Negligible	87%	2008			44	22	6.3%	5.9%	-4.9%	5.6%	13.4%	11.7%
Salt	2008			15%	17%	2008				60+	2.8%	3.7%	-0.9%	2.2%	3.0%	0.8%
Selenium	1969	0%	-1.5%	33%	N/A	1996	65%	-3.8%	59	56	2.7%	0.1%	-3.1%	32.7%	5.3%	1.1%
Silicon	1979	28%	-4.5%	33%	56%	2008				N/A	2.5%	6.3%	0.2%	7.7%	2.8%	-7.5%
Silver	1916	51%	-0.7%	Negligible	60%	2008			13	12	1.2%	1.8%	-0.9%	16.2%	2.7%	0.4%
Soda Ash	2008			0%	0%	2008			2,034	60+	2.2%	3.7%	-2.0%	4.4%	3.0%	-0.1%
Strontium	1943	0%	-4.7%	100%	100%	2008			13	12	6.4%	3.3%	0.8%	2.5%	7.1%	-16.5%
Sulfur	1981	75%	-1.1%	18%	28%	2008				N/A	3.8%	1.9%	-2.1%	15.8%	3.0%	0.1%
Tantalum	pre-1959			80%	100%	2004	54%	-14.4%	160	N/A	3.3%	-3.3%	-0.2%	9.6%	2.9%	-1.0%
Thallium	1977	0%	N/A	100%	100%	1989	63%	-2.4%	38	38	0.7%	-4.9%	3.0%	14.9%	-3.2%	-11.7%
Tin	1945	0%	-7.2%	84%	80%	2008			17	15	1.2%	2.3%	-0.5%	13.1%	0.5%	0.6%
Titanium Con	1964	55%	-1.4%	0%	77%	2007			119	35	8.6%	6.2%	N/A	N/A	3.4%	-1.8%
Tungsten	1955	0%	-9.8%	87%	61%	2004	82%	-4.8%	55	34	3.4%	2.7%	-0.3%	16.1%	5.4%	-0.2%
Vanadium	1981	0%	-4.3%	Negligible	100%	2008			217	51	3.9%	4.9%	-2.1%	17.5%	7.1%	-2.1%
Zinc	1969	13%	-5.3%	51%	73%	2008			16	14	3.0%	3.2%	-0.5%	3.1%	2.7%	-3.4%
Zirconium	1989	0%	-2.9%	Negligible	0%	2007			38	17	6.9%	8.1%	-0.5%	6.9%	13.2%	0.0%
										R/P data						

Appendix B: NNR Shortfall Analysis Ratings Detail

NNR	USA Peak Production			US	Global Peak Production			Years to	WW Production	Price	US Utilization	Supply Constraints		Cum.
	Year	Cur/Peak	Yrly Decline	Import %	Year	Cur/Peak	Yrly Decline	Exhaust	CAGR	CAGR	CAGR	Geopolitical	Substitutability	Rating
Aluminum	2	2	2	0	0	0	0	2	1	2	2	1	1	15
Antimony	4	4	2	4	0	0	0	3	0	2	2	2	1	24
Arsenic	4	4	3	4	1	2	3	3	1	0	2	2	1	30
Barite	2	4	3	3	1	1	1	3	1	0	1	2	2	24
Bauxite	4	4	3	4	0	0	0	1	1	2	2	1	2	24
Beryllium	2	2	2	0	3	3	1	2	0	2	2	2	2	23
Bismuth	2	4	4	4	0	0	0	2	0	2	0	2	1	21
Boron	2	4	1	0	1	2	3	1	2	1	0	1	1	19
Bromine	0	0	0	1	0	0	0	0	2	2	1	1	1	8
Cadmium	3	4	3	0	2	1	1	3	1	2	2	0	1	23
Cement	1	1	1	1	0	0	0	0	1	2	2	0	0	9
Chromium	3	4	4	3	0	0	0	2	1	2	2	1	2	24
Coal	0	0	0	0	0	0	0	2	0	2	2	0	1	7
Cobalt	3	4	4	4	0	0	0	2	0	2	2	2	2	25
Copper	2	2	3	2	0	0	0	2	1	1	2	1	1	17
Diamond (Indus)	0	0	0	4	1	1	1	2	1	0	1	2	1	14
Fluorspar	4	4	3	4	0	0	0	2	1	1	2	2	1	24
Gallium	3	4	4	4	0	0	0	2	1	1	2	2	2	25
Garnet (Indus)	2	1	2	2	0	0	0	2	1	0	0	1	2	13
Germanium	2	4	3	4	2	1	1	2	0	2	0	1	2	24
Gold	2	2	2	0	1	1	1	3	2	2	2	1	2	21
Graphite	4	4	2	4	0	0	0	1	0	2	1	2	2	22
Gypsum	0	0	0	2	0	0	0	0	0	1	2	1	1	7
Hafnium	2	4	2	2	3	0	0	2	1	2	1	1	1	21
Indium	3	4	4	4	0	0	0	2	0	2	1	2	2	24
Iron Ore	3	3	1	0	0	0	0	3	0	2	2	0	1	15
Lead	3	3	2	0	0	0	0	3	0	2	2	2	2	19
Lime	0	0	0	1	0	0	0	0	0	2	1	1	0	5
Lithium	3	4	2	3	0	0	0	4	0	0	2	2	1	21
Mag Comp	3	3	2	3	0	0	0	1	1	1	2	2	1	19
Manganese	4	4	3	4	0	0	0	3	0	1	0	2	2	23
Mercury	4	4	3	0	3	4	3	1	2	2	1	1	0	28
Molybdenum	2	1	1	0	0	0	0	3	1	2	1	0	2	13
Natural Gas	0	0	0	1	0	0	0	2	1	1	1	1	1	8
Nickel	2	4	4	2	0	0	0	2	1	2	2	0	1	20
Niobium	4	4	4	3	0	0	0	3	0	0	0	2	2	22
Nitrogen (fixed)	2	2	1	2	0	0	0	2	1	2	1	2	2	17
Oil	3	2	1	3	0	0	0	2	1	1	2	2	2	19
Phosphate Rock	2	2	2	1	0	0	0	1	1	2	2	2	2	17
PGM	1	1	2	4	0	0	0	1	0	0	1	2	1	13
Potash	3	3	1	4	0	0	0	0	1	2	1	2	1	18
REM	2	4	3	4	0	0	0	0	1	2	2	2	2	22
Rhenium	2	3	3	4	0	0	0	3	1	2	1	2	1	22
Salt	0	0	0	1	0	0	0	0	0	2	1	0	2	6
Selenium	3	4	1	2	2	2	2	1	1	2	1	0	0	21
Silicon	3	3	2	3	0	0	0	2	0	1	2	2	1	19
Silver	4	2	1	3	0	0	0	3	0	2	1	2	1	19
Soda Ash	0	0	0	0	0	0	0	0	0	2	2	0	0	4
Strontium	4	4	2	4	0	0	0	3	1	1	2	2	2	25
Sulfur	2	2	1	2	0	0	0	2	1	2	1	1	2	16
Tantalum	4	4	4	4	1	2	4	2	2	2	2	2	2	35
Thallium	3	4	2	4	2	2	2	2	2	1	1	2	2	29
Tin	4	4	3	4	0	0	0	3	0	2	0	1	0	21
Titanium Con	3	2	1	3	0	0	0	2	1	1	2	2	2	19
Tungsten	3	4	3	3	1	1	2	2	1	2	2	2	2	28
Vanadium	2	4	2	4	0	0	0	1	0	2	2	2	1	20
Zinc	3	4	3	3	0	0	0	3	0	2	2	2	1	23
Zirconium	2	4	2	0	0	0	0	3	0	2	1	1	1	16
Insufficient Data														

