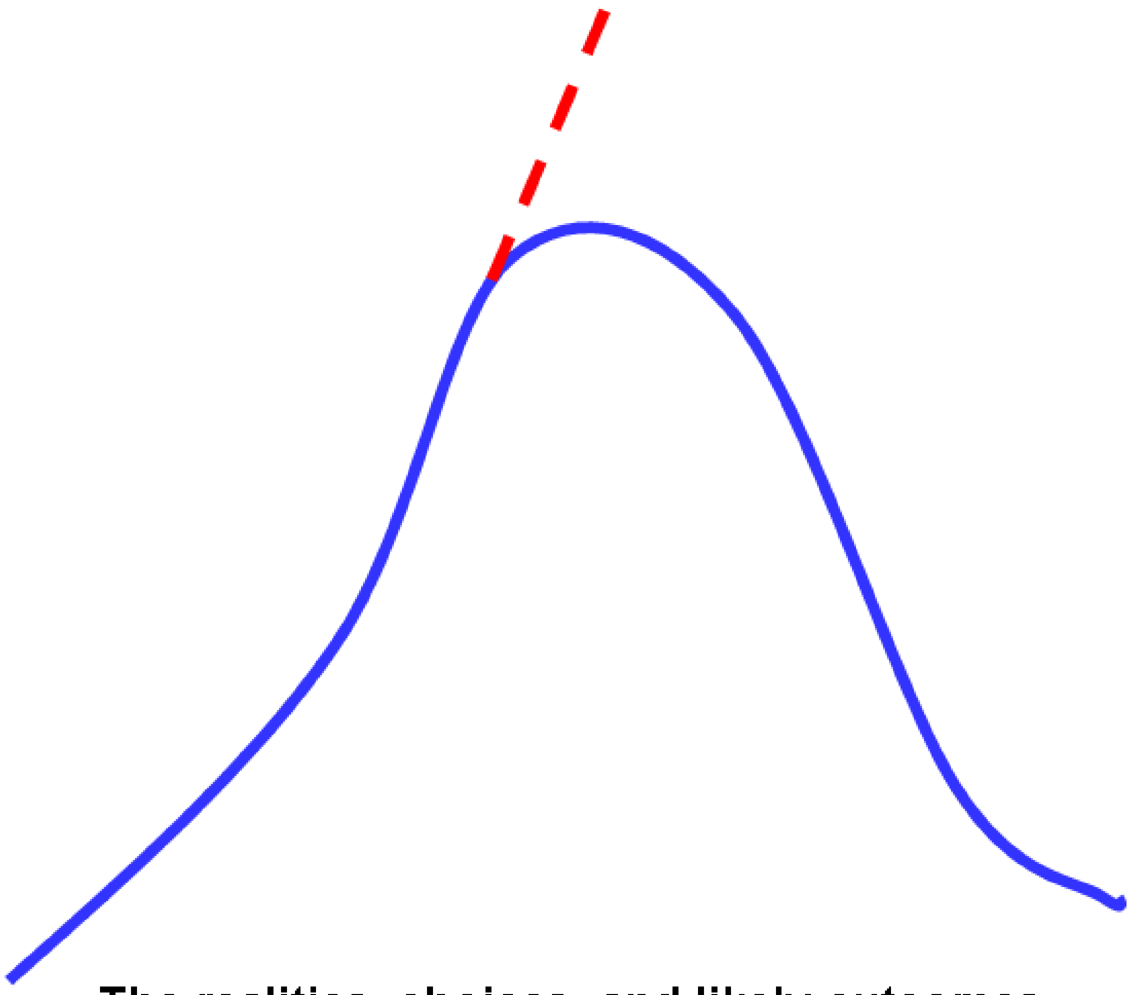
Scarcity

Humanity's Final Chapter?



The realities, choices, and likely outcomes associated with ever-increasing nonrenewable natural resource scarcity

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Foreword by William R. Catton Jr.

Domestic (US) "At Risk" NNRs (continued)

Nonrenewable Natural Resource (NNR)	NNR Criticality	Permanent US NNR Scarcity	Permanent US Peak Extraction/ Production	Permanent US Peak Utilization	Potential Geopolitical Supply Constraints
Vanadium	Critical	Almost Certain	Almost Certain		China and South Africa each account for approximately 40% of proven global vanadium reserves.
Zinc	Indispensible	Almost Certain	Almost Certain	Likely	68% of US zinc ore and concentrate imports come from Peru.

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

Global NNR Scarcity Analysis

The following table summarizes global criticality and scarcity associated with each of the 89 analyzed NNRs; salient findings include:

- An overwhelming majority, 63 of the 89 analyzed NNRs, were considered "scarce" globally in 2008, immediately prior to the Great Recession;
- A significant number, 28 of the 89 analyzed NNRs, is almost certain to remain permanently scarce globally going forward; and a sizeable number, 16 of the 89 analyzed NNRs, is likely to remain scarce permanently; (See Appendix C for Permanent Global NNR Scarcity Definitions.) and
- Global extraction/production levels associated with a small but significant number, 8 of the 89 analyzed NNRs, have likely peaked permanently. (See Appendix C for Permanent Global Peak NNR Extraction/Production Level Definitions.)

2008 Global NNR Criticality and Scarcity Summary

Nonrenewable Natural Resource (NNR)	NNR Criticality	Global NNR Limits			
		Global Scarcity		Global Extraction/ Production Peak	
		In 2008	Permanent	Year	Permanent
Abrasives (Manufactured)	Critical	No	Unclear	Inconclusive	
Abrasives (Natural)	Declining	No	Unlikely	1974	Unclear
Aluminum	Indispensible	Yes	Unclear	2008	Unlikely
Antimony	Critical	Yes	Almost Certain	2008	Unlikely
Arsenic	Critical	No	Unclear	2003	Unlikely
Asbestos	Important	Yes	Unclear	1977	Unclear
Barite	Important	Yes	Almost Certain	1981	Unlikely
Bauxite	Indispensible	No	Likely	2008	Unlikely
Beryllium	Critical	Yes	Likely	1961	Likely
Bismuth	Critical	Yes	Almost Certain	2008	Unlikely
Boron	Critical	No	Unclear	2004	Unlikely
Bromine	Important	Yes	Unclear	2006	Unlikely
Cadmium	Important	Yes	Likely	1988	Unlikely
Cement	Indispensible	Yes	Unclear	2008	Unlikely
Cesium	Important	No	Unclear	1982	Likely
Chromium	Indispensible	Yes	Almost Certain	2008	Unlikely
Clays	Indispensible	Yes	Unclear	Inconclusive	

2008 Global NNR Criticality and Scarcity Summary (continued)

Nonrenewable Natural Resource (NNR)	NNR Criticality	Global NNR Limits			
		Global Scarcity		Global Extraction/ Production Peak	
		In 2008	Permanent	Year	Permanent
Coal	Indispensible	Yes	Almost Certain	2008	Unlikely
Cobalt	Indispensible	Yes	Almost Certain	2008	Unlikely
Copper	Indispensible	Yes	Almost Certain	2008	Unlikely
Diamond (Industrial)	Important	No	Unclear	2007	Unlikely
Diatomite	Important	No	Unlikely	2008	Unlikely
Feldspar	Important	No	Unclear	2008	Unlikely
Fluorspar	Critical	Yes	Likely	2008	Unlikely
Gallium	Critical	No	Unclear	2008	Unlikely
Garnet	Important	No	Unclear	2006	Unlikely
Gemstones	Important	No	Unlikely	2006	Unlikely
Germanium	Critical	No	Unclear	2008	Unlikely
Gold	Important	Yes	Almost Certain	2001	Likely
Graphite (Natural)	Critical	Yes	Likely	2008	Unlikely
Gypsum	Indispensible	Yes	Likely	2007	Unlikely
Hafnium	Important	Yes	Unclear	1963	Unlikely
Helium	Important	No	Unlikely	2008	Unlikely
Indium	Critical	Yes	Almost Certain	2006	Unlikely
Iodine	Critical	Yes	Unclear	2006	Unlikely
Iron Ore	Indispensible	Yes	Almost Certain	2008	Unlikely
Iron/Steel	Indispensible	Yes	Almost Certain	2007	Unlikely
Kyanite	Important	Yes	Unclear	2008	Unlikely
Lead	Critical	Yes	Almost Certain	2008	Unlikely
Lime	Critical	Yes	Unclear	2008	Unlikely
Lithium	Critical	Yes	Likely	2006	Unlikely
Magnesium Compounds	Critical	Yes	Unclear	2008	Unlikely
Magnesium Metal	Indispensible	Yes	Likely	2007	Unlikely
Manganese	Indispensible	Yes	Almost Certain	2008	Unlikely
Mercury	Declining	Yes	Unclear	1971	Unlikely
Mica (Scrap and Flake)	Important	Yes	Unclear	2005	Unclear
Mica (Sheet)	Declining	No	Unclear	1975	Unlikely
Molybdenum	Critical	Yes	Almost Certain	2008	Unlikely
Natural Gas	Indispensible	Yes	Almost Certain	2008	Unlikely
Nickel	Critical	Yes	Likely	2007	Unlikely
Niobium	Critical	Yes	Almost Certain	2008	Unlikely
Nitrogen (Ammonia)	Indispensible	Yes	Almost Certain	2008	Unlikely
Oil	Indispensible	Yes	Almost Certain	2005	Unclear
Peat	Declining	No	Unlikely	1984	Unlikely
Perlite	Important	Yes	Unclear	1999	Likely
Phosphate Rock	Indispensible	Yes	Almost Certain	1988	Unclear
Platinum Group Metals (PGM)	Indispensible	No	Unclear	2006	Unlikely
Potash	Indispensible	Yes	Likely	2007	Unlikely
Pumice	Important	No	Unlikely	2007	Unlikely
Quartz Crystal	Critical	Inconclusive		1966	Likely
Rare Earth Minerals (REM)	Indispensible	Yes	Unclear	2006	Unlikely
Rhenium	Critical	Yes	Almost Certain	2008	Unlikely
Rubidium	Important	Inconclusive		Inconclusive	
Salt	Critical	Yes	Unclear	2006	Unlikely
Sand & Gravel (Construction)	Indispensible	Yes	Unclear	Inconclusive	
Sand & Gravel (Industrial)	Indispensible	Yes	Likely	2007	Unlikely
Selenium	Important	Yes	Almost Certain	1996	Likely
Silicon	Indispensible	Yes	Likely	2008	Unlikely
Silver	Critical	Yes	Almost Certain	2008	Unlikely
Soda Ash	Important	Yes	Unclear	2008	Unlikely
Sodium Sulfate	Important	No	Unlikely	2008	Unlikely

