Making Nature Useless

Relative Dematerialization & Absolute Peaks

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Resources For the Future
Washington DC
November 5, 2014

Report on work done with Jesse Ausubel, Alan Curry and Paul Waggoner

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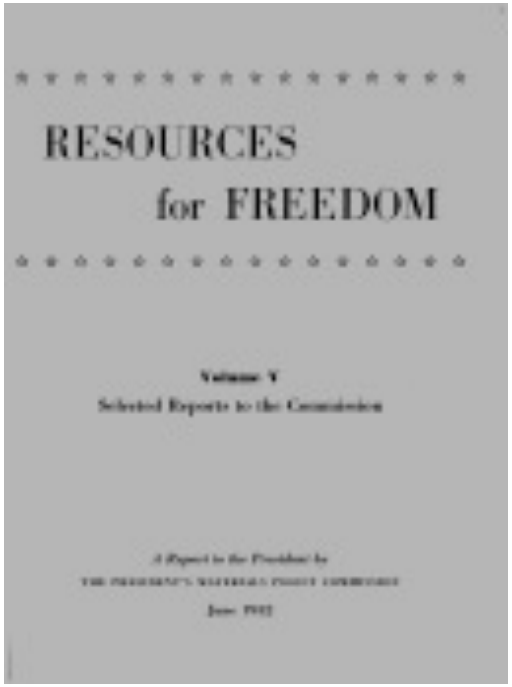
Can improving efficiency and changing consumer preferences overwhelm rising population and affluence to reduce the tons of material that Americans use? The World?

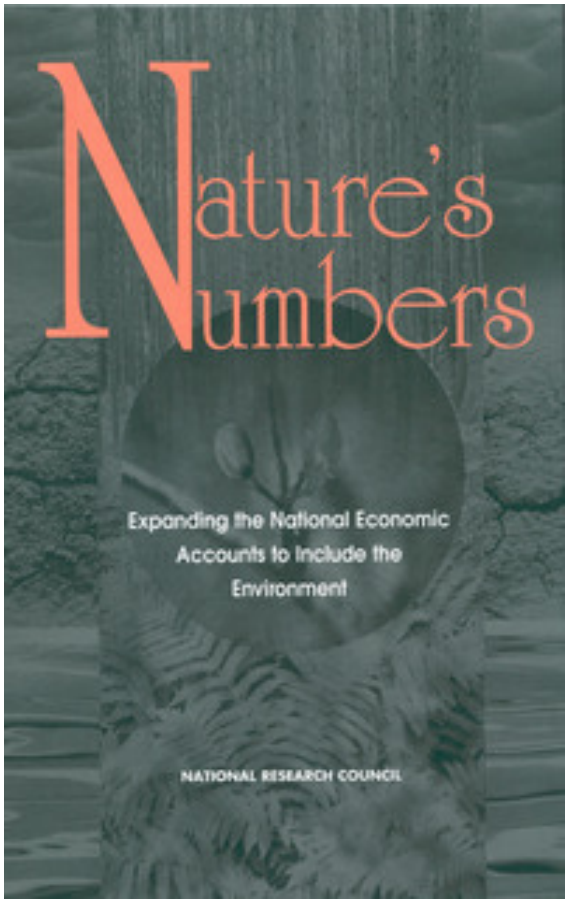
Resource Concerns

1. National Security
2. Commerce
3. Environmental Quality



1952

1972



1999

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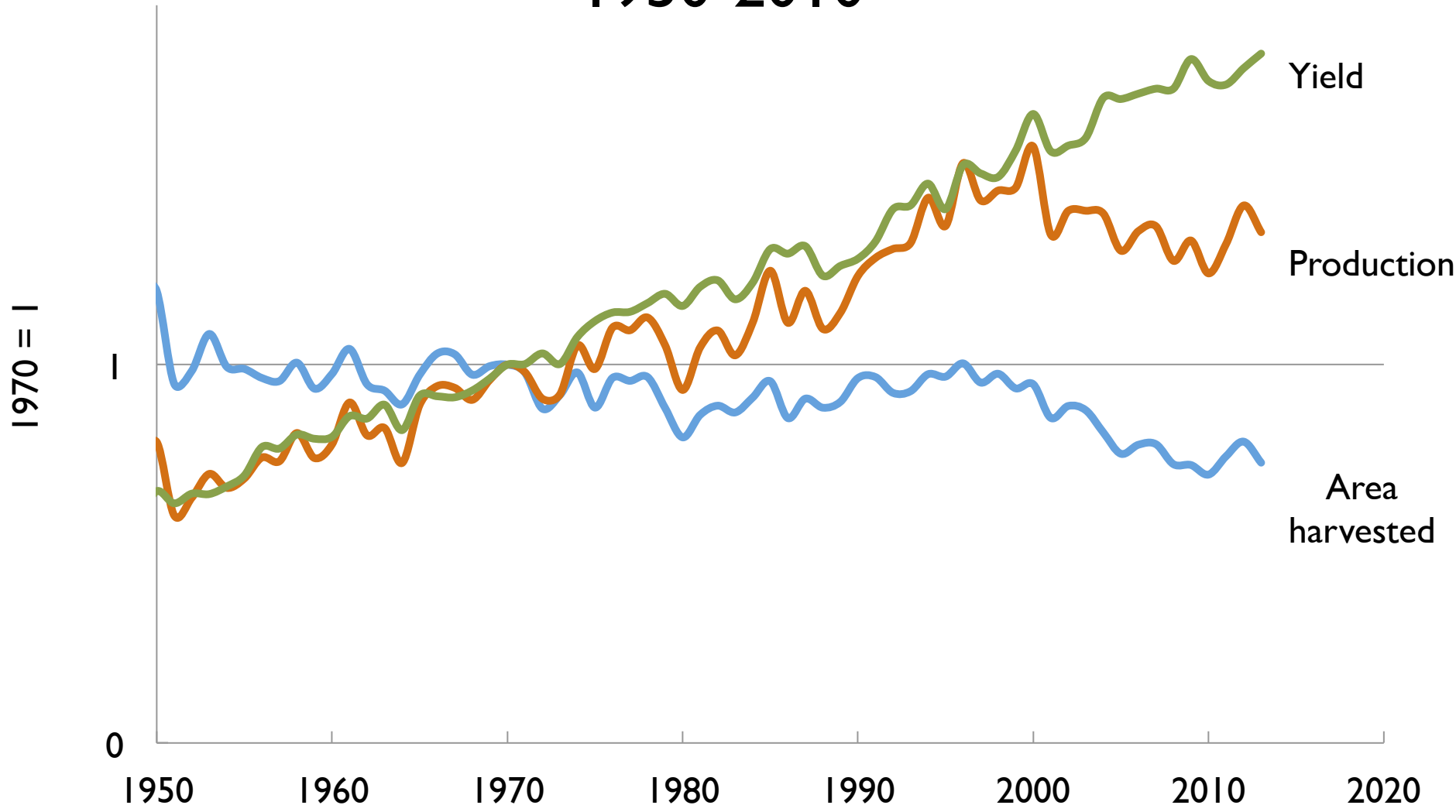
Resource Efficiency

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



Data source: USDA 2013

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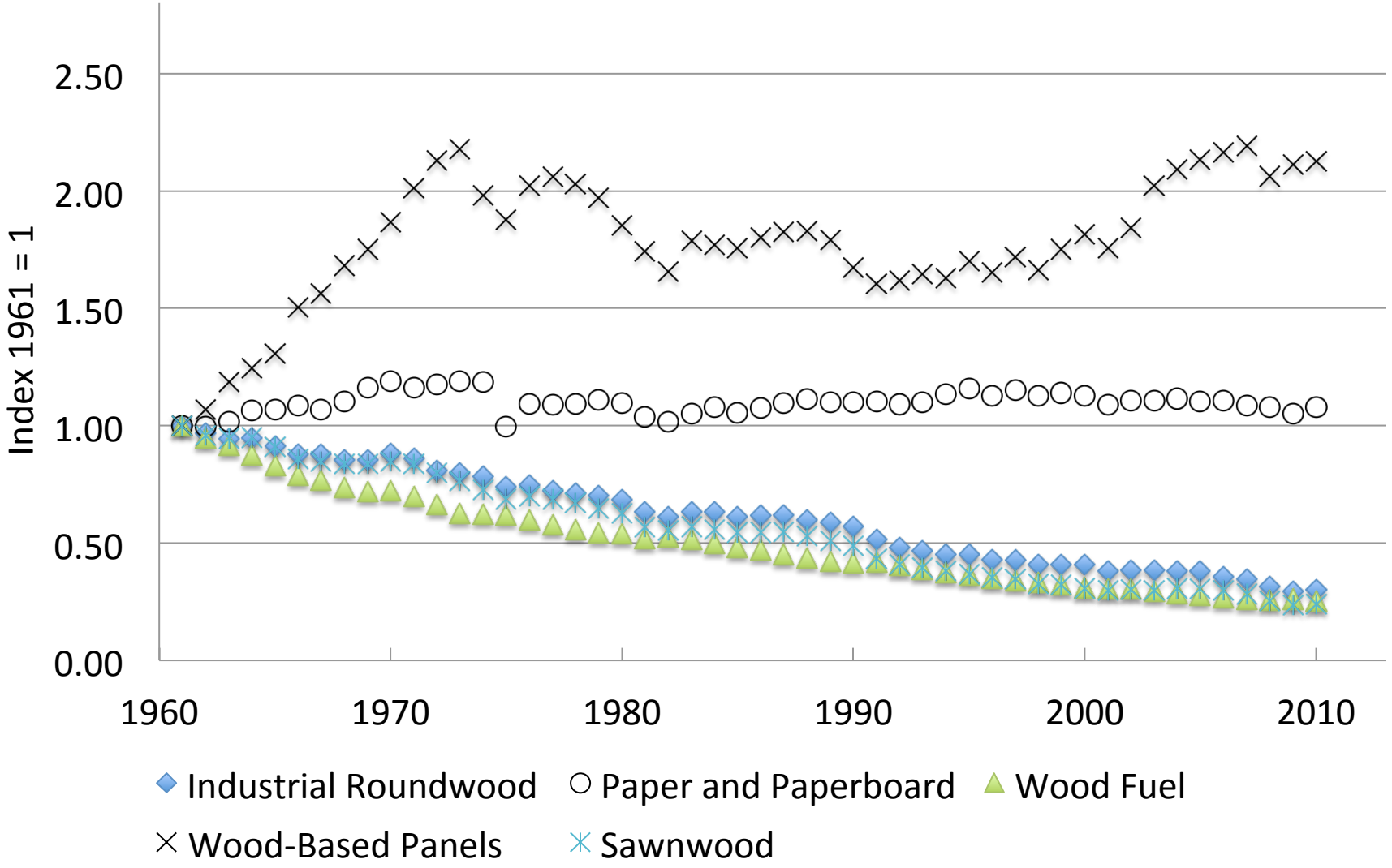
Global Forest Products Intensity of Use