Appendix C: NNR Applications

NNR	Critical Applications	NNR	Critical Applications	NNR	Critical Applications
Aluminum	Many and varied	**Gold**	Electronics, jewelry, dental	**Platinum Group**	Catalytic converters, fuel cells, ICs, LCDs
Antimony	Batteries, flame retardants, alloy (hardens lead)	**Graphite**	Refractory applications, steelmaking, batteries, fuel cells, brakes	**Potash**	Fertilizers, chemicals
Arsenic	Batteries, semiconductors, solar cells, pesticides, herbicides	**Gypsum**	Wallboard, plaster, cement, agricultural applications	**Rare Earths**	Catalytic converters, computer monitors, radar, magnets
Barite	CRT glass, x-ray shield, oil and gas well drilling mud	**Hafnium**	Semiconductors, nuclear energy applications	**Rhenium**	Super alloys (turbines), catalysts, ICs
Bauxite	Primary feedstock for aluminum	**Indium**	Semiconductors, LCDs, solar cells, alloys	**Salt**	Caustic sodas, highway deicing, agriculture, food
Beryllium	Computers, telecoms, aerospace, defense—alloy (copper)	**Iron Ore**	Feedstock for steel	**Selenium**	Fertilizers, alloy, catalyst, solar cells, glass colorization
Bismuth	Metal alloys, munitions, pharmaceuticals, chemicals	**Lead**	Batteries, ammunition, solder, pigments	**Silicon**	Alloys, chemicals, semiconductors
Boron	Glass, fiberglass, ceramics, detergents, plant nutrient	**Lime**	Steel making, flu gas desulfurization, water treatment	**Silver**	Catalytic converters, batteries, solar cells, electronics, coins
Bromine	Flame retardant, oil and gas well drilling fluid, pesticides	**Lithium**	Batteries, lubricants, ceramics, possible E-car batteries	**Soda Ash**	Glass, chemicals, soaps, flu gas desulfurization
Cadmium	Batteries, coatings, metal alloys, photovoltaics	**Magnesium**	Refractories, agricultural, chemical, construction	**Strontium**	Pyrotechnics, signals, magnets, alloys, CRTs
Cement	Building and construction	**Manganese**	Steel production, alloys, batteries, fertilizers	**Sulfur**	Fertilizer, petroleum refining
Chromium	Super alloys, stainless steel, plating	**Mercury**	Caustic soda, fluorescent lamps, vinyl monomer	**Tantalum**	Capacitors (electronics), alloys
Coal	Electricity generation, heating and cooking	**Molybdenum**	Iron and steel production, super alloys	**Thallium**	Medical imaging, MRI, radiation detection, catalyst, high temperature superconductors
Cobalt	Super alloys, aircraft engines, chemical apps.	**Natural Gas**	Electricity generation, heating and cooking, fertilizers	**Tin**	Cans, containers, solder, electrical, construction
Copper	Electronics, wiring, construction products	**Nickel**	Stainless steel, super alloys, alloys, batteries, electroplating	**Titanium**	Aerospace, armor, medical, high strength super alloy
Diamond	Computer chips, construction, cutting	**Niobium**	Alloys and super alloys for aerospace	**Tungsten**	Cutting materials, wear-resistant materials, super alloy, lighting
Fluorspar	Uranium, aluminum, and steel processing; precision optics	**Nitrogen—Fixed (Ammonia)**	Fertilizers, blasting agents, plastics	**Vanadium**	Super alloy, aerospace
Gallium	High speed semiconductors, laser diodes, solar cells, LEDs, alloys	**Oil**	Transportation fuel, plastics, pharmaceuticals; over 4,000 products	**Zinc**	Galvanizing, alloy
Garnet	Cutting, water filtration, abrasives	**Phosphate Rock**	Fertilizers, animal feed supplements	**Zirconium**	Abrasives, alloy, coating (nuclear industry)
Germanium	Fiber optics, infrared optics, solar electronics				

Appendix D: NNR Myths

We may not actually believe that nonrenewable natural resources are "unlimited", but we certainly believe—erroneously—that there will always be "enough".