2008 Global NNR Criticality and Scarcity Summary (continued)

Nonrenewable Natural Resource (NNR)	NNR Criticality	Global NNR Limits			
		Global Scarcity		Global Extraction/ Production Peak	
		In 2008	Permanent	Year	Permanent
Stone (Crushed)	Indispensible	Yes	Unclear	Inconclusive	
Stone (Dimension)	Important	No	Unlikely	Inconclusive	
Strontium	Important	Yes	Likely	2004	Unclear
Sulfur	Indispensible	Yes	Almost Certain	2008	Unlikely
Talc	Declining	No	Unclear	1997	Unlikely
Tantalum	Critical	No	Unlikely	2004	Unlikely
Tellurium	Critical	No	Unclear	1974	Likely
Thallium	Important	Yes	Almost Certain	1989	Likely
Thorium	Declining	Yes	Unclear	1972	Inconclusive
Tin	Critical	Yes	Almost Certain	2007	Unlikely
Titanium Mineral Con.	Indispensible	Yes	Likely	2007	Unlikely
Titanium Metal	Indispensible	Yes	Unclear	Inconclusive	
Tungsten	Critical	Yes	Almost Certain	2004	Unclear
Uranium	Critical	Yes	Almost Certain	1982	Inconclusive
Vanadium	Critical	Yes	Likely	2007	Unlikely
Vermiculite	Declining	No	Unlikely	1987	Unlikely
Zinc	Indispensible	Yes	Likely	2008	Unlikely
Zirconium	Critical	Yes	Almost Certain	2007	Unlikely

Global NNR Scarcity

2008 Global NNR Scarcity Summary

Global NNR Scarcity	NNR Criticality				Totals
	Indispensible	Critical	Important	Declining	
2008 Global NNR Scarcity					
Scarce	26	22	13	2	**63**
Not Scarce (Sufficient)	2	7	10	5	**24**
Inconclusive	0	1	1	0	**2**
Totals	**28**	**30**	**24**	**7**	**89**
Permanent Global NNR Scarcity					
Almost Certain	12	12	4	0	**28**
Likely	8	6	2	0	**16**
Unclear	8	10	11	4	**33**
Unlikely	0	1	6	3	**10**
Inconclusive	0	1	1	0	**2**
Totals	**28**	**30**	**24**	**7**	**89**

63 of the 89 analyzed NNRs were “scarce” globally in 2008—i.e., the (inflation adjusted) price levels associated with these NNRs increased between 2000 and 2008.

In some cases, the 2000-2008 price level increases were significant (50%-100%):

2000-2008 Price Increases for Globally Scarce NNRs	2000-2008 Price Increases for Globally Scarce NNRs
Coal: 52%	Rare Earth Minerals: 58%
Cobalt: 84%	Rhenium: 86%
Magnesium: 99%	Silicon: 59%
Nickel: 96%	Zirconium: 68%

In other cases, the 2000-2008 price level increases were extraordinary (100%+):

2000-2008 Price Increases for Globally Scarce NNRs	2000-2008 Price Increases for Globally Scarce NNRs	2000-2008 Price Increases for Globally Scarce NNRs
Antimony: 243%	Lead: 121%	Selenium: 572%
Bismuth: 175%	Manganese: 227%	Silver: 146%
Chromium: 266%	Molybdenum: 795%	Sulfur: 750%
Copper: 190%	Natural Gas: 156%	Thallium: 202%
Gypsum: 115%	Nitrogen (ammonia): 179%	Tin: 145%
Indium: 192%	Oil: 244%	Tungsten: 239%
Iron Ore: 132%	Phosphate Rock: 145%	Uranium: 215%
Iron and Steel: 105%	Potash: 230%	Vanadium: 547%

Of the 63 NNRs that were scarce globally in 2008:

- 26 NNRs—including aluminum, chromium, coal, cobalt, copper, gypsum, iron ore, natural gas, nitrogen (ammonia), oil, phosphate rock, potash, rare earth minerals, silicon, and zinc—are indispensible to modern industrial existence; and
- 22 NNRs—including antimony, bismuth, indium, lead, lithium, molybdenum, nickel, niobium, rhenium, tin, tungsten, uranium, and vanadium—are critical to modern industrial existence.

24 of the 89 analyzed NNRs were “not scarce” globally in 2008—i.e., globally available, economically viable supplies were sufficient between 2000 and 2008 to prevent price level increases during the period.

Of the 24 globally sufficient NNRs:

- 2 NNRs—bauxite and platinum group metals (PGM)—are indispensible to modern industrial existence; and
- 7 NNRs—including boron, gallium, germanium, tantalum, and tellurium—are critical to modern industrial existence.

Barring future reductions in global NNR requirement trajectories and/or major new economically viable discoveries, 44 of the 89 analyzed NNRs are either “almost certain” or “likely” to remain scarce permanently going forward:

- 28 NNRs—including chromium, coal, cobalt, copper, gypsum, iron, ore, manganese, natural gas, oil, phosphate rock, tin, and uranium—are “almost certain” to remain scarce globally; and
- 16 NNRs—including fluorspar, graphite, lithium, magnesium, nickel, potash, vanadium, and zinc—are “likely” to remain scarce globally.

Globally available, economically viable supplies associated with 10 of the 89 analyzed NNRs—including diatomite, helium, peat, pumice, sodium sulfate, tantalum, and vermiculite—are “unlikely” to become permanently scarce globally in the immediate future.

Peak Global NNR Extraction/Production

2008 Annual Global Peak NNR Extraction/Production Summary

Global NNR Extraction/Production	NNR Criticality				Totals
	Indispensible	Critical	Important	Declining	
Almost Certainly Peaked Permanently	0	0	0	0	**0**
Likely Peaked Permanently	0	3	5	0	**8**
Unclear	2	1	3	2	**8**
Unlikely Peaked Permanently	22	24	14	4	**64**
Inconclusive	4	2	2	1	**9**
Totals	**28**	**30**	**24**	**7**	**89**

Annual global extraction/production levels associated with 18 of the 89 analyzed NNRs peaked (to date) prior to 2000. Annual extraction/production levels associated with 8 of the 18 NNRs—beryllium, cesium, gold, perlite, quartz crystal, selenium, tellurium, and thallium—have "likely" peaked permanently on the global level. Beryllium, quartz crystal, and tellurium are critical to modern industrial existence.

Increasing Global NNR Scarcity

The following three indicators of increasing global NNR scarcity underscore the challenges facing industrialized and industrializing nations as they attempt to reestablish and exceed pre-recession economic output (GDP) levels and growth rates going forward.

Required Global NNR Extraction/Production Growth Rates

A "doubling time" is the number of years within which annual NNR extraction or production will double assuming a specified compound annual growth rate (CAGR) in extraction/production—in this case the CAGR that existed prior to the Great Recession.

Following are the pre-recession CAGRs and approximate doubling times associated with 22 indispensible and critical NNRs.

