Scarcity

Humanity's Final Chapter?

Nonrenewable Natural Resource Scarcity

— Causes, Implications, & Consequences —

Christopher O. Clugston

Figures for Earth's Dwindling Supplies of Resources

Earth's Ability to Absorb Wastes

In 1981 James Hansen provided figures on the ability of the earth to absorb the CO_2 that we now spew into the atmosphere. The CO_2 content had been steady at about 280 parts per million (ppm) during the first 10,000 years in which agriculture provided food for humans, but that regimen changed with our use of fossil fuels energy. 350 to 360 ppm is now accepted as the maximum for maintaining the kind of civilization we're accustomed to, but the CO_2 we keep pushing into the atmosphere through our use of fossil energy has now raised the content to 393 ppm with still higher levels forecast. The consequence is increasingly disruptive global warming. We can track these trends with figures.

Earth's Ability to Provide Bounty from Renewable Resources

In 1992 Mathis Wackernagel and William Rees attached figures to the annual bounty that humans obtain from what grows – forests, soils, fisheries, etc. Building on this, a Living Planet Index now indicates the health of world biodiversity and an Ecological Footprint provides a measure of our demands on Earth's resources. These figures show that our consumption of the earth's renewable resources is now one and a half times the rate at which the earth produces its bounty, with the excess coming from consumption and depletion of the feedstocks. By 2030 our over-consumption is likely to be double today's. These findings are based upon extensive studies, including trends in forests, fields, and in almost 8000 vertebrate species and demands of more and more people. The consequence must be higher food prices. We can track these various trends with figures.

Earth's Non-Renewable Resources: Fossil Fuels, Metals, and Non-Metallic Minerals

Now for the first time, in 2012, a comprehensive set of figures has become available that discloses the use of the minerals that have made industrialized civilization possible. With publication of *Scarcity, Humanity's Final Chapter?*, by Christopher O. Clugston, we now have a comprehensive study that shows mineral usage rates. Meticulous examination of 89 of Non-Renewable minerals shows that usage rates are peaking and that remaining supplies are dwindling rapidly. This means that continuance of existing living standards that are dependent upon these minerals is impossible. Instead, societal collapse world-wide must be expected by 2050. We now have figures to track these various trends.

J.R.B.

SCARCITY:
HUMANITY'S FINAL CHAPTER?

By

Christopher O. Clugston

What follows is a summary of key features of this newly published book that is now available at http://booklocker.com/books/6175.hyml for $19.95 plus $4.00 for shipping.

Clugston tracks the availability and usage of 89 non-renewable mineral resources (NNRs) are critical to the existence of industrialized civilization. For the US economy they are 95% of the annual raw material inputs, and we're using them up. Clugston explains the causes, implications and consequences of NNRs ever-increasing scarcity and rising costs of exploration, extraction and production. If prevailing trends continue, global societal collapse will almost certainly occur by 2050. The data will be reviewed with intense interest by economists, environmentalists, politicians, investors, and philosophers.

For the benefit of friends and acquaintances who will find many of Clugston's ideas and schedules interesting but who think they are too busy to read the book, I have prepared this summary. Perhaps it will persuade them to buy the book and learn more.

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Clugston argues that our modern industrialized civilization and improving standards of living are made possible by an indispensable use of fossil fuels, metals, and non-metallic minerals that are never replenished in any relevant time span. There are 89 of these non-renewable minerals and Clugston meticulously analyses each. Those that are viable economically are becoming scarcer and more costly. When their extraction/ production ceases to rise, as is now happening, it is inevitable that a sharp decline in global societal wellbeing must follow. Indeed, he shows that the Great Recession of 2008 was precipitated by the rising costs of NNRs. Separate pages provide specific information for each of 89 Non-renewable Natural Resources. The report on cadmium is attached as the final two pages of this summary. For each mineral the following information is given:

- Primary uses
- Critical applications
- Substitutes
- US scarcity in 2008
- Likelihood of permanent US scarcity
- Historical US import trends
- Historical US usage trends
- US peak production year
- US peak utilization year
- US scarcity assessment
- Possible geopolitical supply constraints
- Global scarcity in 2008
- Likelihood of permanent global scarcity
- Historical global production trends
- Global peak production year (thru 2008)
- Years to global reserve exhaustion
- Projected global peak production year
- Projected global peak supply year

The author's ideas are based entirely upon data assembled from the most reliable government and NGO sources available. Every significant statement is supported in the book's 20 pages of endnotes and references. To emphasize key points, numerous schedules are scattered throughout the book such as the one that follows.

Permanent Global NNR Supply Shortfall Probabilities (by the Year 2030)