Plentiful NNR Supplies Remain to be Discovered

Myth: The earth is a literal treasure trove of nonrenewable natural resources; plentiful NNRs are there for the taking.

Reality: Deposits of most nonrenewable natural resource types are neither abundant nor randomly distributed. NNR deposits of sufficient quality to be extracted profitably from both an economic perspective and a "net NNR" perspective occur only rarely and in well understood geological formations. Because geologists have been searching for such formations for centuries, most of the high quality NNR deposits have been discovered and exploited.

Additional high quality NNR deposits undoubtedly remain to be discovered, but new NNR discoveries in almost all cases will be fewer in number, smaller in size, and lower in quality—which accounts for the fact that all NNRs, with the possible exception of "practically inexhaustible" minerals such as salt and soda ash, are becoming increasingly scarce.

It should also be noted that crustal NNR occurrences, which are often enormous in size and are certainly "there for the taking", are not recoverable from an ROI standpoint. Producing sufficient NNR quantities from the earth's crust to enable our industrialized American way of life has never been feasible from either an economic ROI perspective or a "net NNR" ROI perspective; nor will it ever be.

Even in the unlikely event that exploiting crustal NNRs becomes ROI positive at some point in the future the resulting "net NNR" yields would be woefully inadequate to perpetuate our industrialized lifestyle paradigm.

Historical "Low NNR Reserve" Projections Proved to be False Alarms

Myth: During the past century, remaining NNR reserves, as measured by "official" government estimates, often appeared to be critically low. In each case, additional investment produced new NNR discoveries, and/or new technologies increased the percentage of recoverable NNRs from known deposits—and reserves were increased to acceptable levels. This will always be the case.

Reality: Historically, during the era of "continuously more and more", it was to be expected that incremental investments and new technologies would "create" additional NNR reserves—essentially "on demand". Large, high quality NNR deposits remained to be discovered, and rudimentary NNR exploration and production techniques were subject to tremendous technological improvement.

As we transition to the era of "continuously less and less"—as an increasing number of NNRs peak and go into terminal decline—our traditional "solutions" for increasing NNR reserves—incremental investment and new technology—are naturally experiencing diminishing returns.

Newly discovered NNR deposits are fewer, smaller, and of lower quality. The new technologies required to optimize these lower quality NNR deposits are becoming increasingly complex and expensive. As a result, NNR investment returns are declining from both an economic perspective and a "net NNR" perspective.

During the global "economic boom" experienced in the early years of the 21st century, NNR supplies could not keep pace with global demand in most cases; providing compelling evidence that incremental investments and new technologies were failing to produce sufficient incremental NNR reserves "on demand", as had historically been the case. This is our new reality.

Technological Innovation will Produce Additional NNR Supplies

Myth: New technologies will enable us to discover additional NNRs and to recover greater percentages of the NNRs that we discover. Such has been the case since the inception of our industrial revolution, and it will always remain so.

Reality: It is true that new technologies have enabled NNR discoveries in increasingly remote and difficult to access areas; and that new technologies have enabled us to recover increasing percentages of NNRs in place.

However, even new technologies experience diminishing returns. Each new technology is more complex and expensive, yet it produces marginally fewer "net NNRs" because the NNR deposits to which new technologies are applied are of declining quality and are more difficult and costly to exploit.

So despite new technological advances, we are running harder just to try to stay even—and we are invariably falling behind. That we must resort to increasingly complex and expensive technologies in order to discover and produce increasingly complex and expensive NNR deposits—the only remaining NNR deposits—is the most telling argument that NNR supplies are becoming increasingly scarce.

Finally, it should be noted that human technologies will never "produce" NNRs; only Nature can do that, and the processes take thousands or millions of years.

Recycling will Extend NNR Supplies Indefinitely

Myth: Recycling will enable us to reuse previously produced NNRs indefinitely, thereby greatly reducing or eliminating our future requirements for newly mined NNRs.

Reality: NNR recycling is already practiced extensively, both domestically and globally. In the US, recycled copper constitutes 31% of our total annual utilization level; recycled aluminum, 30%; recycled gold, 67%, and recycled tin, 20%. Yet mine production associated with these and other recycled NNRs increases unabated, until geological constraints dictate otherwise.

In total, recycled NNRs currently account for approximately 8% of annual US NNR utilization.[39] While this percentage is probably subject to improvement, the question is "by how much" (?); given that considerable recycling already occurs and that many heavily utilized NNRs, such as fossil fuels, cannot be recycled at all.

Too, since recycling processes produce NNR loss during each recycling iteration, recycling has its limits as well.

NNR Substitution will Alleviate NNR Scarcity and Avert Shortfalls

Myth: Readily available NNR substitutes have displaced and will continue to displace increasingly scarce NNRs, thereby dramatically reducing demand for today's increasingly scarce NNRs.

Reality: Readily available NNR substitutes exist in some cases, although price/performance degradation in targeted applications typically results. In many cases, however, no viable NNR substitutes exist, especially in critical applications—either because the price/performance compromise is unacceptably large or because the intended substitute is becoming increasingly scarce as well. In the remainder of cases, NNR substitutes simply do not exist.

Unless we can discover ways to substitute "practically inexhaustible" NNRs such as bromine, gypsum, lime, and soda ash for the multitude of energy resources, metals, and minerals that are becoming increasingly scarce—which is highly unlikely—we should not expect NNR substitution, especially "forced" substitution, to save the day.

Incremental Investment will Produce Sufficient Additional NNRs

Myth: Remaining NNR supplies are essentially unlimited, or are certainly sufficient to meet our current and long term needs. We need only make sufficient investments in exploration and production to insure sufficient NNR supplies for centuries to come.

