Global Status of Phosphorus

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Phosphorus a Limited Resource – Closing the Loop
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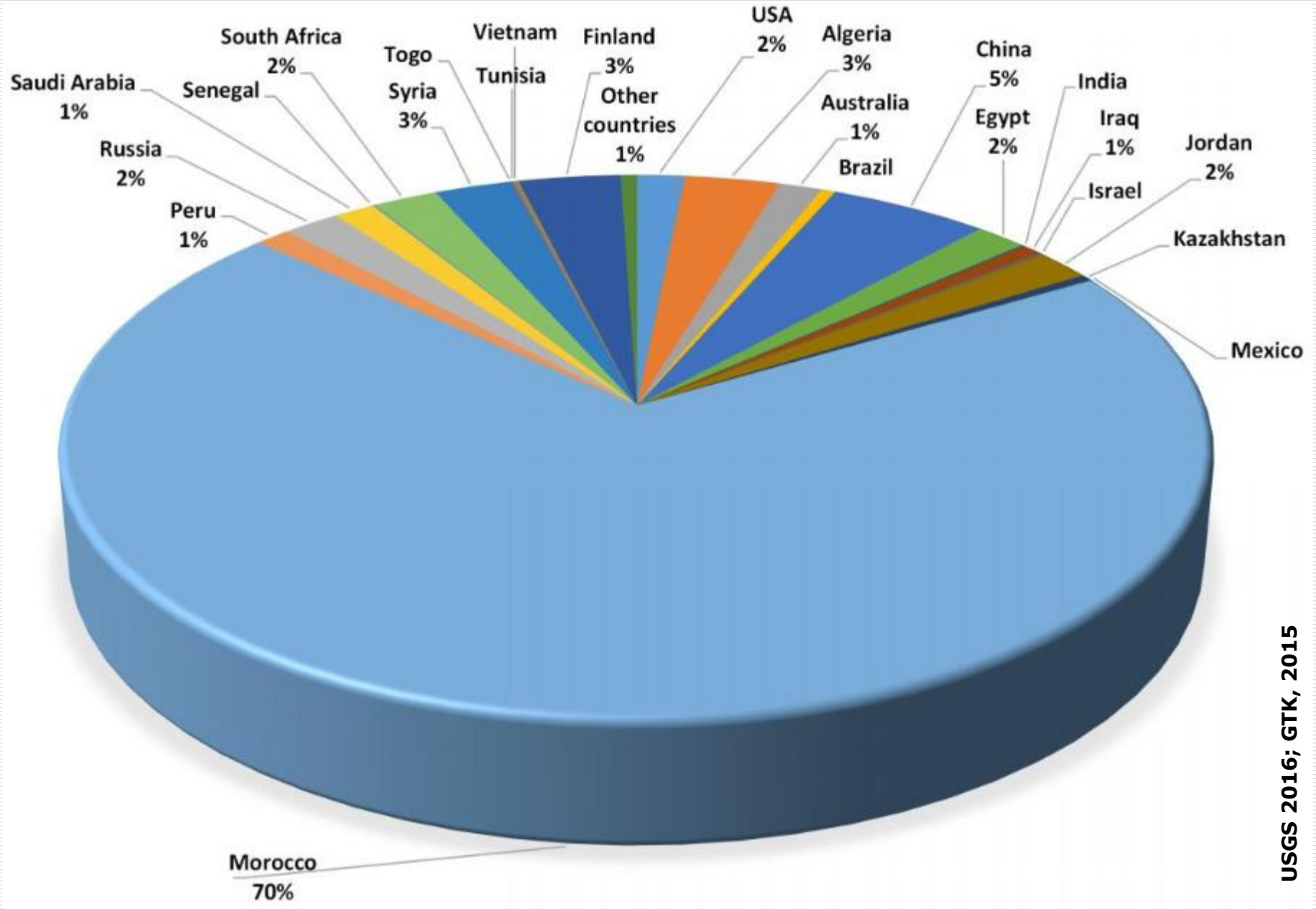
Global distribution of commercial phosphate rock reserves