(Cubic Meters/$ GDP)



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"

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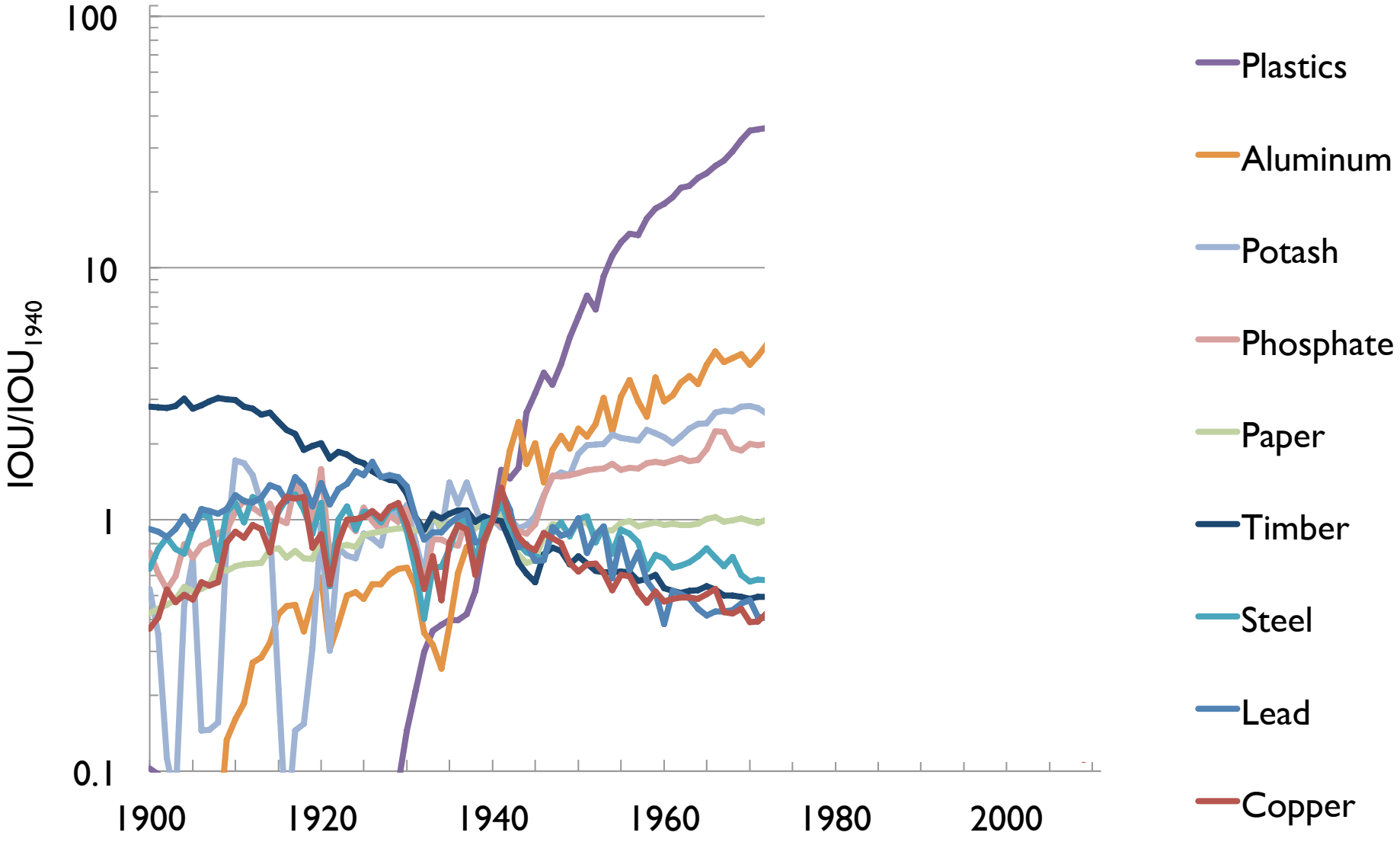
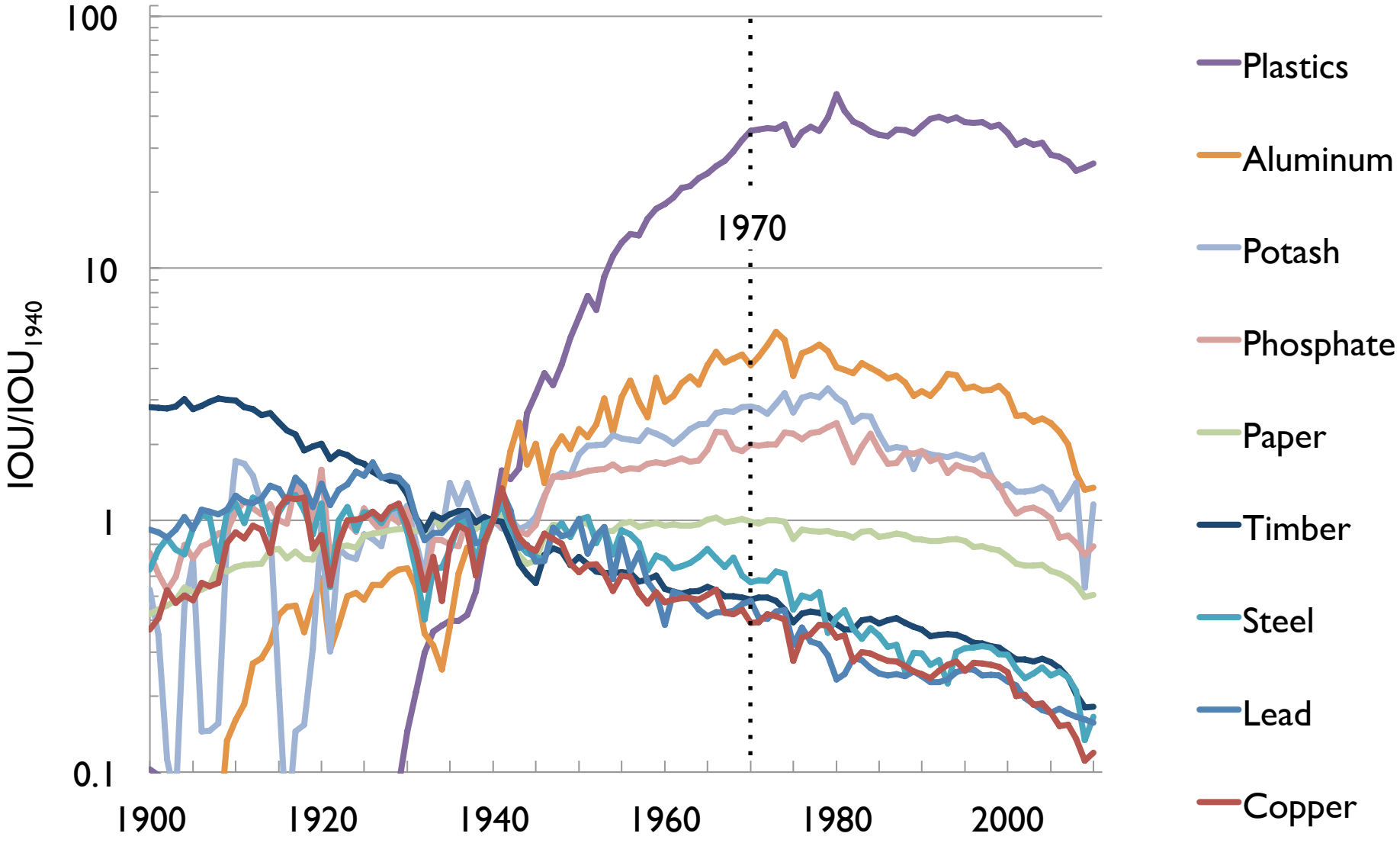
IOU of 9 basic commodities: US 1900-1970