Reality: Both economic investments and natural resource investments are subject to and are experiencing diminishing returns with respect to NNR exploration and production. Fewer, smaller, lower quality NNR deposits produce lower "net NNR" quantities, despite ever-increasing investments—our "decreasing NNR ROI" double whammy.

Available NNR supplies will continue to become increasingly scarce and expensive precisely because continuously increasing economic investments and natural resource investments are required to produce continuously decreasing NNR quantities—that is exactly what ever-increasing NNR scarcity is all about!

Unfortunately, ever-increasing supplies of "high ROI" NNRs are required to perpetuate our American way of life.

Conservation will Solve our NNR Scarcity Problem

Myth: We will dramatically decrease our NNR utilization levels through conservation efforts such as "green initiatives"; we will become more "environmentally responsible".

Reality: Really—when? And, even if we were to launch significant national and global NNR conservation initiatives, reducing our NNR utilization levels would merely defer societal collapse, not avert it. We would simply deplete finite NNR reserves more slowly and collapse at a slightly later date.

In reality, however, we show no inclination toward adopting self-limiting natural resource utilization behavior. We never have and never will because reducing our natural resource utilization levels would reduce our material living standards—which we consider to be a birthright. Both our NNR and RNR utilization levels will increase steadily, until geological and/or geopolitical factors intervene to constrain supplies.

Population Stabilization will Solve our NNR Scarcity Problem

Myth: Population stabilization or reduction will dramatically reduce our NNR utilization levels, thereby "saving sufficient NNRs for future generations".

Reality: Population stabilization or reduction, assuming that either could be accomplished, would only defer our inevitable societal collapse, not avert it. Suppose we could magically reduce our population level by 50%—instantaneously. All else being equal, we would reduce our NNR utilization level by 50% as well—thereby merely doubling the time interval between now and our societal collapse, to 50 years at the outside instead of 25 years.

Reducing our NNR utilization levels through population reduction, NNR conservation, or by any other means affords us a temporary stay of execution, at best, not a pardon.

Global NNR Redistribution will Solve our NNR Scarcity Problem

Myth: Our real problem is that natural resources are distributed inequitably; a majority of the world's wealth is currently held by a small elite minority. If the world's economic output were distributed equally among the world's population, everyone would enjoy a relatively comfortable living standard.

Reality: It is true that current global economic output, if divided equally, would provide a comfortable living standard for the world's population. Today's global per capita GDP approximates that of Brazil—certainly a comfortable material living standard, and actually an improvement for the populations of 123 of the world's countries.[40]

Unfortunately, the redistribution of natural resources, wealth, and/or income would not solve our fundamental problem of increasing NNR scarcity—the global demand/supply dynamics associated with future NNR availability remain the same. Global NNR supplies will decline going forward—irrespective of who owns or controls them—thereby reducing attainable material living standards for all.

Increased Efficiency and Productivity Gains will Reduce NNR Demand

Myth: We will reduce our NNR demand through increased efficiency and through productivity gains. Electric cars, LED lights, solar and wind power, computerization, and other technical advances will make us more efficient and more productive, while reducing our NNR utilization levels in the process.

Reality: Actually, new technologies typically tend to save human labor at the expense of additional NNR usage. We think in terms of human labor efficiency and productivity, not in terms of NNR utilization efficiency and productivity. And, contrary to conventional wisdom, efficiency gains associated with new technologies typically produce net increases (not decreases) in NNR utilization. (See Jevons Paradox—http://en.wikipedia.org/wiki/Jevons_paradox.)

Service Economies Use Fewer NNRs

Myth: As the US transitions from a production economy to a service economy, our NNR utilization levels are declining.

Reality: Our "direct" NNR utilization levels have declined over the past several decades, in parallel with our transition from a production economy to a service economy. This transition was brought about not by choice, but by the peaks and declines associated with domestic US NNR production levels.

We have, however, continued to increase our "real" NNR utilization levels in almost all cases, despite our transition, through our offshore outsourcing of manufacturing to foreign production facilities and our net imports of foreign goods and services. While the NNRs associated with these activities are not included in USGS NNR utilization data, they are real NNRs used by real Americans.

Too, even if we (Americans) manage to decrease our real NNR utilization levels in the future, ever-increasing NNR utilization by foreign industrializing nations will more than offset our reduced utilization levels. Given that our future operating environment will be characterized by continuously declining global NNR supplies, the NNR supplies available to America will be insufficient to perpetuate our American way of life in any case.

American Societal Wellbeing Cannot Possibly Peak and Decline

Myth: American societal wellbeing will not peak and decline; nor will our lifestyle attributes. Our population level will continue to increase and our material living standards will continue to improve going forward, as they have historically.

Reality: A country's level of societal wellbeing—the material living standards enjoyed by the country's population—is determined by the natural resource mix and levels utilized by the country's population. An industrialized country's level of societal wellbeing is determined by the mix and levels of nonrenewable natural resources utilized by the country's population. Given that NNR supplies available to America are peaking and declining, it follows that American societal wellbeing must peak and decline as well.

Post-industrial Life will be Preferable to Our Industrial Lifestyle Paradigm

Myth: Industrialization has brought nothing but misery and degradation to the human race; our quality of life (and spiritual wellbeing) will improve substantially in a post-industrial world.

Reality: The post-industrial lifestyle awaiting the few who survive our impending societal collapse will under the best of circumstances share many attributes with pre-industrial America. Unfortunately, the realities associated with such a lifestyle paradigm bear little semblance to the Hollywood version.

Pre-industrial life was cold in the winter and hot in the summer; work was physically demanding and dangerous; if the crops failed, people starved; if someone got sick, they died; infant mortality was high; and average human life expectancy was about 36 years.

Those who anxiously await our post-industrial way of life will be disappointed, assuming they live to experience it.