NNR	Global NNR Extraction Data and Estimates			Projected Peak Global (Annual) NNR Extraction Level[1]	Probability of a Permanent Global Supply Shortfall by the Year 2030
	Current Annual Extraction Level	2000-2008 Annual Extraction Growth Rate	Projected 2030 Annual Extraction Level		
Bauxite	205M MT	5.3%	639M MT	1,400M MT	Low
Cadmium	20.8K MT	Global Extraction Has Likely Peaked		21.9K MT	Nearly Certain
Chromium	6.6M MT	4.0%	19.5M MT	8.5M MT	High
Coal	6,900M ST	6.0%	26,300M ST	11,000M ST	High
Cobalt	71.8K MT	9.0%	478M MT	70K MT	Very High
Copper	15.7M MT	2.2%	25.3 M MT	20M MT	High
Gold	2.3K MT	Global Extraction Has Likely Peaked		2.6K MT	Nearly Certain
Indium	568 MT	6.8%	2,415 MT	830 MT	High
Iron Ore	2.2B MT	9.4%	15.9B MT	3.9B MT	High
Lead	3.8M MT	2.2%	6.1M MT	3.4M MT	Very High
Lithium	27.4K MT	9.6%	206M MT	57K MT	High
Manganese	14M MT	9.1%	95M MT	73M MT	High
Mercury	1K MT	Global Extraction Has Likely Peaked		10.4 K MT	Nearly Certain
Molybdenum	212K MT	5.8%	733M MT	180K MT	Very High
Natural Gas	110T CF	2.8%	207T CF	140T CF	High
Nickel	1.6M MT	2.8%	2.9M MT	1.85M MT	High
Oil	31.5B bbls	1.4%	43.3B bbls	35B bbls	High
PGM	504 MT	4.8%	1,481 MT	440 MT	Very High
Phosphate Rock	167M MT	3.0%	320M MT	150M MT	Very High
REM	124K MT	4.0%	294K MT	3,050K MT	Low
Silver	20.9K MT	1.8%	31K MT	16K MT	Very High
Tellurium	<95 MT	Global Extraction Has Likely Peaked		212 MT	Nearly Certain
Tin	333K MT	2.3%	549K MT	730K MT	Low
Titanium	9.6M MT	6.2%	39M MT	9M MT	Very High
Tungsten	54.6K MT	Global Extraction Has Likely Peaked		66.5K MT	Nearly Certain
Zinc	11.3M MT	3.2%	23M MT	10.3M MT	Very High

(1) In cases where the annual "global extraction level has likely peaked", the figure is the USGS global "peak-to-date" NNR extraction (production) level.

What follows are the author's words that I have copied from the text. Quotation marks are omitted. My occasional comments are in brackets.

About the author: Since 2006, Chris Clugston has conducted extensive independent research into the area of "sustainability", with a focus on nonrenewable natural resource scarcity. He 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. He makes his home in Bethlehem, Pennsylvania.

INTRODUCTION

Non-Renewable Natural Resources (NNRs) are fossil fuels, metals, and nonmetallic (industrial and construction) minerals—which serve as the raw material inputs to our industrialized economies, as the building blocks that comprise our industrialized infrastructure and support systems, and as the primary energy sources that power our industrialized societies.

Renewable Natural Resources (RNRs)—i.e., air, water, soil (farmland), forests, and other naturally occurring biota—enable all life, including human life. RNRs provide all or most of the life supporting essentials—water, food, energy, shelter and clothing—in pre-industrial societies. [This book being about NNRs, RNRs are seldom mentioned.]

1
NATURE'S ROLE IN HUMAN EXISTANCE

NNRs enable [make possible] the production and provisioning of the manmade goods and infrastructure that differentiate industrial societies from pre-industrial societies—industrial societies are inconceivable through the exclusive use of RNRs.

NNR reserves are depleted primarily through human exploitation. Persistent depletion will result in exhaustion.

The industrialized worldview perceives Nature as something to be harnessed in order to continuously improve human societal wellbeing. America is a unique industrialized society—an extreme case with regard to its worldview, resource utilization behavior, and resulting level of societal well-being. Especially since the inception of the American industrial revolution, the mix of natural resources flowing into the US economy has shifted from "almost exclusively renewable" to "almost exclusively non-renewable." The shift has enabled the meteoric increase in American societal wellbeing over the past 200 years—ever-increasing material living standards enjoyed by an ever-increasing population.

While industrialized nations—especially the US—have certainly experienced historically unprecedented increases in societal well-being over the past several hundred years, their continued "success" is predicated upon continued access to sufficient supplies of essential natural resources, especially NNRs.

2
NON-RENEWABLE NATURAL RESOURCS

All else being equal, greater NNR quantities (economic input) enable greater levels of goods and services (economic output), which enable greater levels of social well-being. Therefore, in order to provide ever-growing material living standards for ever-increasing segments of our ever-expanding global population, we must obtain ever-increasing quantities of NNRs—specifically, "economically viable" NNRs.

NNR Applications: All systems, networks, products, and processes associated with industrialized societies are enabled, either exclusively or nearly exclusively, by NNRs. Specific NNR applications vary widely, but share common attributes as a function of the NNR type: fossil fuels, metals, and nonmetallic (industrial and construction) minerals.

Fossil Fuels: coal, natural gas, and oil provide 85% of the world's primary energy (2007) and are expected by the US energy Information Administration to provide over 80% of global primary energy in the year 2035. Petroleum also serves as a "feedstock" for thousands of products that are indispensable to modern industrial existence, including fertilizers, plastics, pharmaceuticals, paints, insecticides, herbicides, and various synthetic fabrics.

Metals: 48 of the 89 NNRs analyzed are metals. Metals are ideally suited to structural, electrical conductivity, and thermal conductivity applications.

Nonmetallic Minerals: 37 of the 89 NNRs analyzed are non-metallic minerals also known as industrial minerals and construction minerals.

NNR Significance: NNR utilization by industrialized and industrializing nations has increased dramatically during the past several hundred years. America currently (2008) uses approximately 6.5 billion tons of newly mined NNRs each year. This compares with approximately 4 million tons in the year 1800. NNRs as a percentage of raw material inputs to the US economy increased from less than 10% in 1800 to approximately 95% today. As a result of these increases in NNR utilization, the size of the US economy (GDP) increased from approximately $7.4 billion (2005 USD) in 1800 to $13.2 trillion (2005 USD) in 2008—an increase of nearly 1800 times.

Global NNR utilization has increased dramatically as well. Global NNR extraction/pro duction levels have increased up to ten fold during the past 50 years. And, given our incessant quest for global industrialization, it is almost certain that our future NNR requirements will increase unabated in most cases.

NNR Occurrence: While NNRs are essentially ubiquitous, useful or "economically viable" NNR supplies are rare in most cases.