USGS 2016; GTK, 2015

Commercial Reserves P-Rock 2016

Country	Gigatons of P-rock	% of global
Global	71	100
Morocco	50	70
China	3.7	5
Finland	2.4	3
Algeria	2.2	3
Syria	1.8	3
South Africa	1.5	2
Jordan	1.3	2
Russia	1.3	2
USA	1.1	2
Australia	1	1
Saudi Arabia	0.96	1

USGS 2016; GTK, 2015

94% in 11 countries

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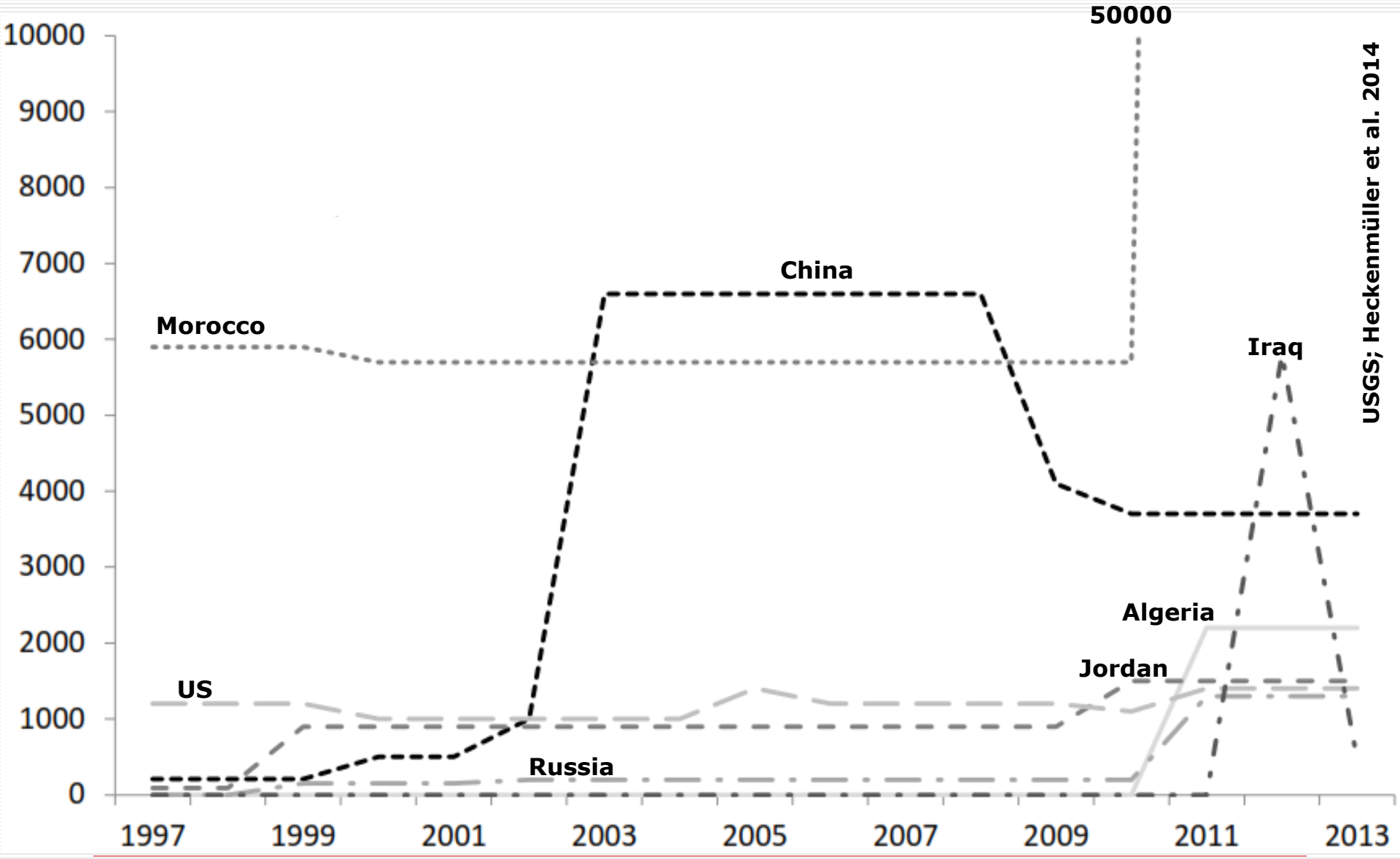
Varying trends in estimates of phosphate rock reserves (megatons)