Appendix E: Possible Sources of Error

Possible sources of error associated with analyses and findings contained in the preceding paper fall into three categories:

- Future NNR Supplies are Understated
- Analytical Methods are Flawed
- Analytical Findings are Flawed

Future NNR Supplies Are Understated

Increasing NNR Scarcity is Overstated

Assertion: Only 14 (at most) of the 58 analyzed NNRs have reached global peak production to date, and 24 of the 58 actually showed increases in annual production growth rates during the 21st century as compared to the 20th century. Adequate supplies associated with many of the NNRs that enable our industrialized lifestyle paradigm remain available.

Response: Only 14 NNRs had reached their US peak production levels as recently as the year 1954. By the year 2000, only 46 years later, 48 of the 58 analyzed NNRs had reached their US peak production levels. The world is simply lagging the US by a few decades.

Too, America and other industrialized nations had a safety valve as their domestic NNR supplies peaked—foreign countries, either as colonies or as "trading partners". Unfortunately, there is no global safety valve on a finite earth.

As an increasing number of NNRs reach global peak production and go into terminal decline, the impacts in terms lifestyle disruptions—population level reductions and material living standard degradation—will be felt by all nations.

While certainly not all NNRs will reach their global peak production levels within the next 5, 15, or 25 years; societal collapse is not contingent upon the "peaking" of all or even a majority of NNRs. Post-peak declines associated with a handful of critical NNRs will produce sufficient NNR supply shortfalls to topple industrialized civilization. (See Liebig's Law of the Minimum—http://en.wikipedia.org/wiki/Liebig's_law_of_the_minimum.)

Recent Declines in NNR Production Growth Rates are Attributable to Declining Demand

Assertion: Recent declines in annual global NNR production growth rates, in cases where they have occurred, are attributable to declining demand, not to permanent geological supply constraints caused by peak NNR production and post-peak declines.

Response: The number of cases in which annual global NNR production growth rates have recently declined or gone negative is simply too great to attribute the overall phenomenon entirely to reduced demand—especially since the pre-recession 21st century was an economic boom time during which demand generally increased continuously and universally.

Annual global production growth rates associated with 27 NNRs slowed during the 21st century; and the annual global production levels associated with an additional 6 NNRs actually declined during the 21st century, after showing positive growth during the 20th century.

NNR price levels also indicate continuously increasing demand for most NNRs. Thirty eight (38) NNRs experienced annual growth in 21st century price levels, after experiencing declining annual price levels during the 20th century. An additional 12 NNRs experienced increases in annual price level growth rates during the 21st century as compared to the 20th century. Continuously increasing price levels typically indicate that supply is unable to keep pace with demand.

With the exception of a very few "practically inexhaustible" NNRs such as soda ash and salt, current annual NNR production levels—much less continued exponential growth in those levels—cannot be maintained indefinitely. Global NNR production peaks are inevitable, and will be experienced with increasing frequency, as evidenced by currently declining annual NNR production growth rates.

Recoverable NNR Quantities are Understated

Assertion: USGS NNR "reserve" data understate ultimately recoverable NNR quantities. Some NNRs currently classified as "reserve base" will be converted to reserves and be recovered; and future investments will yield new discoveries of recoverable NNR reserves.

Response: USGS "reserve base" estimates include NNRs that are currently "marginally economic" and "subeconomic". While it is true that some of these NNRs will ultimately be reclassified as "reserves", and that additional NNR discoveries will be made, there is no guarantee that sufficient economic resources and/or natural resources will be available in the future to actually produce these resources. Both the economic ROI and the natural resource ROI associated with lower quality NNR deposits are declining continuously.

NNR interdependencies will also negatively impact ultimately recoverable NNR quantities in some cases. NNRs that are produced only as byproducts or co-products of other "primary" NNRs might never be recovered in the event that the primary NNRs prove to be unrecoverable.

Finally, it should be noted that estimating remaining NNR reserves is an inexact "science". Data reporting standards vary among countries, and even good NNR reserve estimates are only "estimates". Should the USGS and EIA reserve estimates used in the analyses prove to be optimistic, US NNR supply shortfalls will arrive much sooner and in greater numbers than predicted in the analyses.

Of the multiple government estimates regarding ultimately recoverable NNR quantities, the "reserve" estimate is likely to be the best available.

Peak NNR "False Alarms"

Assertion: NNR peak production levels cited in the analyses might be exceeded in the future, especially in cases where the cited "peak year" is relatively recent (2000-2005).

Response: In general, the more distant the peak production year and the more rapid and/or steady the post-peak production decline rate, the more likely that the cited peak year will be the actual peak year.

For that reason, the most recent peak year cited in the analyses is 2005. Given that a global economic boom continued for at least 2 years after 2005, it could be argued that had sufficient NNR supplies been available, 2005 production levels would have been exceeded in 2006, 2007, or 2008. However, only time will tell if the NNR peak years cited in the analyses will be exceeded.

The inescapable fact is that peak production and post-peak terminal decline are inevitable with respect to every NNR, assuming that production continues. Domestic US NNR peak production levels have been reached for a vast majority of the analyzed NNRs; the same phenomenon is now occurring globally.

US Peak NNR "False Alarms"

Assertion: We in the US have chosen voluntarily to decrease our domestic NNR production levels, or to cease domestic NNR production entirely. Domestic US NNR production levels have not peaked for geological reasons.

Response: It is possible that we, as a society, have chosen to decrease domestic NNR production in some cases and to cease domestic NNR production altogether in other cases.

In almost all cases however, global NNR demand continues to increase; so it would seem logical that domestic US NNR producers would seek to profit from that demand by producing additional domestic NNRs—if they were able to.

For 40 of the 58 analyzed NNRs, we import at least 25% of our annual utilization level, either because imported NNRs are less expensive than domestically produced NNRs or because we physically cannot produce sufficient NNRs domestically. In cases where we physically cannot produce sufficient NNRs domestically, yet our domestic production levels continue to decline, it seems logical that domestic US NNR production levels have peaked.