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]

Wernick & Ausubel 2014

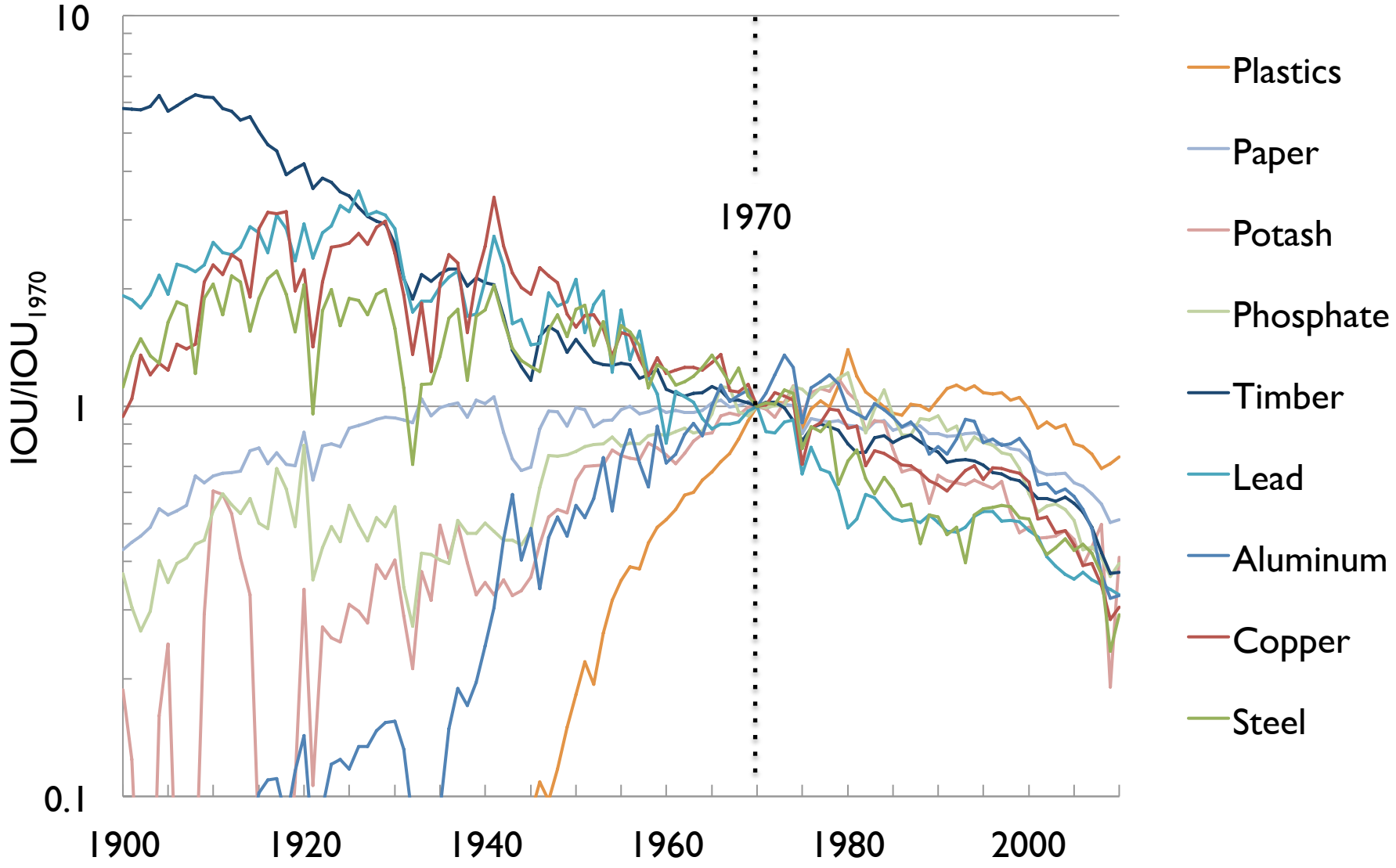
IOU of 9 basic commodities: US 1900-2010



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]

Wernick & Ausubel 2014

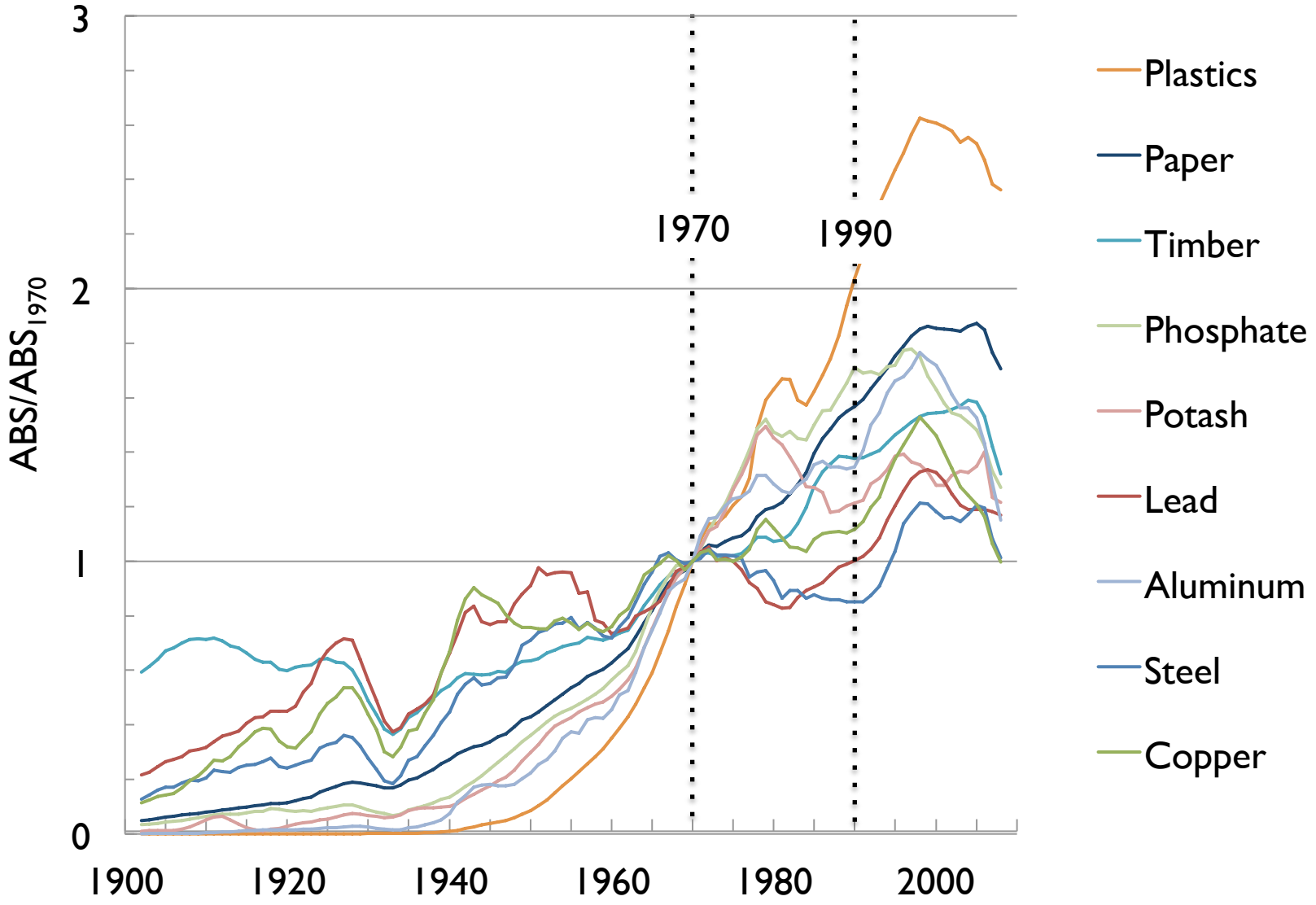
IOU of 9 basic commodities: US 1900-2010



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]

Wernick & Ausubel 2014

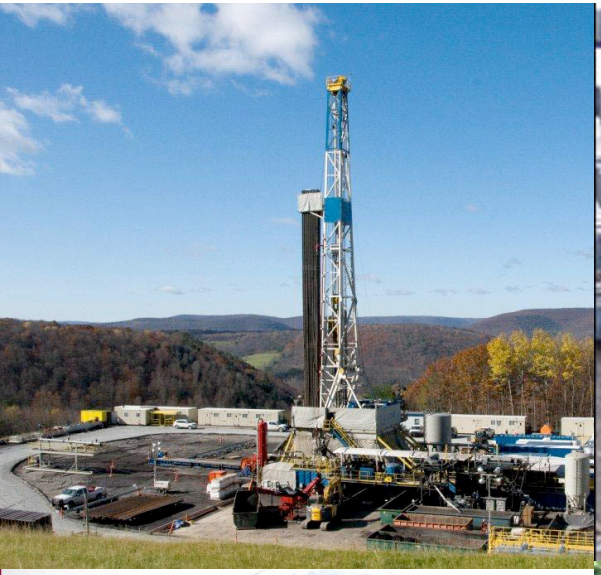
ABS of 9 basic commodities: US 1900-2010