An indicator that global governance is lacking;
UN Does not monitor P-rock reserves

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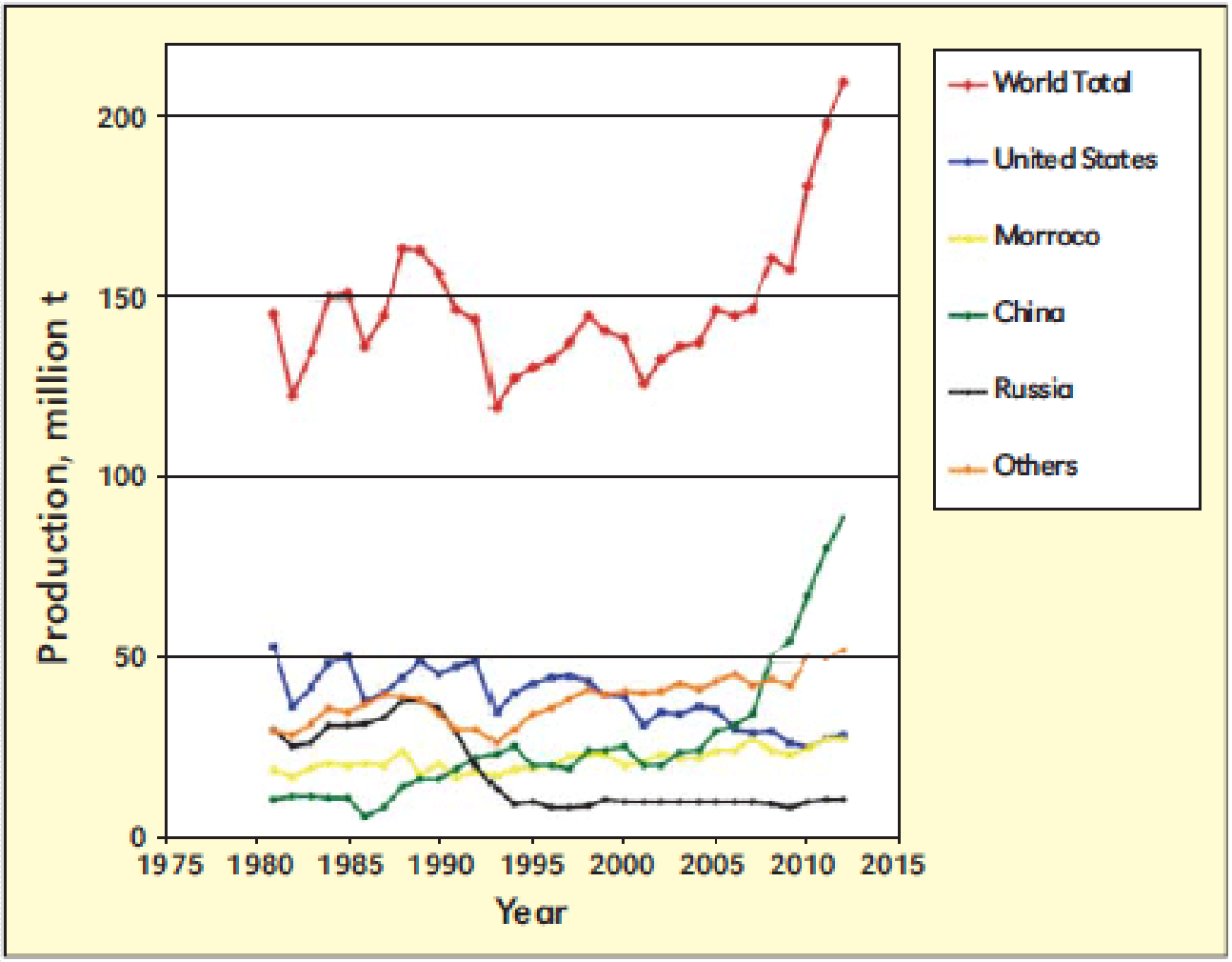
P-rock production (megatons/yr)



USGS

Sharp increase in extraction by China; world level is now 223 megatons
US decreasing, peaked in the 80s