Pre-recession NNR Extraction/Production Level CAGRs and Corresponding Doubling Times

NNR	2000-2008 CAGR	NNR Extraction/ Production Level Doubling Time	Critical NNR Applications
Antimony	6.6%	11 Years	Starter-lights-ignition batteries used in cars and trucks
Bauxite	6.3%	13.5 Years	The only economically viable feedstock for aluminum
Beryllium	6.5%	11 Years	Satellites, military aircraft, nuclear power generation equipment
Bismuth	9.4%	7.5 Years	Nontoxic substitute for lead in solder and plumbing fixtures
Cement	6.8%	11 Years	Ubiquitous building material
Chromium	4.9%	14.5 Years	Stainless steel, jet engines, and gas turbines
Coal	5.1%	14 Years	Largest source of electricity generation in the world
Cobalt	8.6%	8.5 Years	Gas turbine blades, jet aircraft engines, batteries
Fluorspar	4.3%	16.5 Years	Feedstock for fluorine bearing chemicals, aluminum and uranium processing
Germanium	9.1%	8 Years	Fiber optics, thermal imaging, wireless communications
Gypsum	5.0%	14 Years	Wallboard, plaster, cement
Indium	6.9%	10.5 Years	LCDs, touchscreens, thin film solar cells
Iron Ore	9.4%	7.5 Years	The only feedstock for iron and steel
Lithium	8.2%	9 Years	Aircraft parts, mobile phones, batteries for electric vehicles
Magnesium	6.0%	12 Years	Aerospace equipment, electronic devices, beverage cans

Pre-recession NNR Extraction/Production Level CAGRs and Corresponding Doubling Times (cont.)

NNR	2000-2008 CAGR	NNR Extraction/ Production Level Doubling Time	Critical NNR Applications
Manganese	5.1%	9 Years	Stainless steel, gasoline additive, dry cell batteries
Molybdenum	6.2%	11.5 Years	Aircraft parts, electrical contacts, industrial motors, tool steels
Niobium	12.3%	6 Years	Jet and rocket engines, turbines, superconducting magnets
REMs	5.0%	14 Years	Permanent magnets, electric vehicle batteries, superconductors
Rhenium	5.9%	12 Years	Petroleum refining, jet engines, gas turbine blades
Silicon	7.3%	10 Years	Primary component of glass, concrete, and semiconductors
Uranium	4.3%	16.5 Years	Primary energy source, weapons
Zirconium	7.3%	10 Years	Nuclear power plants, jet engines, gas turbine blades

In order to reestablish and maintain pre-recession global extraction/production CAGRs, coal extraction must double every 14 years, cobalt extraction must double every 8.5 years, iron ore extraction must double every 7.5 years, manganese extraction must double every 9 years, and niobium extraction must double every 6 years—forever!

While it is possible that pre-recession global NNR extraction/production CAGRs can be reestablished and maintained in some cases for limited periods of time, it is impossible that these CAGRs can be reestablished and maintained in all or even most cases for an indefinite period of time.

Global NNR Reserves Adequacy

"Years to Exhaustion" is the number of years that proven global NNR reserves would last assuming the reestablishment of pre-recession (2000-2008) compound annual growth rates (CAGRs) in annual NNR extraction/production.

Years to Exhaustion Associated with Proven Global NNR Reserves

Years Until Exhaustion*	NNR #	NNRs
1-10 Years	4	Antimony, Diamond (industrial), Garnet, Lithium
11-20 Years	13	Arsenic, Barite, Bismuth, Iron Ore, Lead, Manganese, Molybdenum, Niobium, Silver, Strontium, Tin, Zinc, Zirconium
21-30 Years	7	Cadmium, Chromium, Cobalt, Copper, Fluorspar, Nickel, Rhenium
31-40 Years	12	Bauxite, Boron, Coal, Gold, Graphite, Mercury, Natural Gas, Oil, Thallium, Titanium Concentrates, Tungsten, Uranium

* Reserve to production (R/P) data used for NNRs with negative 2000-2008 CAGRs: thallium, mercury, gold, cadmium, and boron.

In the event that pre-recession CAGRs are reestablished going forward, proven global reserves associated with 36 of the 89 analyzed NNRs would exhaust within 40 years (by 2048)—including bauxite in 40 years, coal in 40 years, cobalt in 26 years, copper in 27 years, iron ore in 15 years, manganese in 17 years, molybdenum in 20 years, natural gas in 34 years, nickel in 30 years, oil in 39 years, tin in 18 years, uranium in 34 years, and zinc in 13 years.

While it is extremely unlikely that global reserves associated with any of these NNRs will exhaust completely by 2048, barring major new economically viable NNR discoveries and/or new technologies that dramatically increase recoverable NNR quantities, many of these NNRs will likely become increasingly scarce going forward.

Impending Global NNR Extraction/Production Peaks

The annual global extraction/production levels associated with the following 18 NNRs, which are either critical or indispensible to modern industrial existence, are projected to peak by the year 2035.[7]

Projected Global Peak NNR Extraction/Production Years

NNR and Projected Peak Extraction/Production Year	NNR and Projected Peak Extraction/Production Year	NNR and Projected Peak Extraction/Production Year
Chromium – 2035	Magnesium Metal – 2010	Phosphate Rock* – 1988
Coal – 2030	Manganese – 2024	Platinum Group Metals* – 2005
Cobalt – 2035	Molybdenum – 2025	Tin – 2018
Copper – 2030	Natural Gas – 2025	Titanium Concentrates – 2025
Indium – 2018	Nickel – 2025	Tungsten – 2010
Iron Ore – 2015	Oil – 2017	Zinc – 2020

*Possibly already reached global peak extraction.

While it is unlikely that all of these global extraction/production peak projections will be realized, it is likely that many or most of these NNRs will become increasingly scarce in the immediate future.

Global NNR Scarcity Summary Assessment

Total global NNR requirements—i.e., the NNR quantities (economic inputs) necessary to perpetuate pre-recession global economic output (GDP) and growth—had put increasing pressure on globally available, economically viable NNR supplies since the beginning of the new millennium.

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

- 63 of the 89 analyzed NNRs were scarce globally in 2008.
- 28 of the 89 analyzed 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 analyzed NNRs will "likely" remain scarce permanently, barring future reductions in global NNR requirement trajectories and/or major new economically viable discoveries.

Going forward, 39 of the 89 analyzed NNRs are considered "at risk" globally. That is, globally available, economically viable supplies associated with these NNRs will likely experience increasingly severe shortages, as industrialized and industrializing nations attempt to reestablish and exceed pre-recession global economic output (GDP) levels and growth rates on a continuous basis.

Global "At Risk" NNRs

Nonrenewable Natural Resource (NNR)	NNR Criticality	Permanent Global NNR Scarcity	Permanent Global Peak Extraction/ Production	Years to Global Reserves Exhaustion (from 2008)
Antimony	Critical	Almost Certain		8 years
Bauxite	Indispensible	Likely	By 2038	40 years
Beryllium	Critical	Likely	Likely in 1961	
Bismuth	Critical	Almost Certain		17 years
Cadmium	Important	Likely	By 1988*	25 years**
Chromium	Indispensible	Almost Certain	By 2035	26 years
Coal	Indispensible	Almost Certain	By 2030	40 years
Cobalt	Indispensible	Almost Certain	By 2035	26 years

Global "At Risk" NNRs (continued)

Nonrenewable Natural Resource (NNR)	NNR Criticality	Permanent Global NNR Scarcity	Permanent Global Peak Extraction/ Production	Years to Global Reserves Exhaustion (from 2008)
Copper	Indispensible	Almost Certain	By 2030	27 years
Fluorspar	Critical	Likely		23 years
Graphite (Natural)	Critical	Likely		38 years
Indium	Critical	Almost Certain	By 2018	
Iron Ore	Indispensible	Almost Certain	By 2015	15 years
Iron/Steel	Indispensible	Almost Certain		
Lead	Critical	Almost Certain	By 1990*	17 years
Lithium	Critical	Likely		8 years
Magnesium Metal	Indispensible	Likely	By 2010	
Manganese	Indispensible	Almost Certain	By 2024	17 years
Molybdenum	Critical	Almost Certain	By 2025	20 years
Natural Gas	Indispensible	Almost Certain	By 2025	34 years
Nickel	Critical	Likely	By 2025	30 years
Niobium	Critical	Almost Certain		15 years
Nitrogen (Ammonia)	Indispensible	Almost Certain		
Oil	Indispensible	Almost Certain	By 2017	39 years
Phosphate Rock	Indispensible	Almost Certain	By 1988*	
Platinum Group Metals (PGM)	Indispensible		By 2005*	
Potash	Indispensible	Likely		
Rhenium	Critical	Almost Certain		22 years
Selenium	Important	Almost Certain	Likely in 1996	
Silver	Critical	Almost Certain	By 2010	11 years
Sulfur	Indispensible	Almost Certain		
Tellurium	Critical		Likely in 1974	
Thallium	Important	Almost Certain	Likely in 1989	38 years**
Tin	Critical	Almost Certain	By 2018	18 years
Titanium Mineral Concentrates	Indispensible	Likely	By 2025	37 years
Tungsten	Critical	Almost Certain	By 2010	32 years
Uranium	Critical	Almost Certain	By 1982*	34 years
Zinc	Indispensible	Likely	By 2020	13 years
Zirconium	Critical	Almost Certain		19 years

* The (Verhulst) logistics curve fitting analysis projected global peak extraction/production prior to the year 2010. However, either the projected peak was subsequently exceeded or it is currently unclear whether the pre-2010 peak is permanent. While the Verhulst methodology is naturally subject to inaccuracy with regard to precise peak NNR extraction/production timing, it is a viable indicator of existing or impending NNR scarcity.
** 2008 reserve to production (R/P) data were used in lieu of extrapolated extraction/production projections because the 2000-2008 compound annual growth rate (CAGR) associated with annual global extraction/production was negative.