Crustal Occurrences: Huge quantities of nearly all NNRs exist in the undifferentiated earth's crust. Unfortunately, crustal concentrations are too small in all cases to be economically viable. For example, economically viable iron ore concentrations are at least 6 times greater than average crustal concentrations; zinc 30 times greater, titanium 25-100 times greater, copper 100-200 times greater, and for chromium 4000-5000 times greater. Mining the undifferentiated earth's crust is not a viable solution for perpetuating our industrial lifestyle paradigm.

Resources: Slightly greater concentrations exist in deposits classified as "resources". The USGS defines a resource as a "concentration… in such form and amount that economic extraction of a commodity from the concentration is currently or potentially feasible."

Reserves: Economically viable NNR concentrations exist in proven deposits that the USGS classifies as "reserves". An NNR reserve is "(t)hat part of the reserve base which could be economically extracted or produced at the time of the determination."

Salient points regarding NNR occurrence: While sub-economic NNR quantities are enormous, the economically viable NNR quantities that enable our societies are extremely small in nearly all cases. The highest quality occurrences are typically discovered and exploited first. Globally available, economically viable NNR supplies are determined by two diametrically opposing forces that compete within an environment of ever-increasing global NNR requirements: continuously declining NNR quality versos continuously improving technology. Technological improvements, which are subject to diminishing marginal investment returns, inevitably lose the battle—i.e., beyond some point, each incremental unit of technology investment yields smaller quantities of economically viable NNRs. The real wealth surpluses generated by successive NNR exploration and

production investments decrease continuously from that point forward—initially in individual deposits, then in nations, ultimately globally.

NNR "Production" The term "production" when applied to NNR is a misnomer in the sense that humans do not actually "produce" NNRs—we extract and process naturally occurring materials, from which we recover NNRs. NNR exploration, extraction, and processing are complex, costly, risky, and hazardous endeavors that require significant investments of financial resources, energy resources, and non-energy natural resources (such as water and infrastructure), in addition to specialized facilities, equipment, expertise, technology, and processes which are typically unique for every NNR.

One production trend is

becoming increasingly pervasive: as NNR quality decreases due to ever-increasing exploitation, the costs, complexity, and risks associated with all NNR production activities are increasing.

3
NNR SCARCITY, and NNRs AND SOCIETAL WELL-BEING

Society's NNR requirement is the NNR quantity (economic input) necessary to generate the mix and levels of goods and services (economic output) required to enable the society's "expected" level of societal well-being. NNR scarcity exists when the economically viable NNR supply available to a society is insufficient to completely address the society's NNR requirement.

Economically viable NNRs: Economically viable NNRs positively impact economic output (GDP) levels, thereby improving societal well-being levels attainable by industrialized and industrializing nations. [As extractions proceed,] NNR producers must exploit increasingly marginal—and expensive—NNR deposits. NNR producers therefore require higher [constantly rising] prices to cover their operating costs and expenses.

NNR users will initially target investment opportunities offering the highest returns; these are the investment opportunities that can profitably support the highest NNR prices. As investment returns on subsequent investment opportunities decline, the NNR prices that can be profitably supported decline as well.

NNR Sufficiency and Scarcity: The terms "NNR sufficiency" and "NNR scarcity" require a reference point—i.e., an NNR quantity can only be "sufficient" or "scarce" with respect to some specified quantity. As used here, the reference point is the society's "NNR requirement"—that is, the NNR quantity required to generate the economic output (GDP) level necessary to enable the society's prevailing or "expected" level of societal wellbeing.

Within an NNR sufficiency (surplus) scenario, NNR users would likely expand their operations and seek additional investment opportunities that employ the NNR as an input, thereby increasing their demand for the "affordable" NNR. Within an NNR scarcity scenario, however, NNR users would likely curtail operations and cancel or postpone marginal investment opportunities that employ the NNR as an input, thereby reducing their demand for the "overpriced" NNR.

Because economic NNR constraints occur well prior to the point at which incremental NNR extraction/production becomes physically impossible, and because a society's economic output (GDP) level and societal wellbeing are determined by available supplies of economically viable NNRs, the Scarcity Analysis is concerned with maximum economically viable NNR quantities.

NNR Scarcity Dynamics: Economically viable NNR supplies—those that improve societal wellbeing—are small and rare in most cases, extremely small and extremely rate in many cases. Persistent exploitation will therefore deplete economically viable NNR supplies to exhaustion.

As NNR discoveries increase and NNR exploration, extraction, production, and processing technologies improve, the large, easily accessible, high quality NNR deposits are exploited, and annual NNR extraction/production levels increase continuously. Over time, the annual NNR extraction/production level reaches a maximum. As NNR exploitation activities are relegated to fewer, smaller, less accessible, lower quality deposits, annual NNR extraction/production levels decline continuously—ultimately to exhaustion.

The NNR lifecycle is determined by both the NNR discovery cycle and the NNR depletion cycle. NNR discoveries increase initially, as the highest quality deposits are found. NNR discoveries then peak and subsequently decline, as remaining deposits decrease in terms of quantity and quality.

[Both NNR discovery and depletion cycles are characterized by bell curves, with the depletion cycle lagging the discovery cycle in time. Note that levels of annual NNR extraction/production continue to increase even after annual discoveries have peaked, and note how this increase after discoveries have peaked is comparable to the phenomenon of consumption continuing to increase for a while—even after carrying capacity has been surpassed—that is described in *The Limits to Growth* published in 1972.]

The following relationship holds true with respect to NNRs individually, in combination, and in the aggregate: declining NNR discoveries beget declining extraction/production levels of NNRs, which beget declining NNR economic input levels, which cause declining economic output (GDP) levels, which cause declining societal wellbeing.