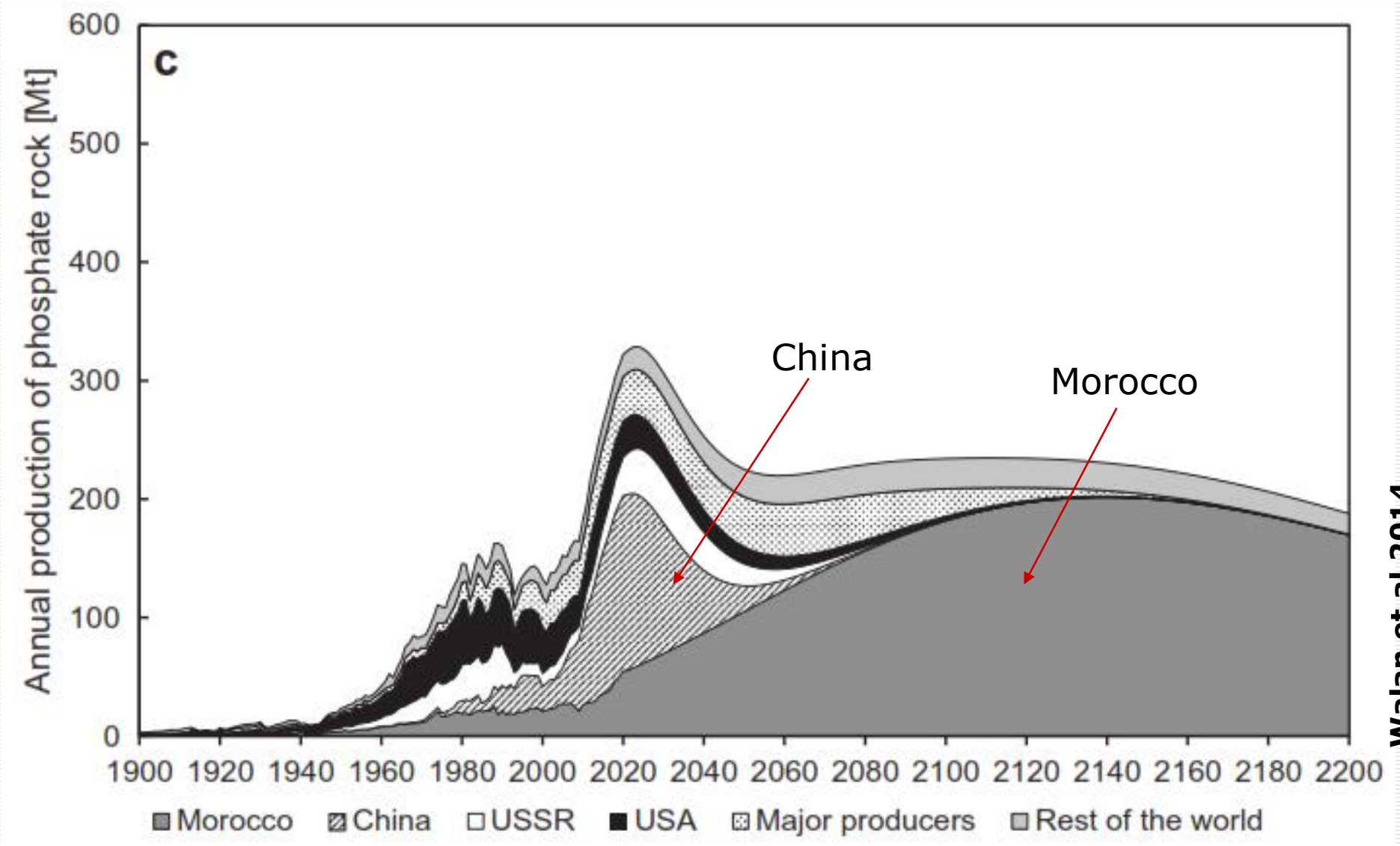
Extraction Rate of P-Rock

Country	Extraction in 2015 (megatons)	% of global capacity	Years to depletion at current rate	Years to depletion at FAO's 2.5% annual growth
Global	223		309	87
Morocco	30 (47 by 2017)	13,5	1667	150
China	100	44,8	37	26
Algeria	1.2	0,5	1833	
Syria	0.75	0,3	2400	
South Africa	2.2	1,0	682	
Jordan	7.5	3,4	173	67
Russia	12.5	5,6	104	51
USA	27.6	12,4	40	27
Australia	2.6	1,2	385	
Saudi Arabia	3.3	1,5	291	
Peru	4	1,8	205	