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

NNR Scarcity and Modern Industrial Existence

Water comes from turning on a faucet; electricity comes from a wall socket; light comes from flipping a switch; heat and air conditioning come from adjusting a thermostat; food comes from a grocery store; gasoline comes from a gas station; and instantaneous global communication comes from pressing buttons on a handheld electronic device—right?

Actually, these essential attributes of our modern industrial existence, in addition to nearly all others, are enabled by enormous and ever-increasing quantities of NNRs.

The following 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 Technology Electronic Devices
- Emerging "Green" Technologies (Electric Cars, Wind Turbines, and Solar Cells)

Consider in each case the domestic (US) peak (to date) NNR extraction/production year, the domestic (US) NNR import percentage, the likelihood regarding permanent NNR scarcity, and the potential geopolitical NNR supply constraints.

Given America's extraordinary levels of foreign NNR dependence and vulnerability, and the fact that all industrialized and industrializing nations are similarly dependent and vulnerable, the potential for conflict—resource wars—will certainly increase going forward as these NNRs become increasingly scarce.

NNRs Used in Essential Infrastructure

The physical foundation of every industrialized nation is infrastructure—buildings, roads, systems, and networks. Infrastructure consists almost entirely of NNRs; and it is produced, provisioned, and maintained almost exclusively through the utilization of NNRs.

NNRs Used in Essential Infrastructure

Infrastructure NNR	Peak US Extraction/ Production Year (to date)	2008 US Import Percent	Permanent Scarcity		Potential Geopolitical Supply Constraints
			US	Global	
Abrasives	1974	76%	Almost Certain	Unclear	83% of US fused aluminum oxide and crude silicon carbide are imported from China
Aluminum	1980	24%	Almost Certain	Unclear	56% of US aluminum imports come from Canada
Boron	1995	0%	Unclear	Unclear	72% of proven global boron reserves are located in Turkey
Cement	2005	11%	Unclear	Unclear	
Chromium	1956	66%	Almost Certain	Almost Certain	Over 75% of proven global reserves are located in South Africa and Kazakhstan
Clays	1973	0%	Unlikely	Unclear	84% of US clay imports come from Brazil

Austerity – Our "New Normal"

Our "old normal" – prosperity – was enabled by abundant and cheap NNRs. Our "new normal" – austerity – is being thrust upon us by increasingly scarce and expensive NNRs.

Introduction

When I wrote **"Scarcity – Humanity's Final Chapter?"** in 2009/10, it was obvious that the episode of epidemic global nonrenewable natural resource (NNR) scarcity that occurred immediately prior to the Great Recession was historically unprecedented. Global NNR prices associated with the vast majority of NNRs had increased during the years immediately prior to the recession, in many cases dramatically, as earth's increasingly constrained – i.e., increasingly expensive, lower quality – global NNR supplies struggled to address our historically unprecedented global NNR requirements.

It was unclear at the time, however, whether the episode of pre-recession global NNR scarcity was predominantly temporary or permanent. That is, in which cases would sufficient economically viable NNR supplies ultimately be brought online to completely address our continuously increasing global requirements; and in which cases would globally available, economically viable NNR supplies never again be sufficient to completely address our global requirements?

Post-recession data indicate that while the earth is still yielding "more" NNR supplies than ever in the majority of cases, it is failing to yield "enough" economically viable NNR supplies in an increasing number of cases to completely address our enormous and ever-increasing global requirements.

While only time will tell whether this trend will continue, the following analysis presents compelling evidence to support the contention that permanent global NNR scarcity is becoming increasingly prevalent – and that ever-increasing global NNR scarcity is the underlying cause associated with our new normal.

NNRs – the Enablers

Our modern industrial existence is enabled almost exclusively by enormous and ever-increasing quantities of nonrenewable natural resources (NNRs) – the fossil fuels, metals, and nonmetallic minerals that serve as:

- The raw material inputs to our industrialized economies;
- The building blocks that comprise our industrialized infrastructure and support systems; and
- The primary energy sources that power our industrialized societies.

As an example, NNRs comprise approximately 95% of the raw material inputs to the US economy each year.[1] During 2006, the year during which aggregate US NNR utilization peaked (to date), America used over 7.1 billion tons of newly mined NNRs – an almost inconceivable 180,000% increase since the year 1800 – which equated to nearly 48,000 pounds per US citizen.[2]

NNRs play two essential roles in enabling our industrial lifestyle paradigm:

- NNRs enable renewable natural resources (RNRs) – water, soil, forests, and other naturally occurring biota – to be exploited in ways and at levels that are necessary to support the extraordinary population levels and material living standards associated with industrialized human societies. Examples include water storage/distribution systems, food production/distribution systems, and energy generation/distribution systems, which would support only a negligible fraction of today's global human population were they enabled exclusively by RNRs.

- NNRs enable the production and provisioning of manmade goods and infrastructure – e.g., airplanes, computers, skyscrapers, super-highways, refrigerators, light bulbs, communication networks, etc. – that differentiate industrialized societies from pre-industrial agrarian and hunter-gatherer societies; goods and infrastructure that are inconceivable through the exclusive utilization of RNRs.

In sum, NNR inputs to our global economy generate the economic output that enables the material living standards enjoyed by our industrialized and industrializing populations.

NNR Inputs → Economic Output → Material Living Standards

Prosperity – Our "Old Normal"

Since the inception of our industrial revolution over 200 years ago until approximately the end of the 20th century, there was "more"; and better yet, there was "enough". As a result, there was increasing "prosperity"!

Global NNR supplies remained generally abundant during the 20th century, despite our continuously increasing utilization levels.[3]

"…a rising long-term price for a commodity indicates increasing scarcity of supply relative to demand. This is what we should expect with minerals as depletion progresses. However, in general, mineral prices have historically fallen in real terms. Therefore, the data show that supply has grown faster than demand [during the 20th century]." – USGS[4]

From the inception of our industrial revolution until approximately the end of the 20th century, mankind, especially people living in the industrialized West, experienced continuously improving material living standards, which were enabled by our ever-increasing utilization of abundant and cheap NNRs.

Throughout this period, there were typically "more" globally available, economically viable supplies of literally every NNR type – i.e., annual NNR extraction/production level trajectories and overall NNR supply level trajectories increased in nearly all cases since the dawn of industrialism.[5]

"Although the U.S. economy generally continues its increasing consumption trend [as did other industrialized nations], the international supply of minerals has been able to keep pace [through the end of the 20th century]." – USGS[6]

More importantly, there were "enough" economically viable supplies of nearly every NNR type during the period – i.e., abundant NNR supplies enabled NNR price trajectories to actually decrease in the vast majority of cases.[7]

"In 1929, D.F. Hewett, of the United States Geological Survey (USGS), reflecting on the effects of war on metal production … (Hewett, 1929). 'Since 1800 the trend of prices for the common metals, measured not only by monetary units but by the cost in human effort, has been almost steadily downward…'" And,

"In spite of the fact that the use of mineral raw materials increased over the last [20th] century, the long-term constant dollar price of key U.S. mineral raw materials declined during the same period." – USGS[8]