Data sources: USGS National Minerals Information Center 2013.
[Notes: Uses 5 yr. moving average; Legend is ordered top down by value in 2010]

Wernick & Ausubel 2014

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 ↑

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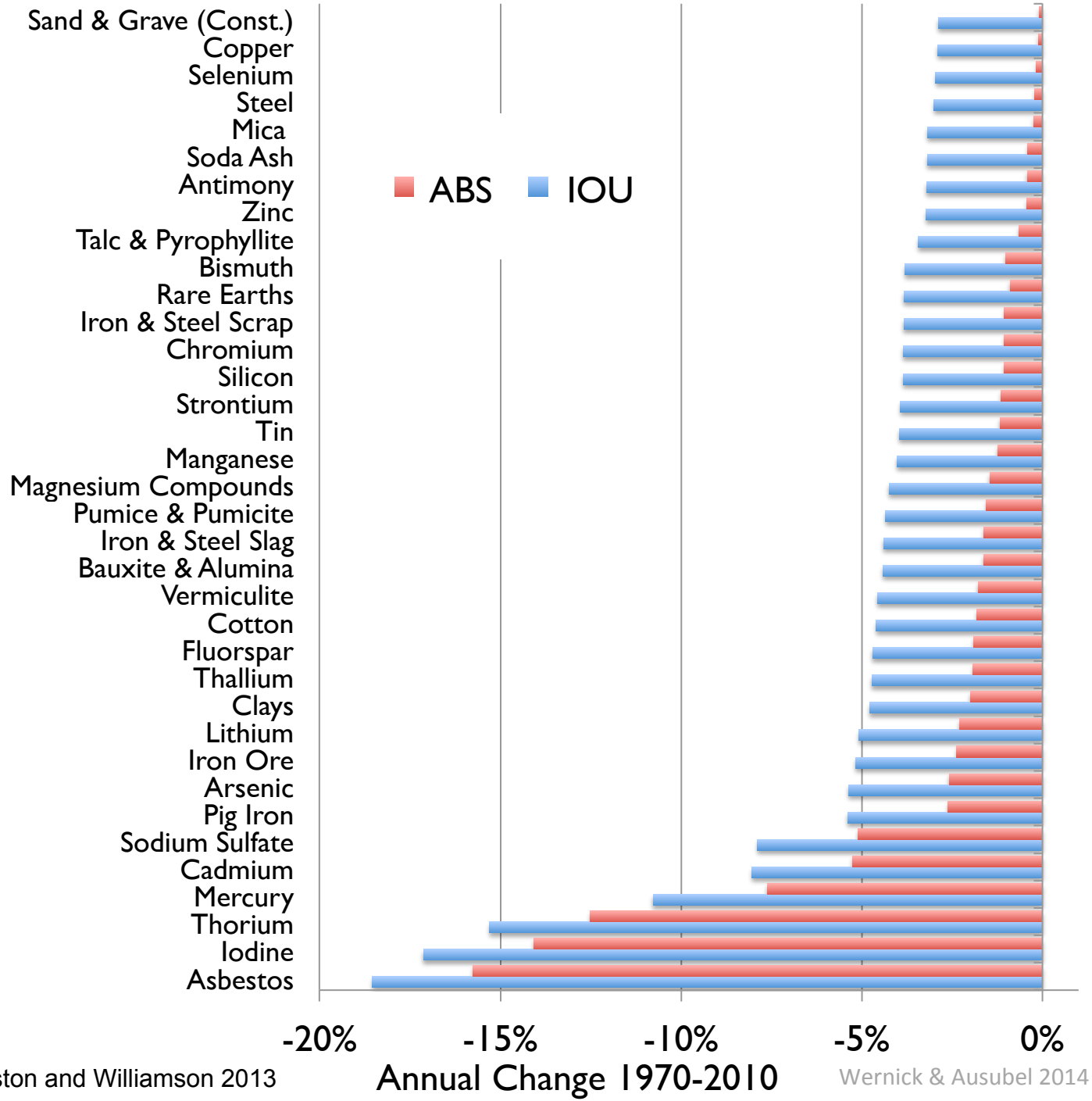
Group 1 (36/100)

$\triangle$ IOU < 0

&

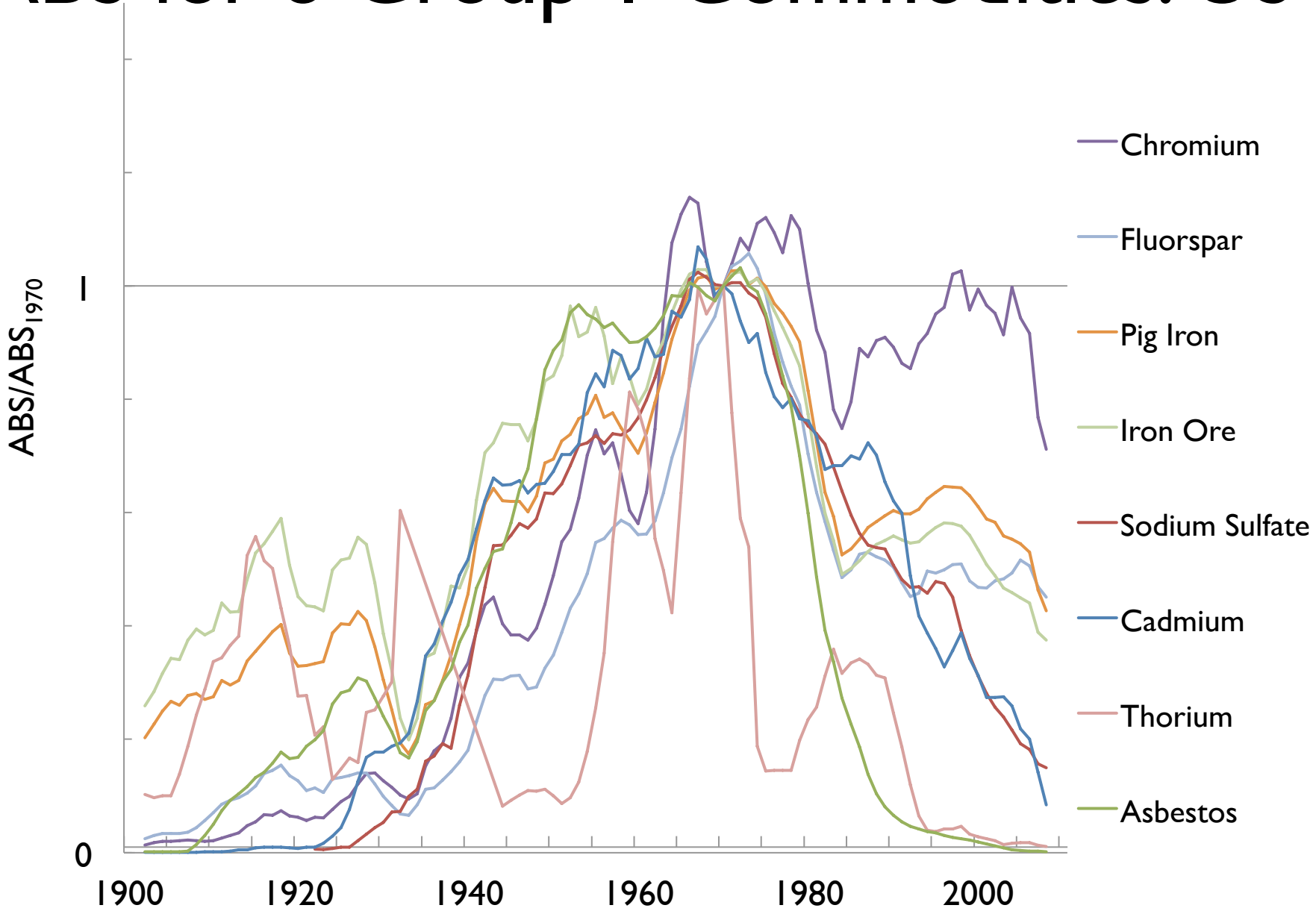
$\triangle$ ABS < 0



Data source: USGS 2013, Johnston and Williamson 2013

Wernick & Ausubel 2014

ABS for 8 Group 1 Commodities: US



Data sources: USGS National Minerals Information Center 2013.
[Notes: Uses 5 yr. moving average; Legend is ordered top down by value in 2010]