In cases where imported NNRs are less expensive than domestic NNRs, the issue becomes “at what price, if any, will remaining domestic US NNRs become cost competitive”?

Only time will tell if domestic US NNR production levels have peaked for geological reasons or for economic reasons. But it seems to be the case that US NNR production level reductions are due for the most part, if not exclusively, to geologically imposed post-peak declines.

Conflicting NNR Scarcity Indicators

Assertion: For certain NNRs, some of the indicators show increasing scarcity while others show currently sufficient supplies. For example, zinc’s indicators show only 14 years of remaining reserves, yet global production had yet to peak by the year 2008, and zinc’s annual production growth rate had actually increased during the 21^{st} century as compared to the 20^{th} century.

Response: Conflicting NNR indicators occur due to temporary supply and/or demand anomalies that distort the prevailing data trends, data reporting or transcribing errors, incomplete or unavailable data, and temporary inconsistencies that will resolve themselves over time.

The Cumulative Vulnerability Indicator in the Shortfall Analysis attempts to compensate for such inconsistencies by considering a wide range of NNR shortfall indicators, under the assumption a cumulative indicator will reflect the discrepancies associated with conflicting indicators—NNRs with conflicting indicators receive lower Cumulative Vulnerability Ratings.

What is known with certainty is that every NNR will reach its peak production level, and decline remorselessly thereafter. Domestic US zinc production peaked in 1969 and is currently being produced domestically at only 13% of its peak production level.

Analytical Methods Are Flawed

The US NNR Supply Shortfall “Timing Window” is Arbitrary

Assertion: The NNR supply shortfall “timing window” used in the analyses—5 years possibly, 15 years probably, and 25 years almost certainly—is arbitrary.

Response: The 25 year time window is a proxy for “imminent”; the intent being to convey the message that US NNR supply shortfalls and American societal collapse will occur in the not-too-distant future—not at some distant time such as 1,000 years, 500 years, 100 years, or even 50 years hence.

Supplies associated with 17 NNRs—including iron ore, manganese, tin, and zinc—are projected to exhaust within 25 years; and an additional 13 NNRs—including bauxite, coal, copper, natural gas, and oil—are projected to exhaust within 40 years. While none of these NNRs will actually deplete to exhaustion, it seems reasonable to expect that several will deplete to levels at which available supplies will be insufficient to meet our minimum societal requirements, thereby causing supply shortfalls.

At the end of the day, it is of little consequence whether American society collapses in 10 years, 25 years, or 40 years—the point is that collapse is imminent, and inevitable.

NNR Growth (Decline) Trend Line Calculations are Inaccurate

Assertion: The "two point" method by which NNR growth (decline) trends were calculated in the analyses yields inaccurate growth and decline rates.

Response: In cases where comparisons are made between 20th century data and 21st century data, 20th century growth (or decline) trends were calculated by comparing the earliest available 20th century data point from USGS or EIA time series data—the year 1900 being the earliest possible year—with the year 2000 data point. 21st century growth (decline) trends were computed by comparing the year 2000 data point from USGS or EIA time series data with the 2008 data point, if available; or the 2007 data point in the event that 2008 data was not yet available.

Regression analyses would yield more accurate growth rates and decline rates than the "two point" method employed in the analyses.

However, the "two point" method contains no systemic bias—growth (decline) rate projections are equally as likely to be "high" as they are "low". And, while less precise than regression analysis, the employed method is sufficiently accurate to compare "century-versus-century" NNR growth (decline) trends.

Scarcity Analysis and Shortfall Analysis Rating Schemes are Arbitrary

Assertion: The indicators and rating schemes employed in the analyses are arbitrary.

Response: The goal was to define the most comprehensive set of NNR scarcity indicators and supply shortfall indicators possible, given available USGS and EIA data. Suggests for improvement are welcomed.

The rating scheme employed in the Shortfall Analysis was based on the perceived relative importance associated with the various indictors. Geological factors were weighted more heavily than geopolitical factors because NNR supply shortfalls resulting from geopolitical factors are potentially overcome or mitigated; NNR supply shortfalls resulting from geological factors—NNR production peaks and declines—are irreversible.

Again, suggestions for improvement are welcomed.

At issue is whether the primary conclusion derived from the Scarcity Analysis and Shortfall Analysis—imminent US societal collapse—is credible. Only time will tell; but the evidence is compelling.

The Analyses Contain Data Errors

Assertion: USGS and/or EIA data have been misreported, misinterpreted, or misapplied; thereby producing flawed findings and conclusions.

Response: Instances of data misreporting, misinterpretation, or misapplication, if they exist, are unintentional; every attempt was made to represent data according to published USGS and EIA definitions. If such errors are found and reported, they will be remedied immediately.

That being said, the preceding analyses contain thousands of data elements and calculations; errors are inevitable. At issue is whether the errors are material—i.e., whether they invalidate the paper's primary conclusion: American societal collapse is inevitable and imminent.

Analytical Findings are Flawed

American Society will Not Collapse within 25 Years

Assertion: American society cannot possibly collapse within 25 years; we are the most powerful nation in the world.

Response: The future is uncertain, and the variables and possible permutations going forward are too many and too complex to model. However, the trends toward ever-increasing NNR scarcity and US vulnerability to imminent and permanent NNR supply shortfalls are undeniable—as are the implications associated with following those trend lines to their logical endpoints.

The question regarding American societal collapse is not "if", but "when"; and the analyses present compelling evidence that "when" will very likely be sooner rather than later. While 25 years is certainly an arbitrary figure, the point is that the relevant timeframe within which American society is likely to collapse is "one generation or so", rather than "several generations (or centuries) from now".

Given the findings associated with the Scarcity Analysis and Shortfall Analysis, it is nearly impossible that America can avert societal collapse beyond the year 2050.