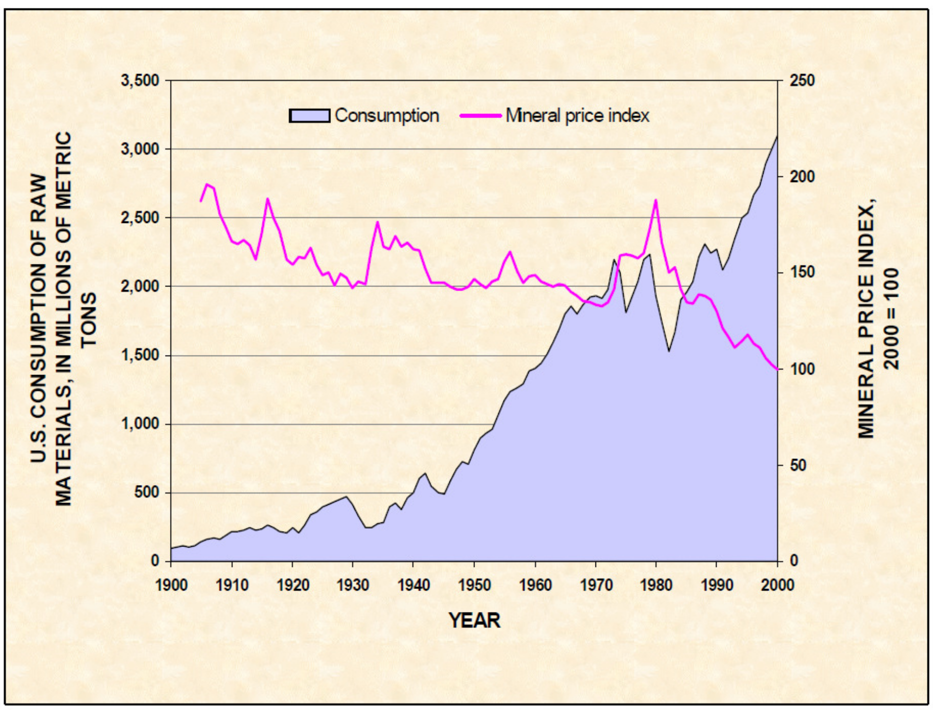
Consequently, globally available, economically viable NNR supplies were sufficient during the 19th and 20th centuries to completely address industrialized humanity's requirements, and thereby provide generally increasing prosperity **–** i.e., improving material living standards for broadening segments of our continuously expanding global population.

NNR scarcity, to the extent that it existed, was a temporary phenomenon that occurred during the "boom" phases of periodic "commodity boom/bust cycles".

"When demand increases, prices tend to rise and/or producers supply more goods to the market to keep up with the rising demand. When demand increases faster than supply**, temporary shortages exist." [emphasis mine]** – USGS[9]

Sufficient additional economically viable NNR supplies were always available during the 20th century to be brought online to resolve temporary NNR shortages and thereby restore decreasing NNR price trajectories.

Our 20th century NNR experience, which was defined by the counterintuitive reality of generally decreasing NNR price levels despite dramatically increasing NNR utilization (extraction/production) levels, is exemplified by the following USGS graph depicting 20th century US NNR utilization levels and pricing levels.[10]



With respect to 20th century NNR scarcity, the USGS concluded:

"The fact that production of mineral commodities has been able to keep up with or exceed the demand for minerals is, in part, an indicator that based on the past, **scarcity has not been an issue for mineral resources in general." [emphasis mine]** – USGS[11]

And the USGS was correct. During the 19th and 20th centuries, industrialized nations experienced only periodic episodes of temporary NNR scarcity within the context of general NNR abundance, which enabled historically unprecedented material living standard improvement for increasing segments of their expanding populations – our old normal prevailed!

Abundant and Cheap NNR Inputs → Robustly Increasing Economic Output (GDP) → Continuously Improving Material Living Standards (Per Capita GDP)

Unfortunately, we misinterpreted temporary NNR abundance as permanent NNR sufficiency.

Austerity – Our "New Normal"

Owing to a fundamental shift in global NNR demand/supply dynamics that occurred during the past several decades, there is still "more" in most cases, but there is no longer "enough" in an increasing number of cases. The result is geologically-imposed austerity – our "new normal".

Why Our "Old Normal" No Longer Applies – Ever-increasing NNR Scarcity

NNR scarcity exists when the economically viable NNR supply available to a society is insufficient to completely address the society's NNR requirement, which is defined as the NNR quantity necessary to generate the mix and levels of goods and services required to provide the society's "expected" level of societal wellbeing (the material living standard enjoyed by its population).

Because NNRs are finite and non-replenishing, global NNR scarcity was inevitable. The persistent utilization of finite and non-replenishing natural resources, especially at levels required to perpetuate our industrial lifestyle paradigm, is unsustainable by definition. Our quest for global industrialism during the past several decades merely expedited the onset of epidemic NNR scarcity by causing a fundamental shift in global NNR demand/supply dynamics.

- On the "demand side", our global NNR requirements are historically unprecedented and are increasing at historically unprecedented rates. Whereas approximately 1.5 billion people occupied industrialized and industrializing nations until the late 20th century, that number increased nearly instantaneously by the beginning of new millennium to over 5 billion, most of whom have yet to even remotely approach their full NNR utilization potential; while

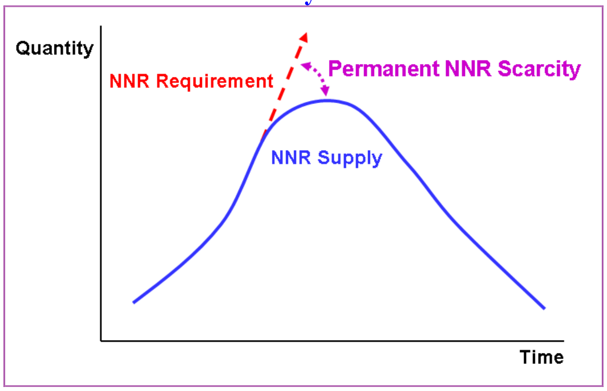
- On the "supply side", NNR supplies are increasingly constrained – i.e., NNR discoveries/deposits are fewer in number, smaller in size, less accessible, and of lower grade and purity. NNR exploration, extraction, production, and processing technologies are failing to keep pace with lower quality NNR supplies, and are therefore experiencing diminishing marginal investment returns – i.e., each incremental unit of technology investment yields smaller quantities of economically viable NNRs.

Our historically unprecedented and ever-increasing global NNR requirements are manifesting themselves within the context of increasingly expensive, lower quality NNR supplies. The unfortunate consequence associated with this "demand/supply imbalance" is that the earth cannot physically support humanity's current – much less continuously increasing – NNR requirements going forward.

In fact, by 2008, immediately prior to the Great Recession, global NNR scarcity had become epidemic. Sixty three (63) of the 89 NNRs that enable our modern industrial existence – including aluminum, chromium, coal, copper, gypsum, iron/steel, magnesium, manganese, molybdenum, natural gas, oil, phosphate rock, potash, rare earth minerals, titanium, tungsten, uranium, vanadium, and zinc – were scarce globally.[12]

At the time this report is being written in August 2012, the vast majority of these NNRs are:

Permanent NNR Scarcity



- Permanently scarce globally – i.e., economically viable supplies will never again be sufficient to completely address our global requirements, or
- Experiencing increasingly severe and protracted episodes of temporary scarcity and will soon become permanently scarce globally as well.

(Note that permanent NNR scarcity occurs well before the annual NNR supply level reaches its peak.)

Humanity's Predicament – the Genesis of Our "New Normal"

Ironically, since the inception of our industrial revolution, we have been eliminating – persistently and increasingly – the finite and non-replenishing NNRs upon which our industrialized way of life and our very existence depend.

Because the natural resource utilization behavior that enables our current "success" – our industrial lifestyle paradigm – and that is essential to perpetuating our success, is simultaneously undermining our very existence, neither our natural resource utilization behavior nor our industrial lifestyle paradigm is sustainable.

This is humanity's "predicament".

2012 Global NNR Scarcity Analysis – Evidence of Our "New Normal"

During the mid/late 20th century (1960-1999), a barrel of oil cost $19 on average; during the years prior to the Great Recession (2000-2008), the average price of a barrel of oil had increased to $47; and during the years immediately following the Great Recession (2009-2012), the average price of a barrel of oil had further increased to $75.

During the same three time periods, the average price of a metric ton of copper increased from $3,085, to $3,715, to $6,281; the average price of a metric ton of iron ore increased from $36, to $57, to $113; and the average price of a metric ton of potash increased from $114, to $185, to $401. (All prices are adjusted for inflation.)

The simple fact is that we cannot grow our global economy and improve our global material living standards on $75 oil, $6,281 copper, $113 iron ore, and $401 potash like we did on $19 oil, $3,085 copper, $36 iron ore, and $114 potash.

It should come as no surprise, especially for those of us living in the industrialized West, that our NNR-dependent national economies have been sputtering and our material living standards have been deteriorating during the early years of the 21st century.

Analysis Overview

The 2012 Global NNR Scarcity Analysis (Analysis), an update to the Global NNR Scarcity Analysis presented in **"Scarcity"**, compares the trends and trajectories between our old normal and our new normal with respect to each of the following criteria:

- NNR "demand/supply" dynamics (NNR requirements, supplies, prices, and demand);
- Global economic output (GDP); and
- Global material living standards (per capita GDP).