Nature's Limits: As NNR exploration continues unabated, instances of NNR scarcity become increasingly severe.

Temporary NNR scarcity occurs when economically viable supply associated with an NNR becomes temporarily insufficient to generate the level of economic output (GDP} required to enable a society's prevailing or expected level of societal wellbeing—i.e., when the economically viable NNR supply level temporarily falls short of the "required" NNR level. Temporary NNR scarcity is exemplified by the "commodity boom/bust cycles" that have characterized most NNRs since the inception of our industrial revolution.

Permanent NNR scarcity occurs when the economically viable supply associated with an NNR will never again be sufficient to generate the level of economic output (GDP) required to enable a society's prevailing or expected level of societal wellbeing—i.e., when the economically viable NNR supply level permanently falls short of the required NNR level. From that point forward, there is no longer "enough" and societal wellbeing levels never completely recover to their expected levels. [Nevertheless, politicians will continue to promise complete recoveries!]

The severity associated with decreases in economic output (GDP) and societal wellbeing resulting from declining post peak NNR utilization is determined by NNR criticality, the post peak decline rate, and the availability of technically and economically viable NNR substitutes.

Pre-2008 Recession NNR Scarcity: America's declining industrial preeminence, declining economic competitiveness, and declining societal wellbeing should come as no surprise. Historically abundant NNRs—the enablers of the American way of life—are becoming increasingly scarce.

The vast majority of the 89 analyzed NNRs that were scarce domestically (US) in 2008 and that are expected to remain scarce permanently going forward include most of the primary energy resources, metals, and nonmetallic minerals that are indispensable to perpetuating the American way of life.

So long as 1.5 billion people seek to perpetuate their industrialized lifestyles and billions more actively aspire to an industrialized way of life, global NNR requirements will increase unabated, while globally available, economically viable NNR supplies will become increasingly constrained as they approach, reach, and pass peak extraction/ production and peak utilization/supply levels.

4
NNR SCARCITY: THE EVIDENCE

Many thanks to the USGS, EIA, BEA, BLS, Fed, CBO, FBI, IEA, UN, World Bank, and countless NGOs and industry associations for providing the 'dots'… I merely connected them.

Because NNR scarcity has been increasing domestically (US) for decades and is now occurring with increasing frequency globally, and because NNR scarcity will undermine, if not preclude, the population levels and material living standards associated with today's industrialized and industrializing nations, it is critical that we understand the extent to which NNR scarcity exists today and the extent to which it is likely to exist in the immediate future.

NNR Criticality and NNR Scarcity

NNR "criticality" considers the importance associated with each NNR in perpetuating our modern industrial existence, while NNR "scarcity" considers the relationship between a population's requirement for an NNR and its availability (supply). An NNR can be critical to modern industrial existence, yet be sufficiently abundant (not scarce)—bauxite in 2008 is a case in point. On the other hand, an NNR can be scarce, yet play only a peripheral (non-critical) role in perpetuating our industrialized way of life—barite in 2008 is a case in point.

NNR Criticality Classifications – The NNR criticality assessment considers the role played by each NNR in producing, provisioning, and supporting the infrastructure, goods, and services that enable global industrialism.

Indispensable: used ubiquitously to provide one or more societal essentials—water, food, energy, and infrastructure—to an entire industrialized population; substitutes are extremely limited or non-existent.

Critical: used extensively to provide one or more societal essentials to broad segments of an industrialized population; substitutes are limited.

Important: used to provide one or more societal essentials to limited segments of an industrialized population; technically viable substitutes are typically available.

Declining: use is in general decline, typically due to toxicity, safety issues, or adverse environmental impacts.

NNR Scarcity Definitions -

An NNR is considered "scarce" domestically (US) in the event that domestically available economically viable NNR supplies were insufficient to completely address domestic requirements in 2008. In such cases, the US relied on (net) foreign NNR imports in 2008 to completely address domestic requirements. An NNR is considered "permanently scarce" domestically in the event that domestically available economically viable NNR supplies will likely or almost certainly never be sufficient o completely address future domestic NNR requirements on a continuous basis. The US will be forced to rely on (net) foreign imports indefinitely.

An NNR is considered "scarce" globally in the event that globally available NNR supplies between the years 2000 and 2008 were insufficient to prevent an inflation adjusted NNR price level increase during the 2000-2008 period. In such cases, the 2008 globally available, economically viable NNR supply was insufficient to completely address the 2008 global NNR requirement. An NNR is considered "permanently scarce" globally in the event that globally available, economically viable NNR supplies will likely or almost certainly never be sufficient to completely address future global requirements on a continuous basis.

Domestic (US) NNR Scarcity Analysis

The following [3-page] table summarizes domestic (US) criticality and scarcity associated with each of the 89 analyzed NNRs; salient findings include:

*An overwhelming majority—68 of the 89 analyzed—were considered "scarce" in 2008 immediately prior to the Great Recession; most (58) are almost certain to remain scarce permanently.

*The US imported some quantity of 69 of the 89 analyzed NNRs in 2008; imports associated with 19 of the NNRs accounted for 100% of the US supply.

*Annual US extraction/production levels associated with a sizeable majority, 61 of the 89 analysed NNRs, have almost certainly peaked permanently; (See Appendix C.)

*US utilization levels associated with a majority, 50 of the 89 analyzed NNRs, have likely peaked permanently; (See Appendix C.)

Domestic (US) NNR Import Reliance.

US NNR import reliance increased steadily during the 20th century and into the 21st. By 2008 the US imported some amount of 69 NNRs and 100% of 19.