Our Post-peak Decline Need Not be Catastrophic

Assertion: Even if America's societal wellbeing level does peak within the next few years, the post-peak scenario need not be one of societal collapse. As the earth's most intelligent species, we will orchestrate a gradual post-peak decline to a sustainable lifestyle paradigm, rather than experience a precipitous collapse.

Response: To date, we have failed to acknowledge our predicament—domestically or globally—much less have we taken meaningful action to mitigate its inevitable and devastating consequences. Actually, we have done just the opposite; we have continuously augmented our unsustainable natural resource utilization behavior, thereby increasing the gap between our "overextended" societal wellbeing level and sustainability.

America's population, who take for granted an operating environment characterized by "continuously more and more", will not accept gracefully our new reality of "continuously less and less". Nor will the populations of nations aspiring to "continuously more and more" accept gracefully the reality that industrialized status will never be realized.

The inevitable result of the shattered dreams to come will be domestic and international conflicts over remaining natural resources, both NNRs and RNRs. A gradual post-peak decline is impossible.

Footnotes

(1) "USA Farm Heritage", The National Museum of Food and Farm Museum - http://www.foodmuseum.com/nmffUSAFarmHeritage.html.
(2) "On American Sustainability", pg. 12; Chris Clugston, 2009 - http://www.wakeupamerika.com/PDFs/On-American-Sustainability.pdf.
(3) 2008 data from "2008 Mineral Baby", Mineral Information Institute, 2009 - http://www.mii.org/pdfs/2009miiMineralsBaby.pdf; 1800 data from "The American Lifestyle", pg. 3 (1776 estimate of 1200 pounds per capita extrapolated to 1500 pounds per capita in 1800); Mineral Information Institute, 2006 - http://www.mii.org/pdfs/Minerals1776vsToday.pdf.
(4) Colin Campbell explains the depletion function associated with nonrenewable natural resources and provides examples pertaining to oil depletion in "The Coming Oil Crisis", pgs. 95-97; Colin J. Campbell, Multi-Science Publishing Company & Petroconsultants S.A; 1988.
(5) "Peak" NNR production does not imply imminent "exhaustion". At peak, approximately half of the ultimately recoverable resource still remains to be extracted. The post-peak half of the resource is simply more energy-intensive, resource-intensive, and expensive to exploit than the pre-peak half.
(6) For an overview of the timing and circumstances associated with the original settlement of the US, see David Stannard's "American Holocaust – The Conquest of the New World", pgs. 9-11; Oxford University Press, NY, NY, 1992.
(7) "2008 World Population Data Sheet", Population Reference Bureau, 2009 - http://www.prb.org/Publications/Datasheets/2008/2008wpds.aspx.
(8) "On American Sustainability", pg. 12; Chris Clugston, 2009 - http://www.wakeupamerika.com/PDFs/On-American-Sustainability.pdf.
(9) "On American Sustainability", pg. 12; Chris Clugston, 2009 - http://www.wakeupamerika.com/PDFs/On-American-Sustainability.pdf.
(10) "Measuring Worth" - http://www.measuringworth.com/calculators/uscompare/result.php.
(11) "Table 1.2.5 'GDP by Major Product Type'", US Bureau of Economic Analysis, 2009 - http://www.bea.gov/national/nipaweb/TableView.asp?SelectedTable=19&ViewSeries=NO&Java=no&Request3Place=N&3Place=N&FromView=YES&Freq=Year&FirstYear=1950&LastYear=2008&3Place=N&Update=Update&JavaBox=no.
(12) "Table 5.1 'Petroleum Overview 1949-2008'", US Energy Information Administration, 2009 - http://www.eia.doe.gov/emeu/aer/txt/stb0501.xls.
(13) "The Bretton Woods System", Wikipedia - http://en.wikipedia.org/wiki/Bretton_Woods_system.
(14) "Table F.107", US Federal Reserve Flow of Funds Accounts of the United States, 2009; 1975 data - http://www.federalreserve.gov/releases/z1/Current/annuals/a1975-1984.pdf; 2008 data - http://www.federalreserve.gov/releases/z1/Current/annuals/a2005-2008.pdf.
(15) "Table L.1" US Federal Reserve Flow of Funds Accounts of the United States, 2009; 1981 data - http://www.federalreserve.gov/releases/z1/Current/annuals/a1975-1984.pdf ; 2008 data - http://www.federalreserve.gov/releases/z1/Current/annuals/a2005-2008.pdf.
(16) "Table 2: International Investment Position of the United States at Yearend 1976-2008", US Bureau of Economic Analysis - http://www.bea.gov/international/xls/intinv08_t2.xls.
(17) "For Many, a Boom that Wasn't", The New York Times, 9 April 2008; http://www.nytimes.com/2008/04/09/business/09leonhardt.html?ex=1365393600&en=83a62b21dfe6f807&ei=5124&partner=permalink&exprod=permalink.
(18) "Fiscal and Generational Imbalances: An Update", pg. 26; Gokhale and Smetters, 2005 - http://www.philadelphiafed.org/research-and-data/events/2005/fed-policy-forum/papers/Smetters-Assessing_the_Federal_Government.pdf.
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(20) "Active Duty Personnel Strengths by Regional Area and by Country", US Department of Defense, 2008 - http://siadapp.dmdc.osd.mil/personnel/MILITARY/history/hst0803.pdf; and "United States Armed Forces", Wikipedia, 2009 - http://en.wikipedia.org/wiki/United_States_armed_forces.