Analyzed NNRs The Analysis considers 16 NNRs for which the World Bank maintains pricing data from the year 1960 to the most current month, June 2012 in this case (exceptions are coal, 1970-2012; steel, 1979-2012; and potash, 1970-2012). Included in the Analysis are the following NNRs:

- Fossil Fuels: coal, natural gas, and oil.
- Metals: aluminum, copper, iron ore, steel, lead, nickel, platinum, silver, steel, tin, and zinc.
- Non-metallic Minerals: phosphate rock, potash, and urea (nitrogen).

These 16 NNRs are representative of the broader NNR base (89 NNRs were analyzed in **"Scarcity"**) and provide a good proxy for global NNR supply, pricing, and scarcity trends and trajectories. (Note that ongoing NNR analyses are necessary as new data become available.)

Analysis Period – (1960–[June] 2012) The Analysis considers three time intervals:

- Mid/Late 20th Century (1960-1999/2000),
- Pre Great Recession (2000-2008), and
- Post Great Recession (2008/2009-2011/2012).

Data Sources Data utilized in the Analysis were obtained from the following sources:

- 20th Century NNR Price, Supply, and Utilization Trajectories – US Geological Survey.
- 2000-2010 Global NNR Supply (extraction/production) Trajectories – US Geological Survey.
- 1960-2012 Inflation Adjusted Global NNR Price Trends – World Bank and US Energy Information Administration.
- 1960-2011 Global Economic Output (inflation adjusted global GDP) Trajectories – World Bank.
- 1960-2011 Material Living Standard Improvement (inflation adjusted global per capita GDP) Trajectories – World Bank.

Key Assumptions The following assumptions underlie the Analysis:

- If global NNR supplies are abundant—i.e., sufficient to completely address our global requirements—NNR price level trajectories remain flat or decline over time.
- If global NNR supplies are scarce—i.e., insufficient to completely address our global requirements—NNR price level trajectories increase over time.
- The post-recession, scarcity-related trends associated with the 16 analyzed NNRs are consistent with the post-recession, scarcity-related trends associated with the broader NNR base.

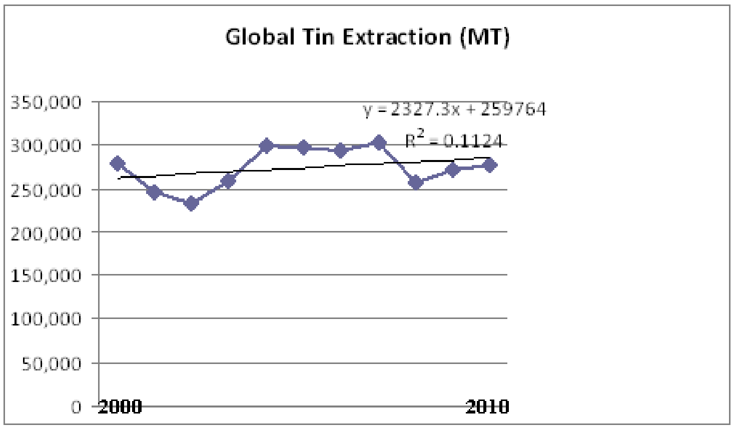
Analysis (Trends and Trajectories)

Global NNR Supply (Extraction/Production) Level Trajectories

Notwithstanding periodic NNR supply level decreases caused by "commodity boom/bust cycles" and geopolitically induced supply restrictions, annual global NNR extraction/production levels and overall NNR supply levels generally trended upward during the 20th century.[13] There were "more" of nearly all NNR types between the years 1900 and 2000 (exceptions being toxic NNRs such as arsenic, asbestos, and mercury).[14]

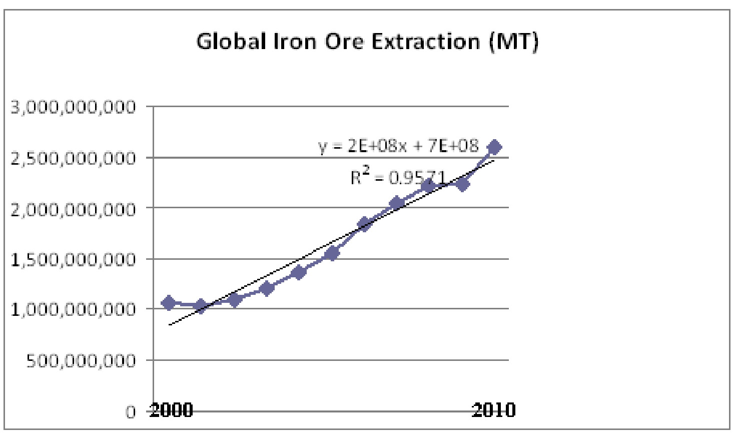
Had this 20th century NNR supply trend persisted into the new millennium, annual NNR supply levels would have continued their upward trajectories from the year 2000 forward. And, based on global NNR extraction/production data for the years 2000 through 2010 (most currently available data), this was the case for all 16 of the analyzed NNRs.[15]

Tin – Annual Global Metric Tons Extracted



Of the 16 analyzed NNRs, annual global tin extraction levels exhibited the slightest upward trajectory between the years 2000 and 2010, while global iron ore extraction exhibited the greatest upward trajectory during the period.[16]

Iron Ore – Annual Global Metric Tons Extracted



Significant Finding In the case of each analyzed NNR, there were "more" globally available, economically viable supplies during early years of the 21st century.

NNR Price Level Trends

Notwithstanding periodic price increases caused by "commodity boom/bust cycles" and geopolitically induced supply restrictions, NNR price levels remained relatively low during the 20th century (specifically during the 1960-1999 period); and actually trended downward in the majority of cases.[17] These relatively low and generally decreasing NNR price levels prevailed despite the fact that NNR supply (extraction/production) levels trended upward in the vast majority of cases during the 20th century.

Had 20th century price level trends persisted into the new millennium, NNR prices would have continued their downward trajectories from the year 2000 forward, and average 21st century NNR price levels would have been lower than average 20th century price levels. With very few exceptions, this was not the case.

Inflation Adjusted Average NNR Prices			
NNR	**1960-1999**	**2000-2008**	**2009-2012**
Fossil Fuels			
Coal (2005 USD per MT)	42	50	84
Oil (2005 USD per barrel)	19	47	75
Natural Gas (Global Index: 2005=100)	27	83	84
Metals			
Aluminum (2005 USD per MT)	1,776	1,937	1,771
Copper (2005 USD per MT)	3,085	3,713	6,281
Iron Ore (2005 USD per Dry MT*)	36	57	113
Lead (2005 US Cents per Kg)	86	105	177
Nickel (2005 USD per MT)	8,107	15,602	16,564
Platinum (2005 USD per Troy Oz)	452	897	1,295
Silver (2005 US Cents per Troy Oz)	772	802	2,125
Steel (Global Index: 2005=100)	69	83	112
Tin (2005 US Cents per Kg)	1,227	839	1,732
Zinc (2005 US Cents per Kg)	122	160	170
Nonmetallic Minerals			
Phosphate Rock (2005 USD per MT)	52	75	131
Potash (2005 USD per MT)	114	185	401
Urea [Nitrogen] (2005 USD per MT)	174	202	293

Data Source: World Bank and US Energy Information Administration

In 15 of the 16 analyzed cases, the exception being tin, average NNR price levels during the pre-recession period (2000-2008) exceeded average price levels during the mid/late 20th century (1960-1999).[18]

And, with the exception of aluminum, average post-recession (2009-2012) NNR price levels exceeded both average mid/late 20th century (1960-1999) price levels and average pre-recession (2000-2008) price levels – in most cases dramatically![19]

Significant Finding While "more" globally available, economically viable supplies existed with respect to each of the 16 analyzed NNRs during the early years of the new millennium, "enough" globally available, economically viable supplies existed in only one case – aluminum. Only in the case of aluminum were globally available, economically viable supplies sufficiently abundant to drive average post-recession prices back down to 20th century levels.

Global Economic Output (GDP) Trajectories

Global economic output (GDP) increased at a 3.81% compound annual rate during the mid/late 20th century (1960-2000).[20]

Had the 20th century global economic growth trajectory persisted into the new millennium, global economic output (GDP) would have increased at approximately 3.8% per annum, and might have exceeded 4%, given the emergence of newly industrializing nations such as China, India, and Brazil. This did not occur.

Compound Annual Growth Rate (CAGR) in Global Economic Output (GDP)		
1960-2000 CAGR	2000-2008 CAGR	2008-2011 CAGR
3.81%	2.90%	1.56%

Data Source: World Bank

The compound annual growth rate in global economic output (GDP) actually decreased to 2.9% during the pre-recession period (2000-2008), and further decreased to 1.56% during the post-recession years (2008-2011).[21]

Significant Finding As the vast majority of NNRs became increasingly scarce and expensive globally during the pre-recession years, the annual growth rate in global economic output (GDP) decreased. As these NNRs became even more scarce and expensive during the post-recession years, the annual growth rate in global economic output (GDP) decreased even further.