Peak Domestic (US) NNR Extraction/Production

Annual domestic (US) extraction/production levels associated with 69 of the 89 NNRs have "almost certainly" or "likely" peaked permanently. It is "unlikely" that annual domestic extraction/production levels associated with 9—including coal, diatomite, lime, pumice, sand and gravel, soda ash, and crushed stone—have peaked permanently.

Domestic (US) NNR Scarcity Summary Assessment

Total US NNR requirements—i.e., the NNR quantities (economic inputs) necessary to perpetuate the American way of life—increasingly exceeded domestically available viable NNR supplies throughout the latter half of the 20th century. By 2008, in a sizeable majority of cases, total US NNR requirements permanently exceeded domestically available economically viable NNR supplies. And in a majority of cases, total US NNR requirements permanently exceeded domestic and imported economically viable NNR supplies combined.

Going forward, 47 NNRs are considered "at risk" domestically. That is, combined domestic and imported economically viable supplies associated with these NNRs will likely experience increasingly severe shortages, as America attempts to reestablish and maintain its pre-recession economic output (GDP) level and growth rate on a continuing basis. [3-page table follows.]

The Great Recession marked a tipping point in US history. The epidemic incidence of permanent domestic NNR supply constraints—permanent scarcity, permanent peak extraction/production levels, and permanent utilization levels—experienced by the onset of the Great Recession, imposed permanent limits on future US economic output (GDP) and societal wellbeing levels.

Global Scarcity Analysis

[A 3-page table summarizes global criticality and scarcity associated with each of the 89 analyzed NNRs. This is followed by 3 pages of smaller tables and discussions.]

Global NNR Scarcity Summary Assessment

By 2008 global NNR requirements exceeded globally available, economically viable NNR supplies in the vast majority of cases.

*63 of the 89 NNRs were scarce globally in 2008

*28 of the 89 NNRs are "almost certain" to remain scarce permanently, barring future reductions in global NNR requirement trajectories and/or major new economically viable discoveries.

*16 of the 89 NNRs will "likely" remain scarce permanently, barring future reductions in global requirement trajectories and/or new economically viable discoveries.

Going forward 39 NNRs are considered "at risk" globally. [Table follows.]

The Great Recession marked a tipping point in world history. Epidemic permanent global NNR scarcity experienced by the onset of the Great Recession permanently depressed the future growth trajectories associated with global economic (GDP) and societal wellbeing.

NNR Scarcity and Modern Industrial Existence

The following [6-page] analysis considers NNR scarcity as it relates to five critical NNR-enabled application areas, each of which is essential to modern industrial existence:

*Essential infrastructure

*Primary energy generation

*Industrial agriculture

*Computers and other high tech electronic devices

*Energy "green" technologies (electric cars, wind turbines, and solar cells)

NNRs enable literally every aspect of our modern industrial existence, and most NNRs, especially those that are indispensable to our industrialized way of life, are now likely or almost certainly scarce permanently, both domestically and globally. NNR scarcity is epidemic; and it is increasing both in terms of incidence and severity despite our efforts and hopes to the contrary. Our incessant quest for global industrialization—and our consequent ever-increasing requirements for nearly all NNRs within an environment of increasingly constrained economically viable supplies—will overwhelm our efforts to mitigate the ultimately devastating effects of NNR scarcity.

2008 Was Different

The period of rapid global economic growth prior to the Great Recession differed fundamentally from the "boom" phases associated with historical commodity "boom/bust" cycles. Both the scope and the magnitude associated with global NNR requirements were historically unprecedented by 2008.

Permanent NNR scarcity did not become epidemic "in" 2008, it became epidemic "by" 2008. An extraordinary number of NNR users were demanding extraordinary quantities from fewer, smaller, less accessible, lower quality NNR deposits.

2008 was simply the transition point, the year during which the number of permanently scarce NNRs became sufficiently large to permanently depress future economic growth trajectories and societal wellbeing improvement trajectories associated with America and the world.

All indications are that we will attempt to reestablish and maintain or exceed pre-recession economic output (GDP) levels and growth rates, both domestically and globally. We will soon discover, however, that ever-increasing NNR scarcity has rendered these goals physically impossible, and that the implications and consequences for human societal wellbeing associated with this reality are catastrophic.

5
IMPLICATIONS OF NNR SCARCITY

The fundamental cause of our predicament is ecological—it is not economic or political. Our attempted economic and political "solutions" are irrelevant. The reality since the inception of the industrial revolution—exponentially improving living standards for ever-increasing segments of our ever-increasing global population—no longer exists. Sufficient economically viable NNR supplies are no longer available to perpetuate this reality.

The level of societal wellbeing attainable by an industrialized nation is determined almost exclusively by the mix and levels of NNRs utilized by the nation's population. NNR inputs to the nation's economic system are converted into infrastructure, goods, and service outputs, which enable the nation's level of societal wellbeing. All else being equal, the greater the mix of NNR inputs to an industrialized nation's economy, the greater the level of economic output (GDP) generated by that nation, and the higher the nation's level of societal wellbeing.

Industrialism Is Not Sustainable

In the process of reaping the benefits associated with "continuously more and more", we have been eliminating—persistently and systematically—the very natural resources upon which our industrialized way of life depends. Humanity's predicament is not unique among species. As William Catton pointed out in *Overshoot*, in 1982, "We need to see that in each case, the organisms using their habitat unavoidably reduce the capacity to support their kind by what they necessarily do to it in the process of living…. This is what mankind has been doing. We have overshot environmental limits and have begun inflicting serious damage upon *our* habitat's capacity to support *our* species."

Implications of NNR Scarcity for US Societal Wellbeing

1900-1950: Continuously More and More

The tremendous financial wealth generated by America's industrializing economy during the 1900-1950 period remained within US borders for the most part—Americans were buying American manufactured goods. In addition, vast amounts of foreign wealth flowed into the US as a result of American (net) exports to foreign countries. America's NNR input, economic output (GDP), population, and material living standard levels increased rapidly during the first half of the 20th century.