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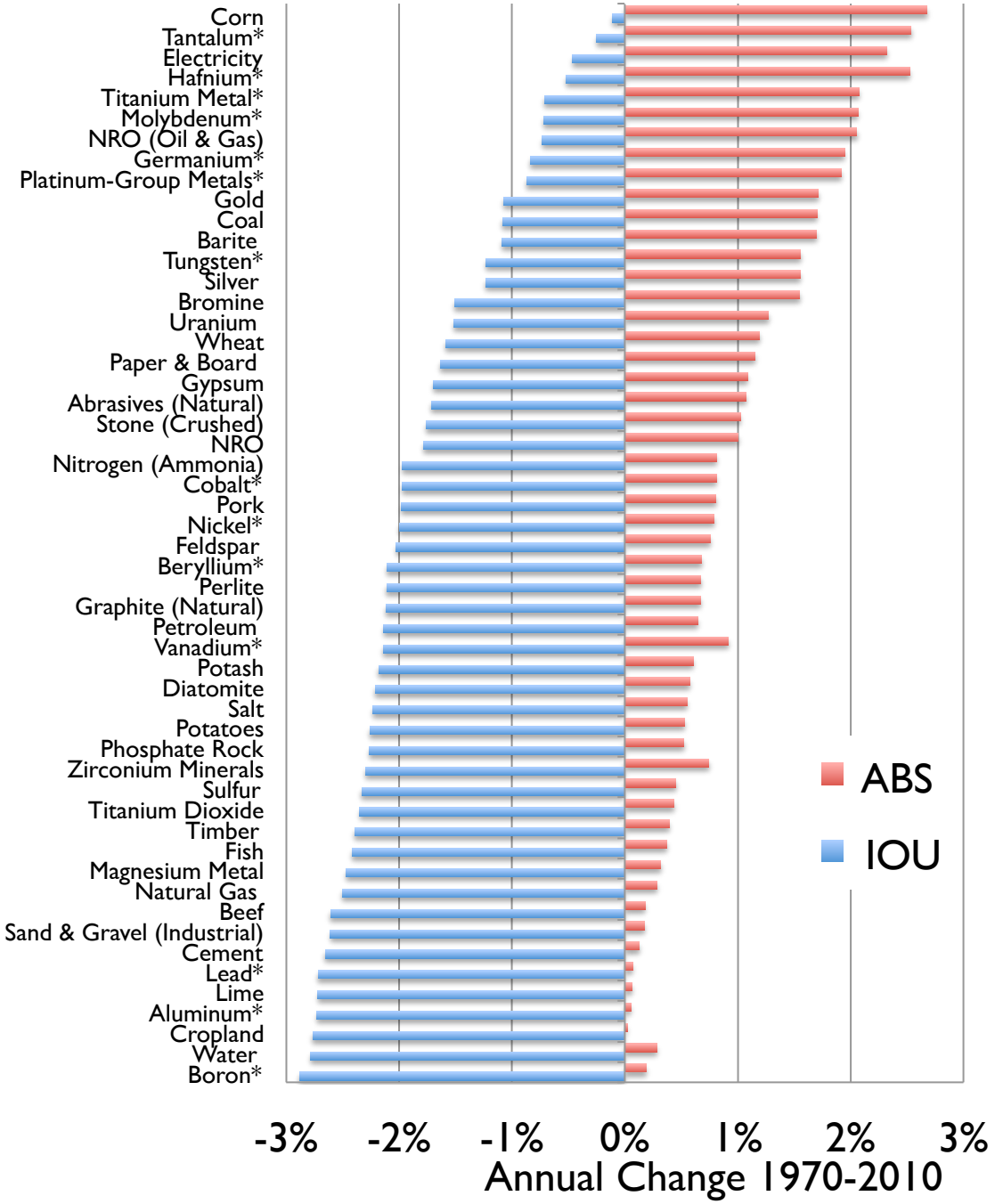
Group 2 (53/100)

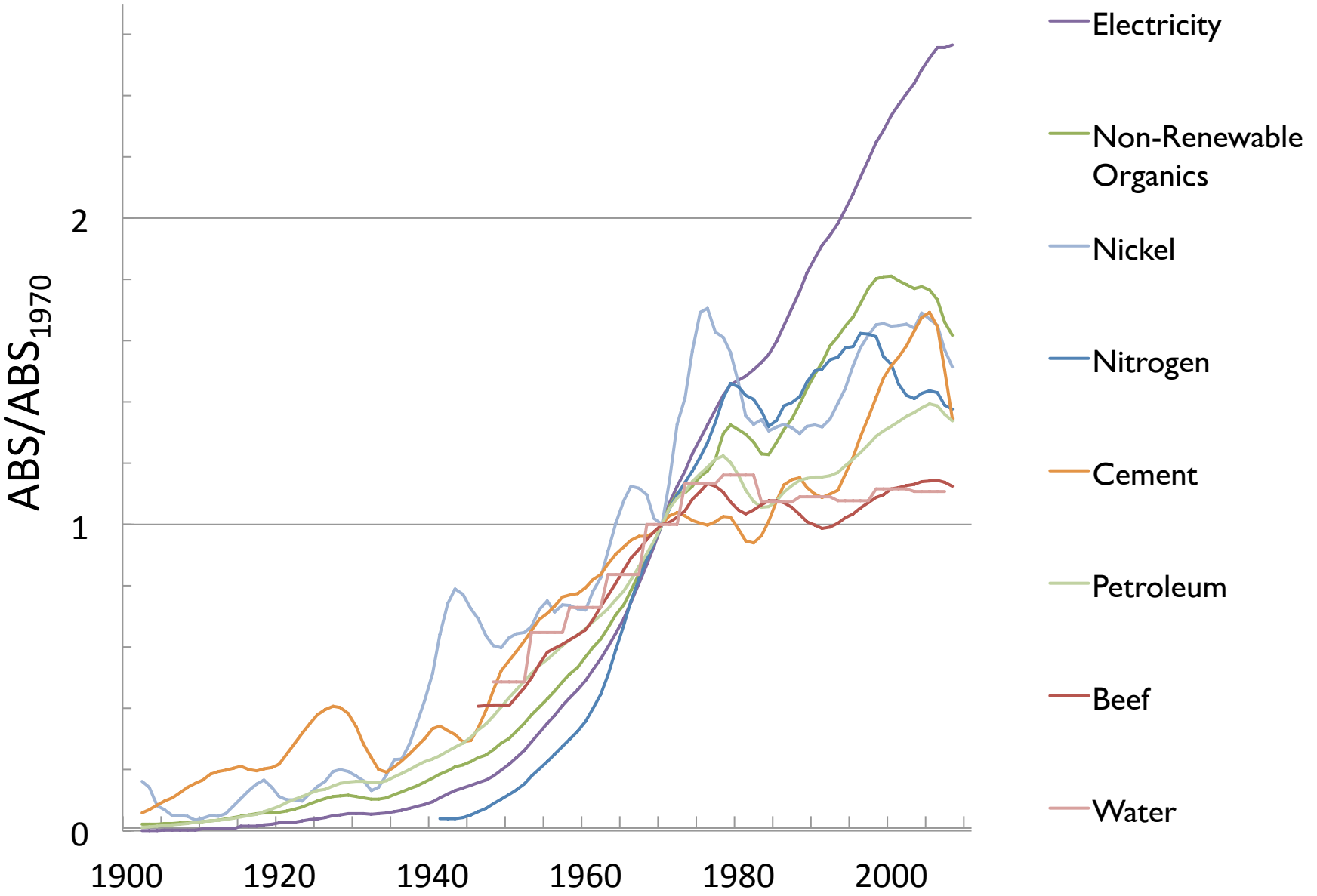
$\triangle$ IOU < 0 &
$\triangle$ ABS > 0



Data sources: USGS National Minerals Information Center, 2013; Johnston and Williamson, 2013.

Wernick & Ausubel 2014

ABS for 8 Group 2 Commodities: US



Data sources: USGS National Minerals Information Center 2013.
[Notes: Uses 5 yr. moving average; Legend is ordered top down by value in 2010]

