Making Nature Useless
Relative Dematerialization & Absolute Peaks

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Program for the Human Environment

Resources For the Future
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Report on work done with Jesse Ausubel, Alan Curry and Paul Waggoner
phe.rockefeller.edu
Can improving efficiency and changing consumer preferences overwhelm rising population and affluence to reduce the tons of material that Americans use? The World?
Resource Concerns

1. National Security
2. Commerce
3. Environmental Quality

RESOURCES for FREEDOM

International Finance Discussion Papers: A Crisis in Critical Commodities

Nature’s Numbers

1952

1972

1999

Wernick & Ausubel 2014
Resource Efficiency

US Potato yield, production, & area harvested: 1950-2010

Data source: USDA 2013

Wernick & Ausubel 2014
Global Forest Products Intensity of Use
(Cubic Meters/$ GDP)

Index 1961 = 1

Sources: FAO (2014); World Bank (2014)

Wernick & Ausubel 2014
Measures of Commodity Use

• Relative
  - *Intensity of Use* (IOU) measured as kg/$GDP
  - Falling IOU ==> “Dematerialization“

• Absolute
  - *Absolute use* (ABS) measured as kg, kWh, Ha, liters…
  - Falling ABS ==> “Peak”
IOU of 9 basic commodities: US 1900-1970

[Notes: Uses 5 yr. moving average; GDP in 2005 dollars; Legend is ordered top down by value in 2010]
IOU of 9 basic commodities: US 1900-2010

[Notes: Uses 5 yr. moving average; GDP in 2005 dollars; Legend is ordered top down by value in 2010]
IOU of 9 basic commodities: US 1900-2010

Data sources: USGS National Minerals Information Center, 2013; Johnston and Williamson, 2013. [Notes: Uses 5 yr. moving average; GDP in 2005 dollars; Legend is ordered top down by value in 2010]
ABS of 9 basic commodities: US 1900-2010

[Notes: Uses 5 yr. moving average; Legend is ordered top down by value in 2010]
Study on the use of 100 commodities in USA 1900 - 2010.

Wernick & Ausubel 2014
Behavior from 1970-2010 gives us 3 distinct groups

Group 1  IOU ↓  ABS ↓

Group 2  IOU ↓  ABS ↓

Group 3  IOU ↑  ABS ↑

Wernick & Ausubel 2014
Group 1
(36/100)

$\Delta \text{IOU} < 0$

$\&$

$\Delta \text{ABS} < 0$

Data source: USGS 2013, Johnston and Williamson 2013
ABS for 8 Group 1 Commodities: US

[Notes: Uses 5 yr. moving average; Legend is ordered top down by value in 2010]

Wernick & Ausubel 2014
<table>
<thead>
<tr>
<th>Group 2 (53/100)</th>
<th>(\triangle \text{IOU} &lt; 0 ) &amp; (\triangle \text{ABS} &gt; 0)</th>
</tr>
</thead>
</table>


Wernick & Ausubel 2014
ABS for 8 Group 2 Commodities: US

[Notes: Uses 5 yr. moving average; Legend is ordered top down by value in 2010]
Group 2 Agricultural Inputs & Outputs

[Notes: Uses 5 yr. moving average; Legend is ordered top down by value in 2010]
US uses of corn

*Includes production of high-fructose corn syrup (HFCS), glucose and dextrose, starch, alcohol for beverages and manufacturing, seed, cereals and other products

Source: USDA Economic Research Service 2013

Wernick & Ausubel 2014
US water withdrawals: Flat since \(~1975\)


Wernick & Ausubel 2014
ABS for 8 Group 3 Commodities: US

[Notes: Uses 5 yr. moving average; Legend is ordered top down by value in 2010]
Commodities Asia

Wernick & Ausubel 2014
Aluminum use in 4 Asian nations

Kilograms per capita

Data sources: USGS 2014, British Geological Survey
Petroleum use in 4 Asian nations

Data sources: USGS 2014, British Geological Survey

Wernick & Ausubel 2014
Petroleum - USA

Data sources: USDOE Energy Information Administration 2013

Wernick & Ausubel 2014
Summary

• Novel consistent measure of
  – Resource demand
  – Demand on nature

• 3 Groups (USA)
  – 36/100 Commodities that ‘Peaked’
  – 53/100 Commodities that have ‘Dematerialized’ relatively and show signs of falling absolute consumption
  – 11/100 Commodities used in small quantities that improve overall system efficiency

• Asian countries at different stages of development show similar patterns leading to eventual saturation
Thank you for your attention

Program for the Human Environment
The Rockefeller University
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Data Sources


• United States Department of Agriculture (USDA). 2012a. Data for cropland was obtained from http://www.ers.usda.gov/datafiles/Major_Land_Uses/Summary_tables/summary_table_3_cropland_used_for_crops_19102012.xls