US Societal Wellbeing 1950-1975: Changes

By the middle of the 20th century, the US and much of the industrialized world were fully ensconced in the post war building boom, which resulted in steadily increasing domestic (US) demand for nearly all NNRs. However, domestic extraction/production levels associated with many NNRs were near, at, or past peak, and the US was forced to import increasing quantities of foreign NNRs in order to enable its increasing economic ourput (GDP) levels. Increasing amounts of US financial wealth flowed beyond US borders to pay for the ever-increasing NNR import flows. America's growing prosperity was being built on an increasingly shaky foundation.

US Societal Wellbeing 1975-2000: Divergence

As domestic extraction/production and utilization (supply) levels associated with an increasing number of NNRs reached their peaks during the latter part of the 20th century, America's position as the world's leading producer of both commodity goods and high-end goods continued to erode. Ever-increasing amounts of US financial wealth flowed beyond US borders to pay for foreign labor, foreign production facilities, and foreign NNRs. Foreign outsourcing did, however, enable the US to further increase its societal wellbeing between 1975 and 2000. The annual growth rate in total US NNR utilization, economic output (GDP), and energy utilization—three indicators of societal wellbeing—all declined during the 1975-2000 period when compared with the 1950-1975 period.

US Societal Wellbeing 2000-2008: Peaking Societal Wellbeing

As America transitioned from the 20th century to the 21st century, domestically available, economically viable NNR supplies continued to decrease—even as US demand for manufactured goods continued to increase unabated. In order to satisfy this demand, Americans resorted increasingly to imported finished goods produced entirely by foreign-owned companies. The inevitable consequence was continuously declining American ownership and control of the NNR inputs, the production facilities and processes, and the goods and services outputs that enable America's way of life. Abundant best-in-class manufacturing capacity and low cost labor existed in newly industrializing nations—nations in which manufacturers could remain profitable despite continuously increasing NNR prices.

US reliance on NNR imports continued to increase unabated during the early years of the new millennium. By 2008, America was (net) importing 68 of the 89 analyzed NNRs, including 100% of 19 NNRs.

US Societal Wellbeing in 2008: Peak Societal Wellbeing; Indicators

While material living standards will improve for a continuously decreasing minority of Americans over the near term—as has been the case during the past several decades—aggregate US societal wellbeing has peaked.

Since the middle of the 20th century, the US has resorted increasingly to unsustainable economic behavior to reinforce its centuries of unsustainable natural resource utilization

behavior, in increasingly desperate attempts to perpetuate its unsustainable American way of life. Indicators have become increasingly pronounced in recent years:

*Continuously devaluing US dollar
*US transition to a service economy
*US foreign oil dependence
*US dollar becomes a fiat currency
*US transition to a net importer
*US transition to a debtor nation
*US transition to a net asset seller
*Declining US real median family income
*Unfunded US "social entitlement" programs
*Unrepayable US debt
*Increasingly costly US military presence
*Aging physical infrastructure
*Post-peak US NNRs

As NNR inputs to the US economy decline, US economic output (GDP) and societal wellbeing must decline as well. However, it is unlikely that US economic output (GDP) and aggregate societal wellbeing will decline continuously from 2008 onward. It is more likely that US economic output and aggregate societal wellbeing will move along a bumpy plateau, possibly for a decade or so, as the US desperately attempts to obtain sufficient NNRs and derived goods and services to perpetuate its American lifestyle.

America will pursue a strategy of "extend and pretend"—i.e., Americans will attempt to perpetuate their way of life at all costs, while professing immunity from the laws of economics and (more importantly) from the laws of Nature—in order to defer the inevitable—economic and societal collapse—for as long as its human and Natural benefactors will permit it to do so.

Implications of NNR Scarcity for Global Societal Wellbeing

Remaining globally available, economically viable NNR supplies are simply no longer sufficient in the aggregate to enable pre-recession growth rates in global economic output (GDP) and global societal wellbeing. NNRs that were scarce globally in 2008 will become increasingly scarce through continued exploitation; and an increasing number of NNRs for which supplies remained sufficient ion 2008 will become scarce going forward through continued exploitation.

The upper limits to growth in global economic output (GDP) and global societal wellbeing have been reached. NNR price levels will increase as they did between 2000 and 2008, and the global economy will encounter a "growth ceiling" created by NNR scarcity, and experience a "Greater Recession."

Sustainability (with Drastically Reduced Population and Societal Wellbeing) is Inevitable

Globally available, economically viable supplies associated with the NNRs required to perpetuate our industrial lifestyle paradigm will not be sufficient going forward. Humanity's transition to a sustainable lifestyle paradigm, within which a drastically reduced human population will rely exclusively on renewable natural resources (RNRs)—water, soil (farmland), forests, and other naturally occurring biota—is therefore inevitable.

6
CONSEQUENCES OF NNR SCARCITY

We are the pathetic victims of tragic circumstances of our own inadvertent creation, which are beyond our capacity to resolve.

NNR scarcity cannot be solved. Rather, it will be resolved, inevitably, through global societal collapse. We will not accept gracefully our new reality of "continuously less and less."

What Happens Next?

We will make a catastrophic situation worse. Our cornucopian worldview has rendered us unable to acknowledge our predicament, much less to face the inevitably painful consequences associated with its resolution. We will squander remaining accessible NNRs in futile attempts to perpetuate our unsustainable industrial lifestyle paradigm for as long as possible—a scenario that is unfolding now.