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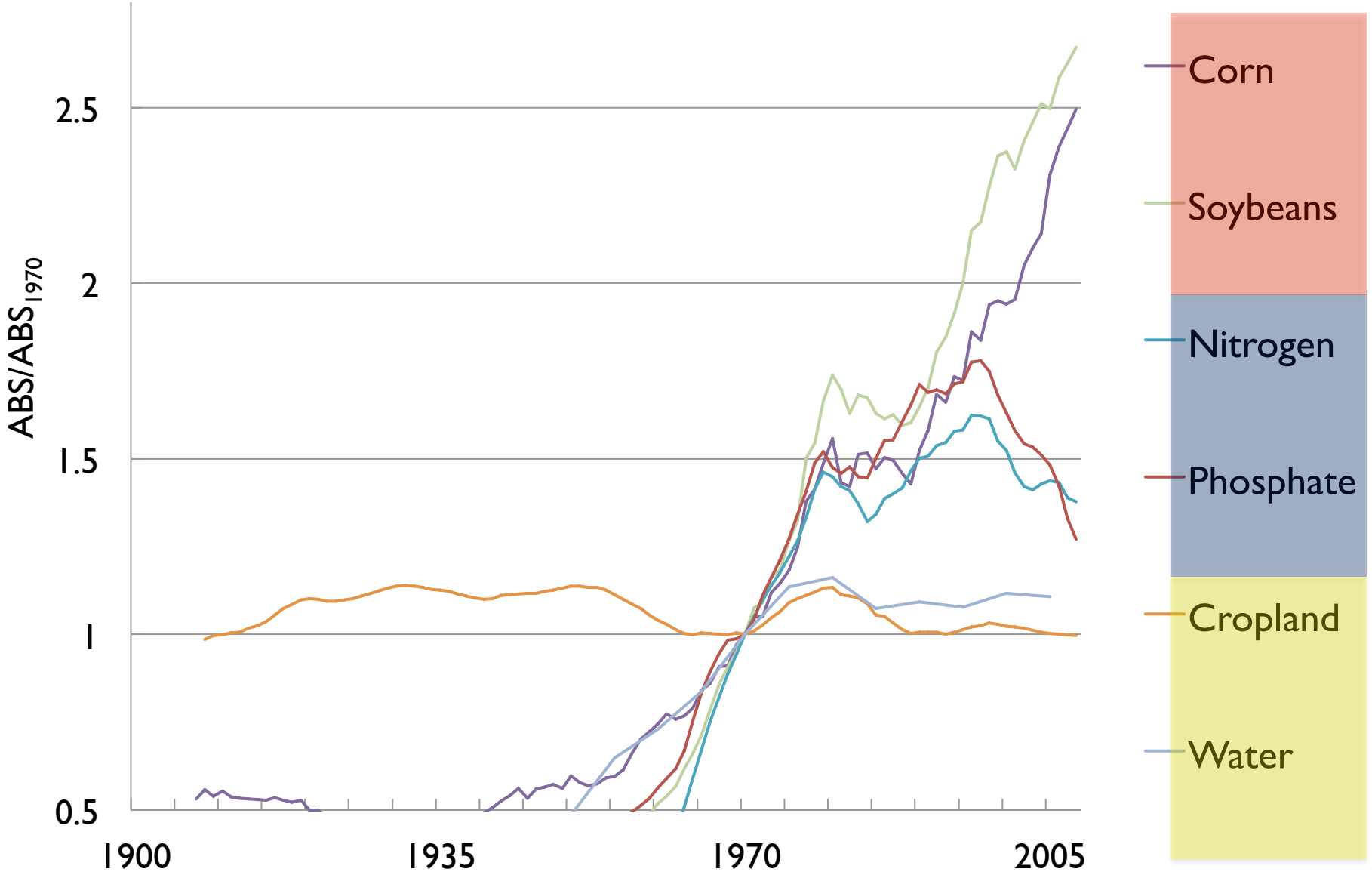
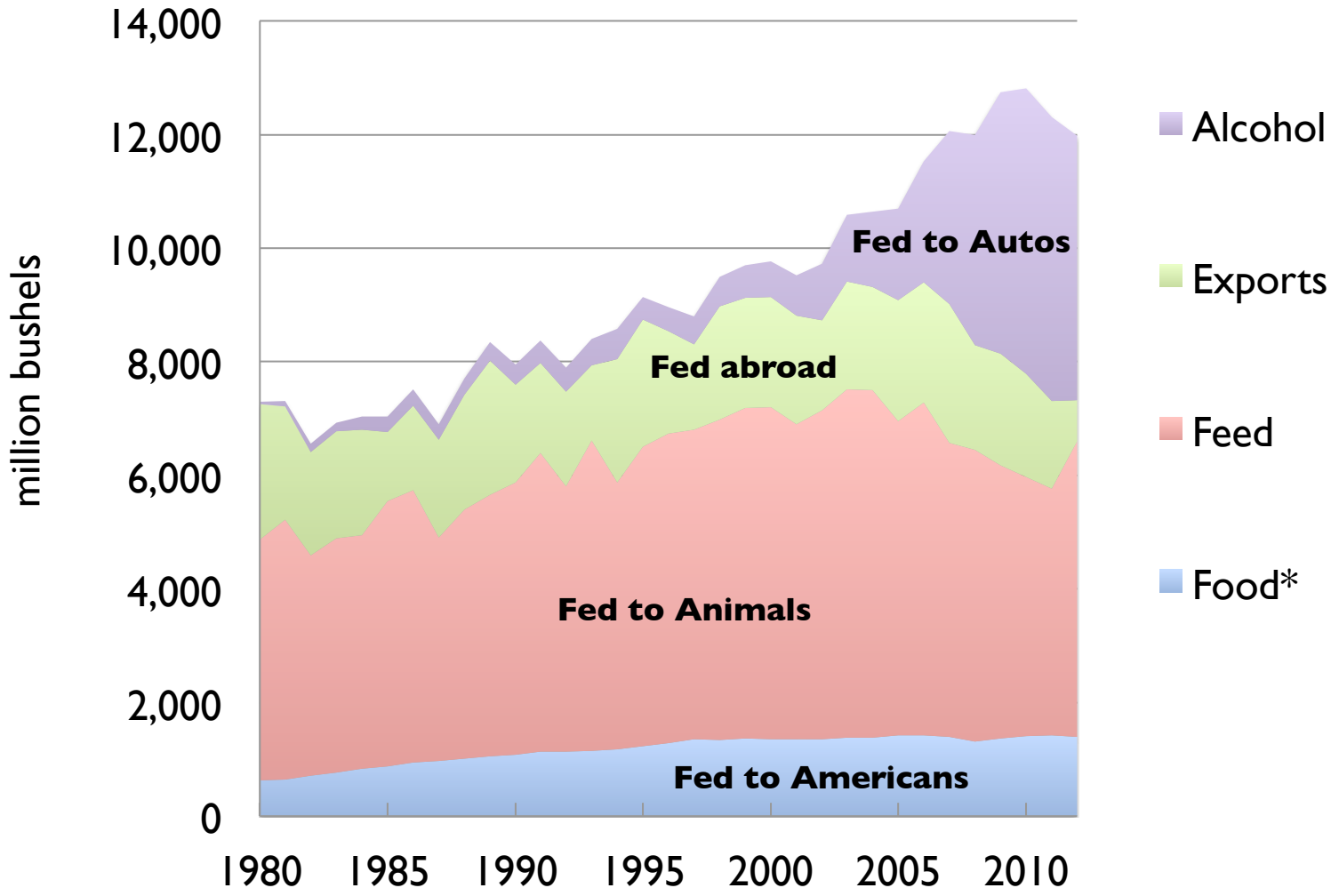
Group 2 Agricultural Inputs & Outputs



Data sources: USGS National Minerals Information Center 2013.
[Notes: Uses 5 yr. moving average; Legend is ordered top down by value in 2010]