Note: “Plastics” data in slides 7 - 10 correspond to a category defined by the USGS National Minerals Information Center as Non Renewable Organics (Oil & Gas products). In Wernick et al. (1997) the IOU data for plastics begin in 1943, and represent production data only. Sources: Modern Plastics 37 (5) (1960); data on US production of plastics resin, personal communication with Joel Broyhill, statistics department, Society of the Plastics Industry, Washington, D.C., 20 August 1993.
<table>
<thead>
<tr>
<th>Group 1 (36/100)</th>
<th>Group 2 (53/100)</th>
<th>Group 3 (11/100)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \Delta \text{IOU} &lt; 0 ) and ( \Delta \text{ABS} &lt; 0 )</td>
<td>( \Delta \text{IOU} &lt; 0 ) and ( \Delta \text{ABS} &gt; 0 )</td>
<td>( \Delta \text{IOU} &gt; 0 ) and ( \Delta \text{ABS} &gt; 0 )</td>
</tr>
<tr>
<td>Antimony</td>
<td>Abrasives (Natural)</td>
<td>Nitrogen (Ammonia)</td>
</tr>
<tr>
<td>Arsenic</td>
<td>Aluminum (Natural)</td>
<td>Non-Renewable Organics (NRO)</td>
</tr>
<tr>
<td>Asbestos</td>
<td>Barite</td>
<td>NRO (Oil &amp; Gas)</td>
</tr>
<tr>
<td>Bauxite &amp; Alumina</td>
<td>Beef</td>
<td>Paper &amp; Board</td>
</tr>
<tr>
<td>Bismuth</td>
<td>Beryllium</td>
<td>Perlite</td>
</tr>
<tr>
<td>Cadmium</td>
<td>Boron</td>
<td>Petroleum</td>
</tr>
<tr>
<td>Chromium</td>
<td>Bromine</td>
<td>Phosphate Rock</td>
</tr>
<tr>
<td>Clays</td>
<td>Cement</td>
<td>Platinum-Group Metals*</td>
</tr>
<tr>
<td>Copper</td>
<td>Coal</td>
<td>Pork</td>
</tr>
<tr>
<td>Cotton</td>
<td>Cobalt</td>
<td>Potash</td>
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<tr>
<td>Fluorspar</td>
<td>Corn</td>
<td>Potatoes</td>
</tr>
<tr>
<td>Iodine</td>
<td>Cropland</td>
<td>Salt</td>
</tr>
<tr>
<td>Iron &amp; Steel Scrap</td>
<td>Diatomite</td>
<td>Sand &amp; Gravel (Industrial)</td>
</tr>
<tr>
<td>Iron &amp; Steel Slag</td>
<td>Electricity</td>
<td>Silver</td>
</tr>
<tr>
<td>Iron Ore</td>
<td>Feldspar</td>
<td>Stone (Crushed)</td>
</tr>
<tr>
<td>Lithium</td>
<td>Fish</td>
<td>Sulfur</td>
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<tr>
<td>Magnesium Compounds</td>
<td>Germanium</td>
<td>Tantalum</td>
</tr>
<tr>
<td>Manganese</td>
<td>Gold</td>
<td>Timber</td>
</tr>
<tr>
<td>Mercury</td>
<td>Graphite (Natural)</td>
<td>Titanium Dioxide</td>
</tr>
<tr>
<td>Mica</td>
<td>Gypsum</td>
<td>Titanium Metal</td>
</tr>
<tr>
<td>Pig Iron</td>
<td>Hafnium</td>
<td>Tungsten</td>
</tr>
<tr>
<td>Pumice &amp; Pumicite</td>
<td>Lead</td>
<td>Uranium</td>
</tr>
<tr>
<td>Rare Earths</td>
<td>Lime</td>
<td>Vanadium</td>
</tr>
<tr>
<td>Sand &amp; Gravel (Cons.)</td>
<td>Magnesium Metal</td>
<td>Water</td>
</tr>
<tr>
<td>Selenium</td>
<td>Molybdenum</td>
<td>Wheat</td>
</tr>
<tr>
<td>Silicon</td>
<td>Natural Gas</td>
<td>Zirconium Mineral Conc.</td>
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<tr>
<td>Soda Ash</td>
<td>Nickel</td>
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<tr>
<td>Sodium Sulfate</td>
<td>Steel</td>
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<tr>
<td>Steel</td>
<td>Strontium</td>
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<tr>
<td>Strontium</td>
<td>Talc &amp; Pyrophyllite</td>
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<tr>
<td>Thallium</td>
<td>Thorium</td>
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<tr>
<td>Thorium</td>
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<tr>
<td>Tin</td>
<td>Vermiculite</td>
<td></td>
</tr>
<tr>
<td>Vermiculite</td>
<td>Zinc</td>
<td></td>
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</tbody>
</table>

\[ \Delta = \text{change per year 1970 – 2010} \]