Global Material Living Standard (Per Capita GDP) Improvement Trajectories

Global material living standards, as proxied by per capita global GDP, improved at a 2.01% compound annual rate during the mid/late 20th century (1960-2000).[22]

Had the 20th century global material living standard improvement trajectory persisted into the new millennium, global material living standards would have continued to improve on the order of 2.0% per annum, or possibly at a greater rate, given the significant material living standard improvement associated with increasing segments of newly industrializing nations such as China, India, and Brazil. This eventuality did not come to pass.

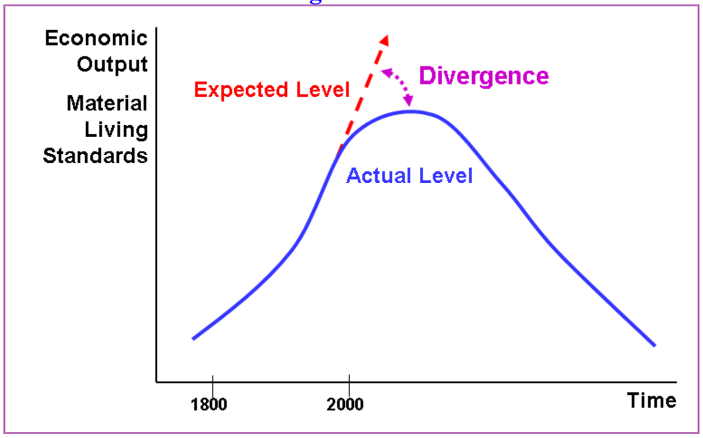
Compound Annual Growth Rate (CAGR) in Global Material Living Standard (Per Capita GDP) Improvement		
1960-2000 CAGR	2000-2008 CAGR	2008-2011 CAGR
2.01%	1.66%	0.40%

Data Source: World Bank

The compound annual growth rate in global material living standard improvement (global per capita GDP) actually decreased to 1.66% during the pre-recession period (2000-2008), and further decreased to 0.4% during the post-recession years (2008-2011).[23]

Significant Finding The declining trend in global material living standard improvement paralleled that of global economic growth.

Global Societal Wellbeing Evolution



As the vast majority of NNRs became increasingly scarce and expensive during the new millennium, both the annual growth rate in global economic output (GDP) and the annual growth rate in global material living standard improvement (per capita GDP) diverged from their expected levels and decreased continuously.

Assessment – Expectations Versus Reality

Given the environment of general NNR abundance that prevailed during most of the 20th century, our expectations regarding 21st century NNR availability, 21st century economic growth, and 21st century material living standard improvement consisted of simple extrapolations of our 20th century experience.

Unfortunately, our expectations have been not realized. Our old normal transitioned – unexpectedly and nearly instantaneously – to our new normal at the dawn of the new millennium, as billions of additional NNR users worldwide generated historically unprecedented requirements for earth's increasingly constrained NNR supplies.

NNRs Given that our current global "demand/supply" dynamics – i.e., our ever-increasing NNR requirements juxtaposed against the earth's increasingly constrained NNR supplies – will almost certainly persist going forward; upward trending NNR price trajectories will almost certainly persist as well.

As a result, an increasing number of NNRs will become permanently scarce globally – i.e., while there will always be plenty of NNRs in the ground, there **will not be enough economically viable NNRs** in the ground to completely address our future requirements.

Increasingly rare instances of future NNR surpluses will result not from over-production (abundant economically viable NNR supplies), but from demand destruction (contracting NNR demand due to increasingly high NNR prices).

Global Economic Output Given that future NNR price level trajectories will continue to trend upward in most cases, future global economic growth will almost certainly continue to trend downward. That is, our annual global economic output (GDP) levels will increase temporarily at a decreasing rate over the near term, peak in the not-too-distant future, and enter terminal decline within the next decade or so. (Please see the Global Societal Wellbeing Evolution diagram.)

As a result, our global economy, which failed to recover from the Great Recession in 2010, 2011, and 2012, will never experience a complete recovery. And our national economies, many of which are already showing signs of stress, will experience increasingly poor performance:

- The economies associated with the weaker, less competitive European nations – including Portugal, Ireland, Italy, Greece, and Spain – are currently in a state of terminal decline;[24]
- Economic growth in the remainder of the industrialized West – including Japan, the UK, Germany, and the US – is faltering;[25] and
- The economies in newly industrializing nations such as China, India, Brazil, South Korea, and Indonesia are growing at decreasing rates.[26]

Material Living Standards So long as global economic growth continues to slow, our material living standards will continue to moderate as well. (Please see the Global Societal Wellbeing Evolution diagram.)

Populations in the industrialized West will see their material living standards deteriorate continuously going forward; and people in newly industrializing nations who aspire to Western material living standards will see their aspirations increasingly frustrated.

Weaker and less competitive industrialized nations in the West are already experiencing deteriorating material living standards[27], especially among their middle class population segments. The real wealth[28] surpluses generated by these nations' economies are no longer sufficient to support their existing middle class populations, much less continuously expanding middle class populations.

Increasingly Scarce and Expensive NNR Inputs → Slowing Economic (GDP) Growth → Moderating Material Living Standard (Per Capita GDP) Improvement

The persistent global economic malaise that we have experienced since the Great Recession is symptomatic of the fact that our actual level of global societal wellbeing has diverged permanently from our expected level – i.e., both our global economic output (GDP) level and our global material living standards (per capita GDP) are in the process of "rolling over".

Implications of Our "New Normal"

The Great Recession was not simply another temporary economic downturn, from which we in the industrialized world will recover by "stimulating" our national economies with borrowed money, printed money, and manipulated (artificially low) interest rates.

The Great Recession was caused by a permanent ecological (geological) phenomenon – ever-increasing global NNR scarcity. The Great Recession marked the permanent transition from our old normal of ever-increasing, NNR-enabled prosperity to our new normal of ever-increasing, geologically-imposed austerity.

Implications associated with this historically unprecedented turn of events include:

- Abundant and cheap NNRs were the enablers of our old normal, increasing prosperity – i.e., the robust economic growth and continuously improving material living standards that most of us who are living today in industrialized nations still consider to be "normal".

- As an increasing number of NNRs are becoming increasingly scarce and expensive, our NNR-enabled prosperity is being displaced by our new normal, geologically-imposed austerity, which is characterized by ever-increasing economic deterioration, material living standard degradation, political instability, and social unrest.

- Because the underlying cause associated with our transition from prosperity to austerity is ecological (geological), not economic or political, our incessant barrage of economic and political “fixes” – fiscal and monetary “stimulus” – is misguided and inconsequential. Our national economies are not “broken”; they are “dying of slow starvation” for lack of sufficient economically viable NNR inputs.

- Our industrial lifestyle paradigm, which is enabled by enormous quantities of finite, non-replenishing, and increasingly scarce NNRs, is unsustainable – actually, physically impossible – going forward.

- Global humanity’s steadily deteriorating condition will culminate in self-inflicted global societal collapse, almost certainly by the year 2050. We will not accept gracefully our new normal of ever-increasing, geologically-imposed austerity; nor will we suffer voluntarily the horrifically painful population level reductions and material living standard degradation associated with our inevitable transition to a sustainable, pre-industrial lifestyle paradigm.

Our Next Normal – Catastrophe

Absent continuous and extraordinary economically viable NNR discoveries of literally every type – especially fossil fuels, major metals, and fertilizer components – humanity’s unraveling will almost certainly devolve into global societal collapse by mid-century.

Over the next decade or so, increasing global NNR scarcity will induce a series of increasingly frequent and severe economic recessions punctuated by increasingly anemic attempted recoveries, a trend that will be especially problematic for the NNR-deficient – but highly NNR-dependent – nations in the industrialized West.

The previously improving material living standards associated with industrializing nations will stagnate; and the previously stagnant material living standards associated with industrialized nations will converge toward those of industrializing nations.

Our situation will continue to deteriorate, despite our ongoing attempts to “fix” it with irrelevant economic and political expedients. NNR scarcity will devolve into increasingly severe temporary NNR supply shortages, as earth’s increasingly constrained NNR supplies fail by increasingly wide margins to completely address our global requirements.

As our economic output (GDP) levels and material living standards continue to decline, we will resort increasingly to conflict at the global, national, regional, and ultimately local levels to obtain the incremental NNRs and derived goods and services required to perpetuate our faltering national economies and our deteriorating individual livelihoods.

Escalating natural resource wars will further reduce our declining economic output levels and material living standards, as war related destruction disrupts our critical natural resource supplies and our critical societal support systems such as water storage/distribution, food production/distribution, energy generation/distribution, sanitation, healthcare, transportation, communications, and law enforcement.