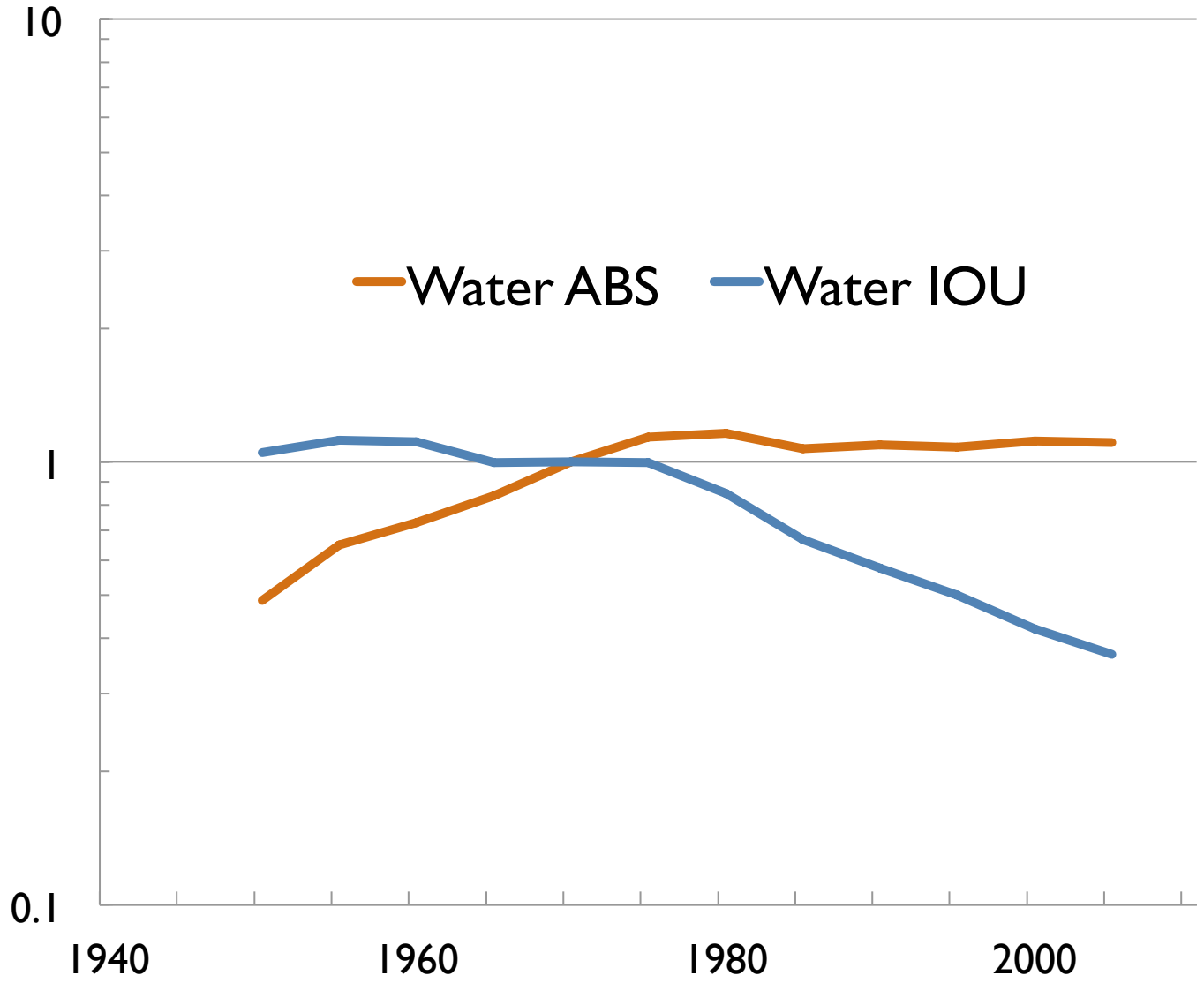
US uses of corn



** 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

US water withdrawals: Flat since ~1975



Data source: USGS 2009, Johnston and Williamson, 2013

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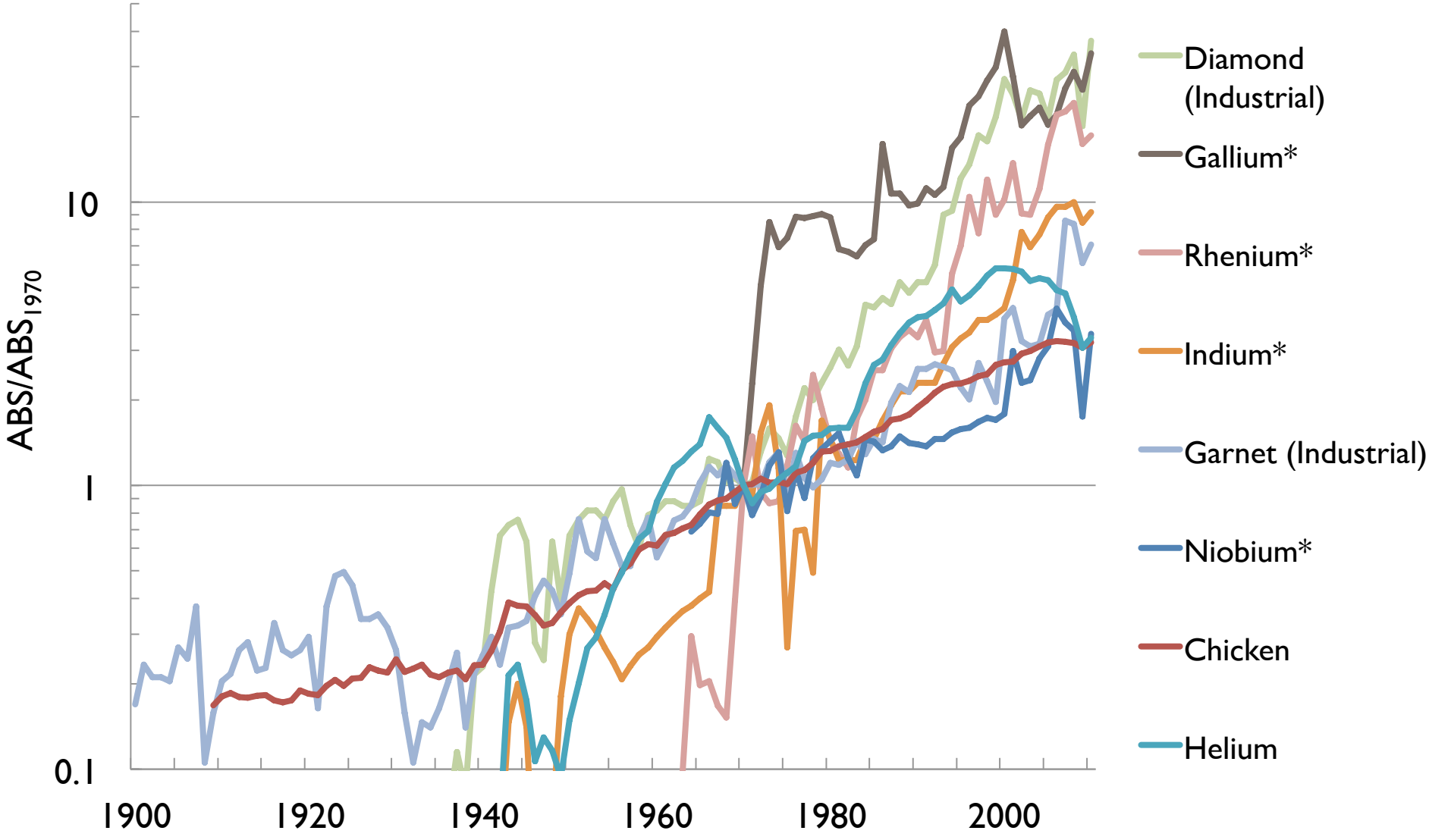
ABS for 8 Group 3 Commodities: US



Data sources: USGS National Minerals Information Center 2013.
[Notes: Uses 5 yr. moving average; Legend is ordered top down by value in 2010]

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Commodities Asia

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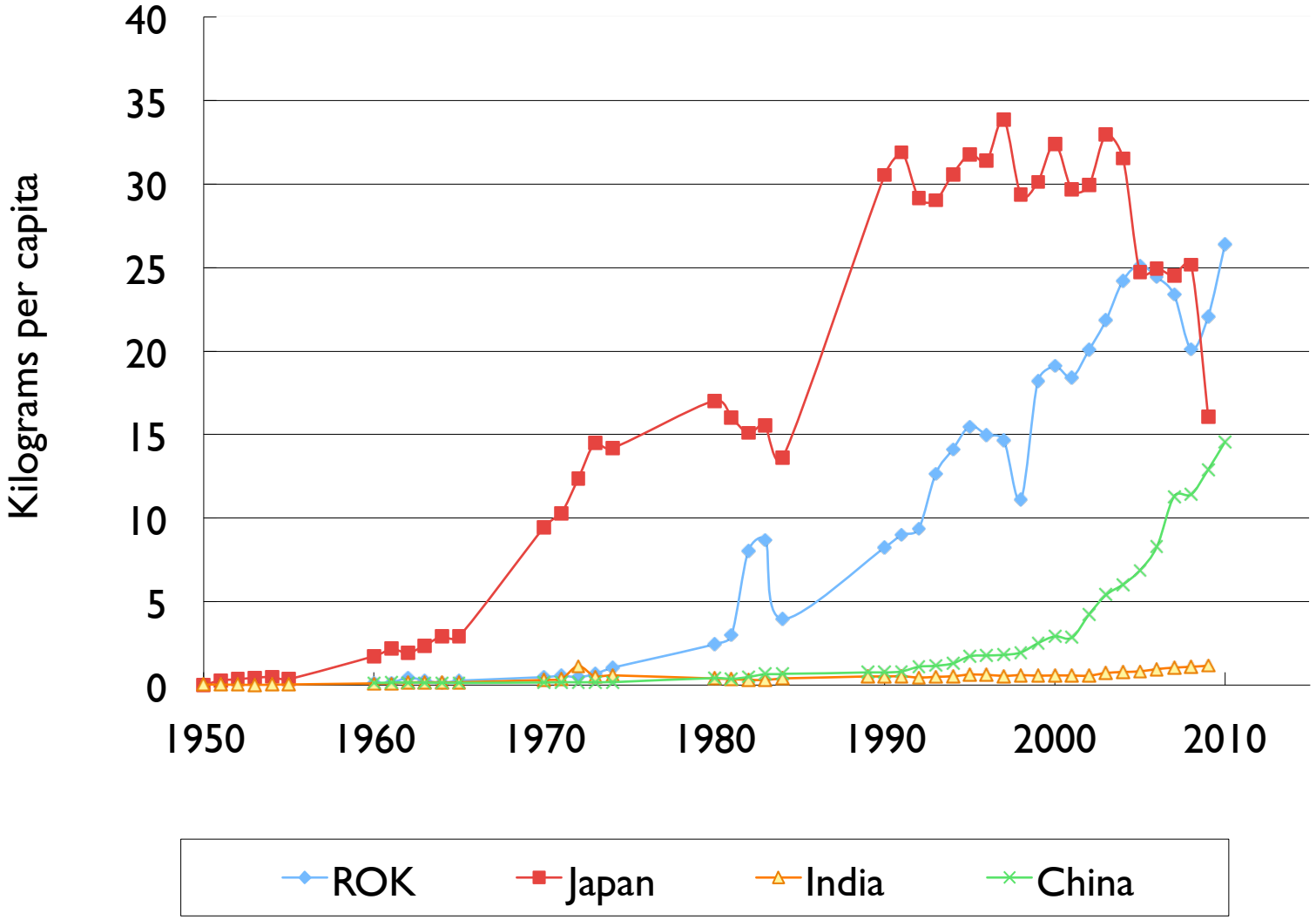
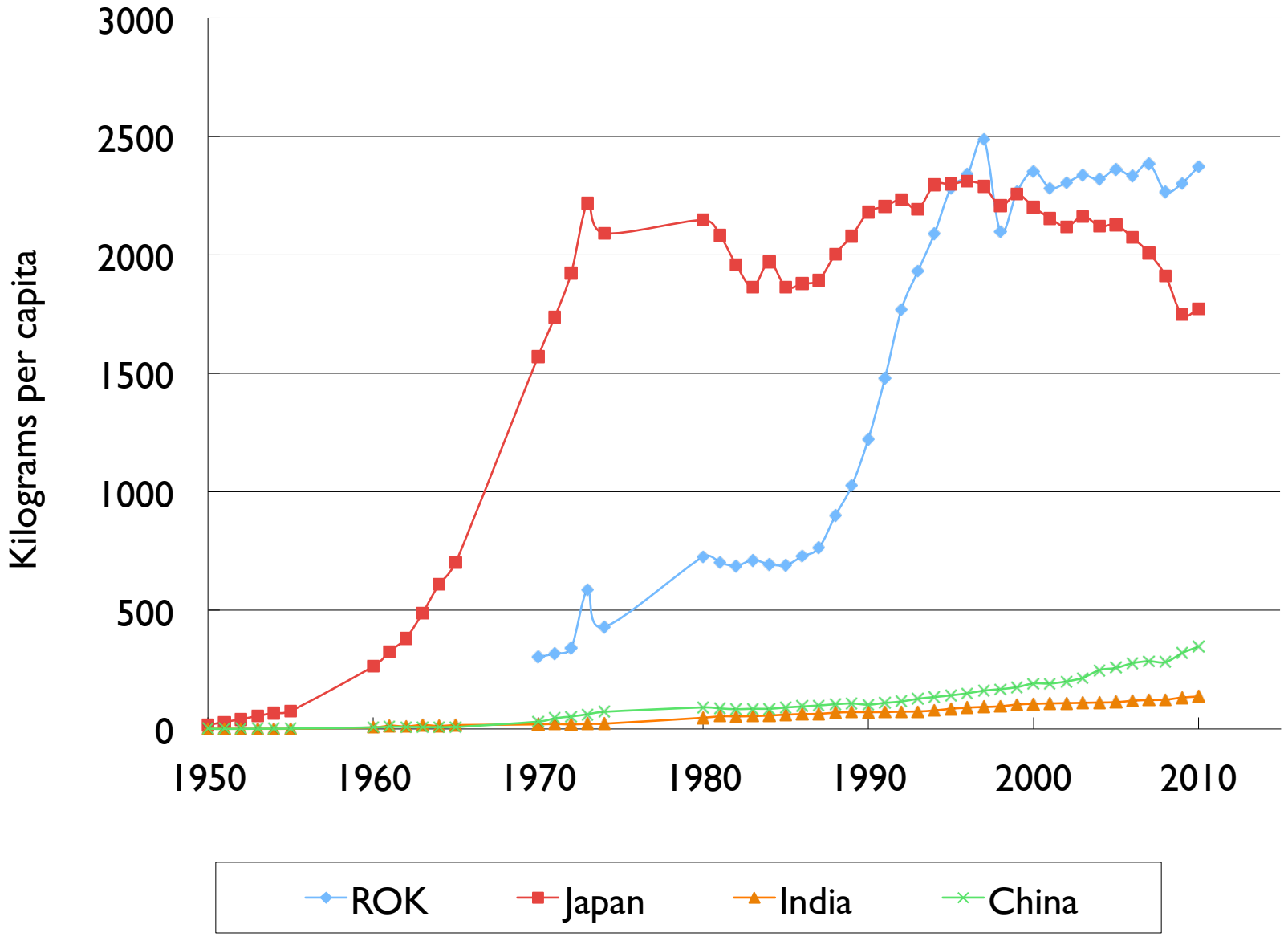
Aluminum use in 4 Asian nations