Humanity's Unraveling

While we may not actually believe that NNR supplies are "unlimited", perpetual NNR sufficiency is presumed without question. Going forward, increasing global NNR scarcity will induce a series of increasingly frequent and severe economic recessions punctuated by increasingly brief and anemic recoveries. Most global "opinion leaders" will erroneously attribute our ongoing decline in societal wellbeing to factors such as insufficient financial investment, insufficient technical innovation, and ineffectual leadership. We will react with shocked disbelief—and increasing desperation—as our economic and political solutions fail dismally and completely to resolve our predicament.

We will realize, too late, that human economics and politics are irrelevant to nature. Escalating natural resource wars in combination with our declining economic output levels will reduce our material living standards and population levels—a situation that will worsen as war related destruction disrupts our critical natural resource supplies and our critical societal support systems: water, food, energy, sanitation, healthcare, transportation, communications, and law enforcement.

All industrialized and industrializing nations, irrespective of their economic and political orientations, will collapse, taking the aid-dependent, non-industrialized world with them.

Under the best case scenario, a surviving global human population of a few million will remain to scavenge among the remnants of decimated natural resource reserves and severely degraded natural habitats. Under the worst case scenario, we will annihilate ourselves through global nuclear war.

Ironically, the more vigorously we strive to perpetuate our unsustainable industrialized way of life through ever-increasing NNR exploitation, the more quickly and thoroughly we will deplete NNR/RNR reserves and degrade natural habitats, thereby hastening and exacerbating our global societal collapse.

The "Squeeze" Is On

The Great Recession was a tangible manifestation of our predicament—NNR scarcity was epidemic in 2008, both domestically (US) and globally. Our unraveling is in process.

Our opinion leaders continue to preach that historically robust levels of economic growth can be sustained indefinitely. The general public adheres steadfastly to the notion that "every generation will have it better than the last". It is likely, however, that the general public will become increasingly frustrated, angry, and scared.

Within the next few years, NNR scarcity will become:

”Noticeable”—NNR supplies will become increasingly constrained and NNR prices will rise continuously; then:

“Inconvenient”—periodic and temporary shortages and rationing associated with NNRs and derived goods and services will occur with increasing frequency; then:

“Disruptive”—shortages and rationing associated with ever-increasing numbers of NNRs and derived goods and services will become permanent; and finally:

“Debilitating”—supplies associated with ever-increasing numbers of NNRs and derived goods and services will become permanently unavailable.

It will become universally understood that the only way to “stay even” within a continuously contracting operating environment—much less to improve one’s lot—is to take from someone else. Life will become a “negative sum game” within the “shrinking pie” of “continuously less and less”.

Historically prevalent public attitudes of generosity and forbearance, which were made possible by abundant and cheap NNRs during our epoch of “continuously more and more”, will be displaced by public intolerance. Previously sporadic social unrest and resource wars will degenerate into full fledged conflicts. Social institutions will dissolve; law and order will cease to exist; and chaos will fill the void—nations will collapse.

Timing

By 2008 [the annual percentage increase of] US economic output (GDP) and societal wellbeing levels had peaked permanently. Global societal collapse will almost certainly occur before 2050.

As NNRs become increasingly scarce and expensive going forward, some nations will fare better than others during the near term. Successful “economically” viable nations will be those that have ongoing access to their required mix and levels of economically viable NNRs. Economically viable nations will experience upward trending economic output (GDP) and societal wellbeing levels, possibly for a decade or more.

Nations that are unable to compete effectively at the global level will experience downward trending economic output (GDP) and societal wellbeing trajectories, a scenario that is currently unfolding within an ever-increasing number of nations.

While some industrialized and industrializing nations will remain economically viable over the near term, none are sustainable. All will collapse in the not-too-distant future, as we resort increasingly to conflict as the primary means by which to allocate earth’s dwindling nonrenewable and renewable natural resources and derived real wealth.

The relevant question is “what will we do?” The answer is “nothing meaningful”. We are culturally incapable of behaving differently. Through industrialism, humanity set out to accomplish great things; and we have accomplished great things. Unfortunately, we have obviated ourselves in the process.

Was 2008 Different?

It is my contention that “2008 was different”—that 2008 was a pivotal year for both the US and the world with respect to future economic growth and societal well-being.

Globally available, economically viable NNR supplies will be insufficient going forward to enable pre-recession domestic (US) and global economic growth and societal wellbeing trajectories on a continuous basis—there are not enough affordable NNRs.

If my contention is wrong, it is either premature or inaccurate. If premature, my assertions will simply be validated at a later date. If inaccurate, then NNR supplies will

remain sufficient to enable economic growth rates and societal wellbeing improvement trajectories for the indefinite future. In either case, the validity associated with my assertions will be known with certainty only in the next 10-20 years.

What remains beyond dispute is the fact that our definition of "enough" NNRs increases continuously, as our quest for global industrialization continues unabated, even as NNR quality declines and economically viable NNR quantities tighten continuously. This scenario cannot end well.

7
MYTHS AND REALITIES

As a result of our extraordinarily positive experience with industrialism, we have developed a set of myths to reinforce our cornucopian worldview and our belief that our industrial lifestyle paradigm will exist in perpetuity. These myths are now unquestioned and are transmitted as part of our "cultural DNA". Unfortunately, while we may find comfort, confidence, and strength in the rationalizations provided by our myths, they will not shield us from reality.

[The author then spends more than ten pages in asserting that the following ideas are myths and in describing the realities that prove them to be myths.]