(21) Tremendous quantities of nearly all NNRs exist in the earth's crust. These NNR occurrences are of such low concentration, however, that their exploitation has never been feasible—and it never will be—from either an economic ROI perspective or a natural resource ROI perspective.
(22) Oil provides an excellent example of diminishing investment returns (net energy in this case) associated with "low ROI" NNR deposits. See "Implications of Energy Return on Investment, Peak Oil and the Concept of "Best First", Charles Hall, The Oil Drum (posting), January 2009 - http://netenergy.theoildrum.com/node/4678.
(23) Scarcity Analysis data sources:

- "Mineral Commodity Summaries 2009", USGS, 2009 - http://minerals.usgs.gov/minerals/pubs/mcs/2009/mcs2009.pdf;
- "Mineral Commodity Summaries (history)", USGS, 2009 - http://minerals.usgs.gov/minerals/pubs/mcs/;
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- "Coal Overview, 1949-2008", EIA - http://www.eia.doe.gov/emeu/aer/txt/stb0701.xls;
- "Crude Oil Domestic First Purchase Prices, 1949-2008, EIA - http://www.eia.doe.gov/emeu/aer/txt/stb0518.xls;
- "Natural Gas Wellhead, City Gate, and Import Prices, 1949-2008", EIA - http://www.eia.doe.gov/emeu/aer/txt/stb0607.xls;
- "Coal Prices, 1949-2008", EIA - http://www.eia.doe.gov/emeu/aer/txt/stb0708.xls;
- "World Proved Reserves of Oil and Natural Gas, Most Recent Estimates", EIA, 3 March 2009 (I used arithmetic averages) - http://www.eia.doe.gov/emeu/international/reserves.html; worldwide coal reserves range from 662 BST (Rutledge) to 930 BST (EIA)—I took the average;
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- "Compound Interest Calculator - http://www.1728.com/compint.htm; and
- "The Inflation Calculator" - http://www.westegg.com/inflation/infl.cgi.

(24) "US Natural Gas: the Role of Unconventional Gas", The Energy Bulletin, Gail Tverberg, 18 May 2008 - http://www.energybulletin.net/node/44389; "North American Natural Gas Production and EROI Decline", The Oil Drum, John Friese (chart from Laherrere), 27 February 2008 - http://www.theoildrum.com/files/laherrere_figure3.png.
(25) The natural gas market is typically national or regional in scope, rather than global. Unlike oil, which is easily transported internationally via tanker ship, natural gas is difficult and expensive to transport except by pipeline. We are therefore unable to import large quantities of natural gas from countries other than Canada and Mexico, even though supplies outside of North America may remain relatively plentiful for the next 10-15 years.
(26) "On American Sustainability", pgs. 46-47; Chris Clugston, 2009 - http://www.wakeupamerika.com/PDFs/On-American-Sustainability.pdf.
(27) "On American Sustainability", pgs. 46-47; Chris Clugston, 2009 - http://www.wakeupamerika.com/PDFs/On-American-Sustainability.pdf.
(28) US NNR Import Reliance (2008): the percentage of total US NNR utilization (apparent consumption) that was imported during the 2004 to 2007 period.
(29) "On American Sustainability", pgs. 456-46; Chris Clugston, 2009 - http://www.wakeupamerika.com/PDFs/On-American-Sustainability.pdf.

(30) New exploration and production technologies can enable increased NNR production from lower quality deposits up to a point, but they cannot enable endless discoveries of high quality, low cost deposits. It is inevitable in all cases that global NNR production will peak and go into terminal decline.
(31) Note "List of Countries by Past GDP (year 2000: $31.6 trillion), Wikipedia, - http://en.wikipedia.org/wiki/List_of_countries_by_past_GDP_(nominal); world GDP in 2008 (average of the 3: $61 trillion; $49.25 trillion in year 2000 USD), Wikipedia - http://en.wikipedia.org/wiki/List_of_countries_by_GDP_%28nominal%29; world GDP in 1900 ($70.25 billion; $1.449 trillion in year 2000 USD) - http://www.ier.hit-u.ac.jp/~kitamura/data/Source/WorldPopulationData.xls.
(32) US NNR utilization (consumption) data includes primary domestic NNR production (mined), secondary domestic NNR production (recycled), and NNR imports. It does not include non-domestic NNRs incorporated in US-consumed goods that are manufactured by US and foreign corporations in offshore facilities.
(33) See note 22 above.
(34) "Innovative Technologies and Innovative Technologies and Strategic Resources", Armin Reller, 27 March 2009 - http://www.lisboncivicforum.org/lisbon09/reller_pr.pdf.
(35) See "Liebig's Law of the Minimum", Wikipedia - http://en.wikipedia.org/wiki/Rare_earth_element.
(36) Oil provides an excellent example of an NNR for which global discoveries peaked years ago (1965), and for which global production is currently near or at peak. See "Peak Oil Primer"—see "The Growing Gap" chart, The Energy Bulletin - http://www.energybulletin.net/primer.php.
(37) See "Complexity is Subject to Diminishing Returns", especially the section on "Technical Innovation", The Anthropik Network (Jason Godesky), October 2005 - http://tobyspeople.com/anthropik/2005/10/thesis-14-complexity-is-subject-to-diminishing-returns/.
(38) "On American Sustainability", pgs. 25-30; Chris Clugston, 2009 - http://www.wakeupamerika.com/PDFs/On-American-Sustainability.pdf.
(39) "Sociocultural and Institutional Drivers and Constraints to Mineral Supply", Brown, USGS 2002, pg. 41 (recycled metals) - http://pubs.usgs.gov/of/2002/of02-333/of02-333.pdf; and "Recycled Aggregates—Profitable Resource Conservation", USGS 2000, pg. 1 (recycled industrial minerals) - http://pubs.usgs.gov/fs/fs-0181-99/fs-0181-99so.pdf.
(40) "List of Countries by GDP (PPP) Per Capita", Wikipedia (CIA Factbook) - http://en.wikipedia.org/wiki/List_of_countries_by_GDP_(PPP)_per_capita.

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Prior to that I spent thirty years working with information technology sector companies in marketing, sales, finance, M&A, and general management—the last twenty as a corporate chief executive and management consultant. I received an AB/Political Science, Magna Cum Laude and Phi Beta Kappa from Penn State University, and an MBA/Finance with High Distinction from Temple University in Philadelphia, PA. I can be reached at coclugston "at" comcast "dot" net.