Data sources: USGS 2014, British Geological Survey

Wernick & Ausubel 2014

Petroleum use in 4 Asian nations



Data sources: USGS 2014, British Geological Survey

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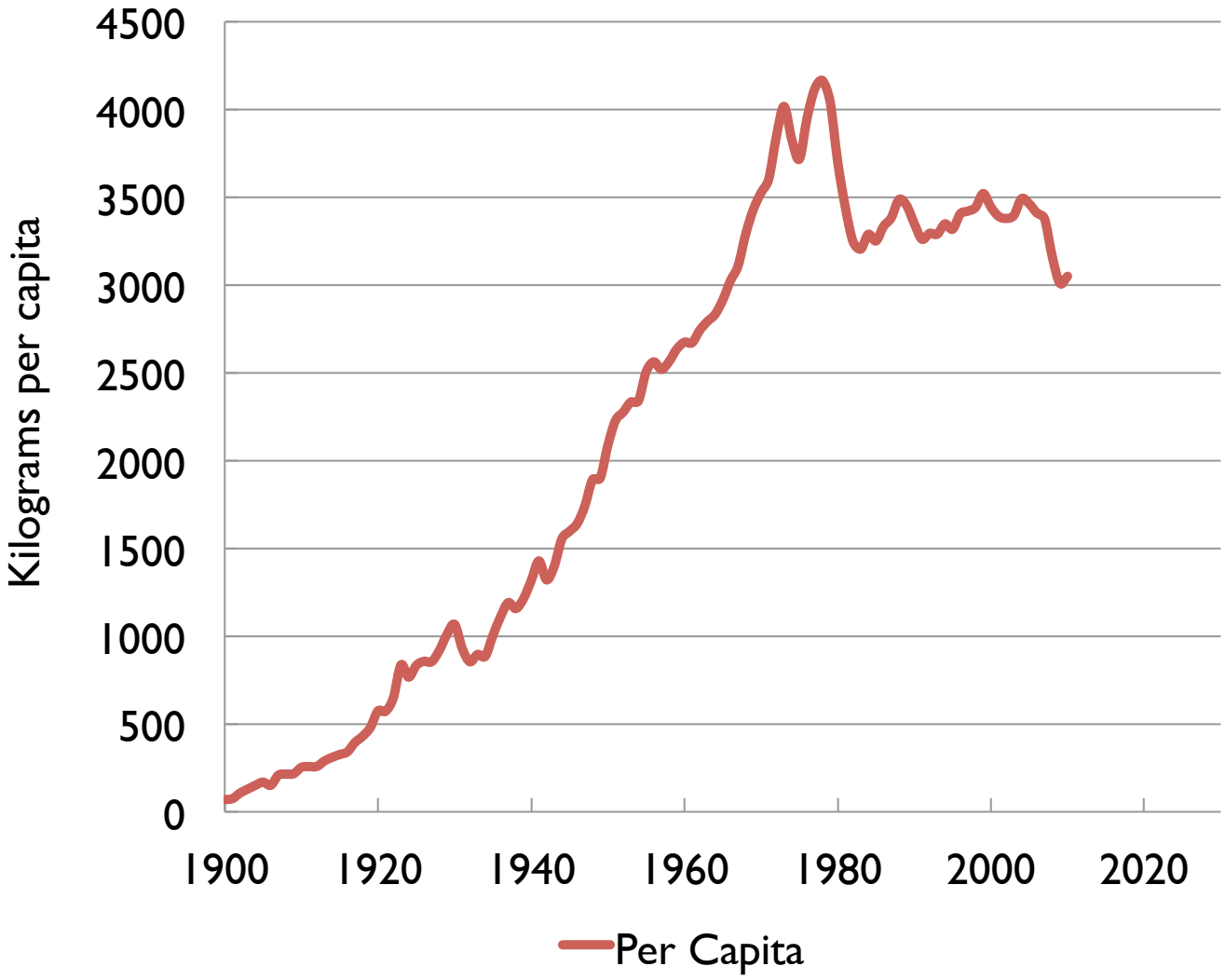
Petroleum - USA



Data sources: USDOE Energy Information Administration 2013

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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

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The Rockefeller University

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Data Sources

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- Wernick, I.K., Herman, R., Govind, S. and Ausubel J.H. 1997. Materialization and dmaterialization: Measures and trends. Pp. 135-156 in Technological Trajectories and the Human Environment, National Academy Press, Ausubel, J.H. and Langford H.D., eds. http://phe.rockefeller.edu/Daedalus/Demat/
- World Bank (2014) World Bank data. Available at http://data.worldbank.org. Accessed January, 2014.

Note: "Plastics" data in slides 7 - 10correspond 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.

Group 1 (36/100)	Group 2 (53/100)		Group 3 (11/100)
ΔIOU < 0 and ΔABS < 0	ΔIOU < 0 and ΔABS > 0		ΔIOU > 0 and ΔABS > 0
Antimony	Abrasives (Natural)	Nitrogen (Ammonia)	Chicken
Arsenic	Aluminum	Non-Renewable Organics (NRO)	Diamond (Industrial)
Asbestos	Barite	NRO (Oil & Gas)	Gallium
Bauxite & Alumina	Beef	Paper & Board	Garnet (Industrial)
Bismuth	Beryllium	Perlite	Gemstones
Cadmium	Boron	Petroleum	Helium
Chromium	Bromine	Phosphate Rock	Indium
Clays	Cement	Platinum-Group Metals*	Niobium
Copper	Coal	Pork	Quartz Crystal (Industrial)
Cotton	Cobalt	Potash	Rhenium
Fluorspar	Corn	Potatoes	Stone (Dimension)
Iodine	Cropland	Salt	
Iron & Steel Scrap	Diatomite	Sand & Gravel (Industrial)	
Iron & Steel Slag	Electricity	Silver	
Iron Ore	Feldspar	Stone (Crushed)	
Lithium	Fish	Sulfur	
Magnesium Compounds	Germanium	Tantalum	
Manganese	Gold	Timber	
Mercury	Graphite (Natural)	Titanium Dioxide	
Mica	Gypsum	Titanium Metal	
Pig Iron	Hafnium	Tungsten	
Pumice & Pumicite	Lead	Uranium	
Rare Earths	Lime	Vanadium	
Sand & Gravel (Cons.)	Magnesium Metal	Water	
Selenium	Molybdenum	Wheat	
Silicon	Natural Gas	Zirconium Mineral Conc.	
Soda Ash	Nickel		
Sodium Sulfate			
Steel			
Strontium			
Talc & Pyrophyllite			
Thallium			
Thorium			
Tin			
Vermiculite			
Zinc			

Δ = change per year 1970 – 2010

Wernick & Ausubel 2014