Human ingenuity and initiative can solve any problem

Economic and political solutions can solve any problem

We will grow our way out of it

Everything is cyclical—with an upward bias

Plentiful NNR supplies remain to be discovered

"Official" NNR reserve estimates typically understate remaining reserve quantities

Increasing NNR prices always bring about sufficient NNR supplies

We can always produce additional NNRs

Legal restrictions currently limit access to plentiful NNR supplies

NNR substitution will eliminate NNR scarcity

Technical innovation will insure sufficient incremental NNR supplies

Incremental financial investment will insure sufficient NNR supplies

Recycling will extend NNR supplies indefinitely

NNR conservation will enable US to reduce NNR utilization levels

Increased efficiency and enhanced productivity will reduce NNR requirements, demand, and utilization

Population stabilization will solve our NNR scarcity problem

"Stopping Growth", "Downscaling", or "Moving toward Sustainability" are viable solutions to NNR scarcity

We can avert societal collapse through a "soft landing"

Humanity's real problem is the unequal distribution of wealth

"Advanced" nations such as the US are less dependent on NNRs

Pre-collapse preparation is the answer

Post-collapse preparation is the answer

Post-collapse life will be preferable to our industrial lifestyle paradigm

8
HUMANITY'S FINAL CHAPTER?

NNR scarcity is the most daunting challenge ever to confront humanity. Should we fail to meet the challenge, "Scarcity" will become "Humanity's Final Chapter".

During the course of our unrelenting pursuit of global industrialization, and our consequent ever-increasing utilization of the earth's increasingly scarce NNRs, we have been eliminating—persistently and systematically—the very natural resources upon which our industrialized way of life and our very existence depend. Our continued success is pushing us toward our imminent demise. This is humanity's predicament.

Our distorted cornucopian worldview and limited anthropocentric perspective have rendered us incapable of understanding our predicament and its fundamental cause, which is ecological—ever-increasing NNR scarcity. The economic or political problems with which we concern ourselves are merely manifestations of our predicament—they are symptoms, not the disease. Metaphorically, our well is running dry, yet we insist on tinkering with the pump.

If humanity is to avert the global societal collapse scenario outlined in Scarcity we must obtain more and more from less and less at existing or lower costs—forever.

Empires have collapsed throughout history, yet because previous instances have occurred within the historical reality of continuously "more and more", the detrimental impacts proved temporary for humanity as a whole. Our impending global collapse will be the first to occur within the contest of our new reality of "continuously less and less". Because NNR supplies will be insufficient to enable a post collapse recovery, our impending collapse will be our last.

The Great Recession and the sputtering post-recession recovery—despite massive central government "fiscal stimulus" programs and "accommodative" central bank monetary policies—clearly demonstrate the pervasiveness and permanence associated with both domestic (US) and global NNR scarcity. If prevailing trends continue, global societal collapse will almost certainly occur well before 2050.

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Postscript: Thoughts on Humanity's Predicament

Essay 1: Ecological and Economic Reality

Our persistent global economic malaise is rooted in ecology. As a consequence of our ever-increasing exploitation since the inception of the industrial revolution, the vast majority of the earth's finite and non-replenishing nonrenewable natural resources, (NNRs), which serve as the primary inputs to our industrialized and industrializing economies, are becoming increasingly scarce globally.

The result is diminishing real economic output (GDP) levels, currently for NNR deficient Western nations with high material living standards, correspondingly high societal support costs, and consequent declining global economic competitiveness, and soon for the world at large.

Our transition to a sustainable lifestyle paradigm, with which a dramatically reduced global population will experience pre-industrial subsistence level material living standards, is both inevitable and imminent. Our transition will occur catastrophically. We will not accept gracefully our new reality of "continuously less and less".

Essay 2: Nature's Ultimate Con

Nature suckered us in with temporary abundance; a condition that we perceived as permanent. This belief became so firmly ingrained in our culture that we promised ourselves and our descendants continuously improving material living standards for our ever-expanding population—to be enabled by our "unlimited" NNRs.

Because NNRs are now becoming increasingly scarce globally as well as domestically, we in the US can no longer perpetuate our American way of life through imported NNRs, NNR-derived products and services, and imported credit. We no longer possess adequate real wealth to offer in return for these imports, and the rest of the world is becoming increasingly wary with regard to accepting our unrepayable debt and continuously devaluing currency in exchange for their real wealth.

Unfortunately, America's predicament cannot be "fixed" through economic and political expedients, because the underlying cause associated with our predicament is ecological—ever-increasing NNR scarcity—it is not economic or political.

Essay 3: Humanity's Fatal Distraction

Metaphysically, our well is running dry, yet we insist on tinkering with the pump

The "Conservative Right" believes excessive government intervention in the economy causes resource misallocation thereby causing suboptimal societal wellbeing. The solution is unfettered free markets. The "Liberal Left" believes unfettered free market capitalism causes resource misallocation toward the wealthy minority, thereby causing suboptimal societal wellbeing. The solution is government sponsored policies and programs. Each side believes that our economic malaise will be resolved only when people "come to their senses" and implement its proposed solution.

We have allowed ourselves to become distracted by an irrelevant argument between two diametrically opposed, physically impossible, economic/political viewpoints, rather than attempting to address the most daunting ecological challenge ever to confront humanity—ever-increasing NNR scarcity.

The probability that we will experience imminent global societal collapse in the event we remain ignorant or in denial and fail to respond intelligently is 100%.

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Epilogue: An Intelligent Response to Humanity's Predicament

In my six years of researching human sustainability and NNR scarcity, I have yet to encounter a prospective "solution" to our predicament that appears even remotely plausible; but I cannot say with certainty that an "intelligent response" does not exist.

It is clear, however, that we cannot possibly formulate an intelligent response if we remain ignorant or in denial regarding our predicament and its consequences.

And, in the event that we do remain ignorant or in denial regarding our predicament and its consequences, the probability that we will experience imminent global societal collapse is 100%.

NNR scarcity is the most daunting challenge ever to confront humanity. If we homo sapiens are truly exceptional, now is the time to prove it.

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