As global NNR supply shortages become increasingly acute, NNR-dependent industrialized nations will be unable to maintain the economic output levels necessary to fund their ballooning debt service, social entitlement, and social services obligations—nor will they be able to obtain additional credit with which to offset their declining real wealth generation capabilities. Western economies – especially those with large debt obligations, fiscal deficits, and balance of payments deficits, such as the US – will experience cascading defaults.

As global NNR supply shortages become permanent, our bankrupt and war ravaged global industrial mosaic will be unable to provide societal essentials—clean water, food, energy, shelter, clothing, and infrastructure—at levels sufficient to support our increasingly angry, confused, and desperate populations. Escalating social unrest will devolve into chaos.

By the year 2050, all industrialized and industrializing nations, irrespective of their economic and political orientations, will collapse, taking the aid-dependent, non-industrialized world with them.

Permanently Scarce and Prohibitively Expensive NNR Inputs → Economic Collapse → Global Societal Collapse

Ironically, we Homo sapiens are both the unwitting perpetrators and the hapless victims of our self-inflicted "predicament" – i.e., our industrial lifestyle paradigm is enabled by natural resource utilization behavior that simultaneously undermines it.

Regrettably, our predicament will be resolved, soon, through self-inflicted global societal collapse – i.e., we will resort increasingly to conflict as the means by which to allocate remaining increasingly scarce NNRs, RNRs, and derived goods.

Endnotes

1. **"Economic Drivers of Mineral Supply" -** U.S. Geological Survey Open-File Report 02-335, page 21; 2002 - Lorie A. Wagner, Daniel E. Sullivan, and John L. Sznopek - http://pubs.usgs.gov/of/2002/of02-335/of02-335.pdf.
2. Mineral Information Institute (Historic US NNR utilization information compiled by the Mineral Information Institute is available upon request from coclugston at Verizon dot net.) – www.mii.org.
3. The cited excerpts are taken from a comprehensive 2002 US Geological Survey (USGS) report entitled "**Economic Drivers of Mineral Supply",** which examines 20th century non-fuel mineral demand, supply, and pricing trends in the US. The report accurately depicts industrialized humanity's historical experience and existing perspective regarding NNR supplies, prices, utilization, and scarcity. In their report, the authors define the conceptual framework for our "old normal". **"Economic Drivers of Mineral Supply" -** U.S. Geological Survey Open-File Report 02-335; 2002 - Lorie A. Wagner, Daniel E. Sullivan, and John L. Sznopek - http://pubs.usgs.gov/of/2002/of02-335/of02-335.pdf.
4. **"Economic Drivers of Mineral Supply"**, USGS, page 98.
5. "**Historical Statistics for Mineral and Material Commodities in the United States"**; US Geological Survey, 2012 - http://minerals.usgs.gov/ds/2005/140/.
6. **"Economic Drivers of Mineral Supply"**, USGS, page 78.
7. "**Economic Drivers of Mineral Supply"**, USGS, page 78; and "**Historical Statistics for Mineral and Material Commodities in the United States"**; USGS.
8. **"Economic Drivers of Mineral Supply"**, USGS, pages 10 and 61.
9. **"Economic Drivers of Mineral Supply"**, USGS, page 20.
10. **"Economic Drivers of Mineral Supply"**, USGS, page 78; NNRs included in the USGS index are cement, clays, lime, phosphate rock, salt, sand and gravel, crushed stone, copper, gold, iron ore, lead, and zinc.
11. **"Economic Drivers of Mineral Supply"**, USGS, page 64.
12. **"Scarcity – Humanity's Final Chapter?"** pages 51-53; Chris Clugston, 2012; www.nnrscarcity.com.
13. **"Economic Drivers of Mineral Supply"**, USGS, page 78; and "**Historical Statistics for Mineral and Material Commodities in the United States"**; USGS.
14. **"Historical Statistics for Mineral and Material Commodities in the United States"**; USGS.
15. **"Historical Statistics for Mineral and Material Commodities in the United States"**; USGS.

16. “Historical Statistics for Mineral and Material Commodities in the United States”; USGS.

17. “Economic Drivers of Mineral Supply”, USGS, page 78; and “**Historical Statistics for Mineral and Material Commodities in the United States”**; USGS.

18. **“Monthly World Prices of Commodities and Indicies”** (Pink Sheets), World Bank, 2012 – http://econ.worldbank.org/WBSITE/EXTERNAL/EXTDEC/EXTDECPROSPECTS/0,,contentMDK:21574907~menuPK:7859231~pagePK:64165401~piPK:64165026~theSitePK:476883,00.html; and **“International Energy Statistics”**, US Energy Information Administration, 2012 – http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm; and note regarding tin – Because tin served as the primary can and container coating material throughout most of the 20th century, tin demand remained strong and tin prices remained relatively high until the mid/late 1980s. As tin was displaced increasingly by aluminum toward the end of the 20th century and into the early years of the 21st century, tin prices declined temporarily.

19. **“Monthly World Prices of Commodities and Indicies”** (Pink Sheets), World Bank; and **“International Energy Statistics”**, US EIA.

20. **“World GDP Production (constant 2000 US$)”,** World Bank, 2012, – http://www.google.com/publicdata/explore?ds=d5bncppjof8f9_&met_y=ny_gdp_mktp_cd&idim=country:USA&dl=en&hl=en&q=us+gdp#!ctype=l&strail=false&bcs=d&nselm=h&met_y=ny_gdp_mktp_cd&scale_y=lin&ind_y=false&rdim=region&idim=country:USA&ifdim=region&tdim=true&hl=en_US&dl=en&ind=false.

21. **“World GDP Production (constant 2000 US$)”**, World Bank.

22. **“World GDP Per Capita (constant 2000 US$)”**, World Bank, 2012, – http://www.google.com/publicdata/explore?ds=d5bncppjof8f9_&met_y=ny_gdp_mktp_cd&idim=country:USA&dl=en&hl=en&q=us+gdp#!ctype=l&strail=false&bcs=d&nselm=h&met_y=ny_gdp_mktp_cd&scale_y=lin&ind_y=false&rdim=region&idim=country:USA&ifdim=region&tdim=true&hl=en_US&dl=en&ind=false.

23**. “World GDP Per Capita (constant 2000 US$)”**, World Bank.

24. **“National GDP Growth (inflation adjusted)”**, example countries: Portugal, Ireland, Italy, Spain, and Greece; World Bank, 2012, – http://www.google.com/publicdata/explore?ds=d5bncppjof8f9_&met_y=ny_gdp_mktp_cd&idim=country:USA&dl=en&hl=en&q=us+gdp#!ctype=l&strail=false&bcs=d&nselm=h&met_y=ny_gdp_mktp_cd&scale_y=lin&ind_y=false&rdim=region&idim=country:USA&ifdim=region&tdim=true&hl=en_US&dl=en&ind=false.

25. **“National GDP Growth (inflation adjusted)”**, example countries: US, UK, Japan, and Germany; World Bank.

26. **“National GDP Growth (inflation adjusted)”**, example countries: China, India, South Korea, Brazil, and Indonesia; World Bank.

27. **“GDP Per Capita Growth (inflation adjusted)”**, example countries: Portugal, Ireland, Italy, Spain, and Greece; World Bank, 2012 – http://www.google.com/publicdata/explore?ds=d5bncppjof8f9_&met_y=ny_gdp_mktp_cd&idim=country:USA&dl=en&hl=en&q=us+gdp#!ctype=l&strail=false&bcs=d&nselm=h&met_y=ny_gdp_mktp_cd&scale_y=lin&ind_y=false&rdim=region&idim=country:USA&ifdim=region&tdim=true&hl=en_US&dl=en&ind=false.

28. All real wealth is derived from the following sources:

- In the water – fish and other aquatic life forms;
- On the ground – livestock and other animal life forms;
- In the ground – crops and other plant life forms; and
- Under the ground – fossil fuels, metals, and nonmetallic minerals (NNRs).

Chris Clugston Bio

Since 2006, I have conducted extensive independent research into the area of “sustainability”, with a focus on nonrenewable natural resource (NNR) scarcity. NNRs are the fossil fuels, metals, and nonmetallic minerals that enable our modern industrial existence.

I have sought to quantify from a combined ecological and economic perspective the extent to which America and humanity are living unsustainably beyond our means, and to articulate the causes, magnitude, implications, and consequences associated with our “predicament”. My research culminated in the publication of ***Scarcity – Humanity’s Final Chapter?*** (Please see www.nnrscarcity.com for additional information.)

My previous work experience includes thirty years in the high technology electronics industry, primarily with information technology sector companies. I held management level positions in marketing, sales, finance, and M&A, prior to becoming a corporate chief executive and later a 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.