USGS 2016

These 5 countries represent 80% of the global capacity. In less than 30 years 57% will be gone leaving mainly Morocco alone to take over (ie much higher growth than 2.5% per yr is required)

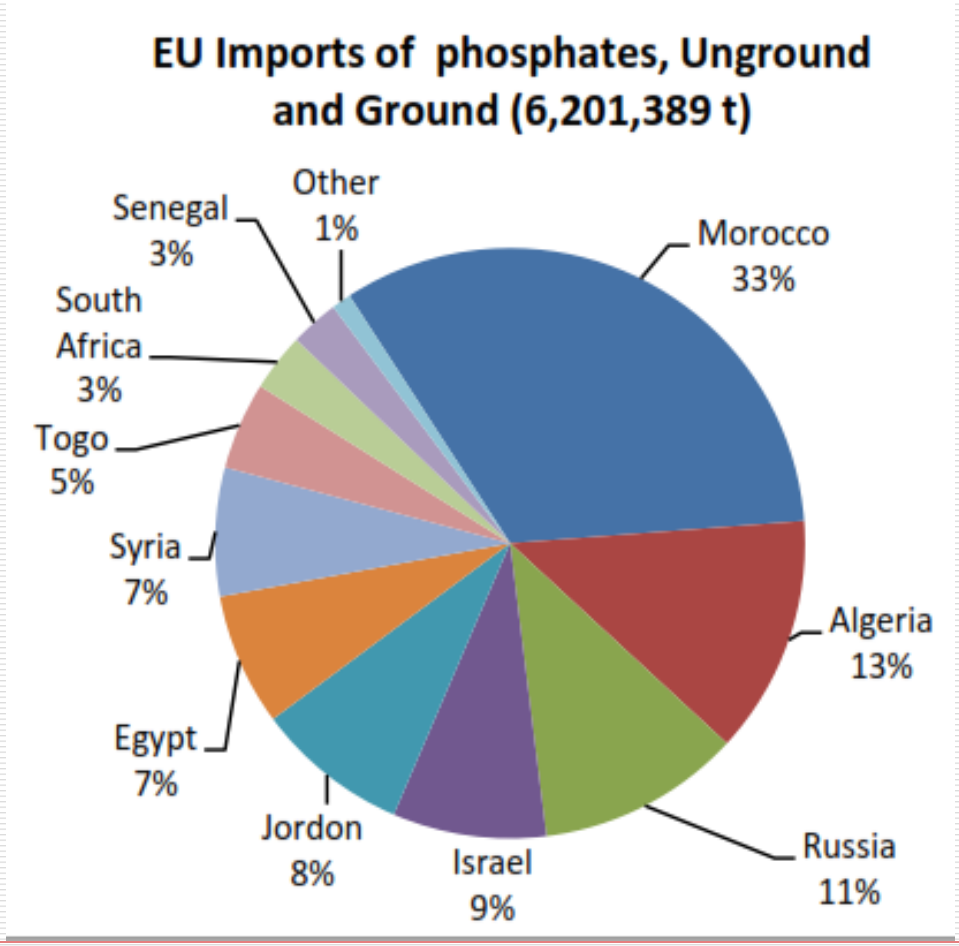
P-rock future trends in production



Walan et al 2014

This prognosis shows a global peak at ca 310 megatons by 2025 draining Chinese and US reserves which would almost disappear in 30 years. To prevent this destabilization the US and other countries are presently building up Morocco's capacity. Global population peaks by 2050 stabilizing levels at ca 220 megatons.

EU imports of phosphates



90% of EU phosphate is imported

75% comes from 5 countries

Finland Europe's only mine (2.4 gtons reserves (4% P_2O_5; 1 megaton per yr extracted); currently being expanded

Source: Eurostat-Comext Database, CN 2510 1000 and CN 2510 2000 [accessed August 2013]

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Phosphate rock since 2014 is on the EU List of Critical Raw Materials

EU DG Enterprise 2014

A signal that supply can be disrupted, recycling is necessary and there are no subsitutes

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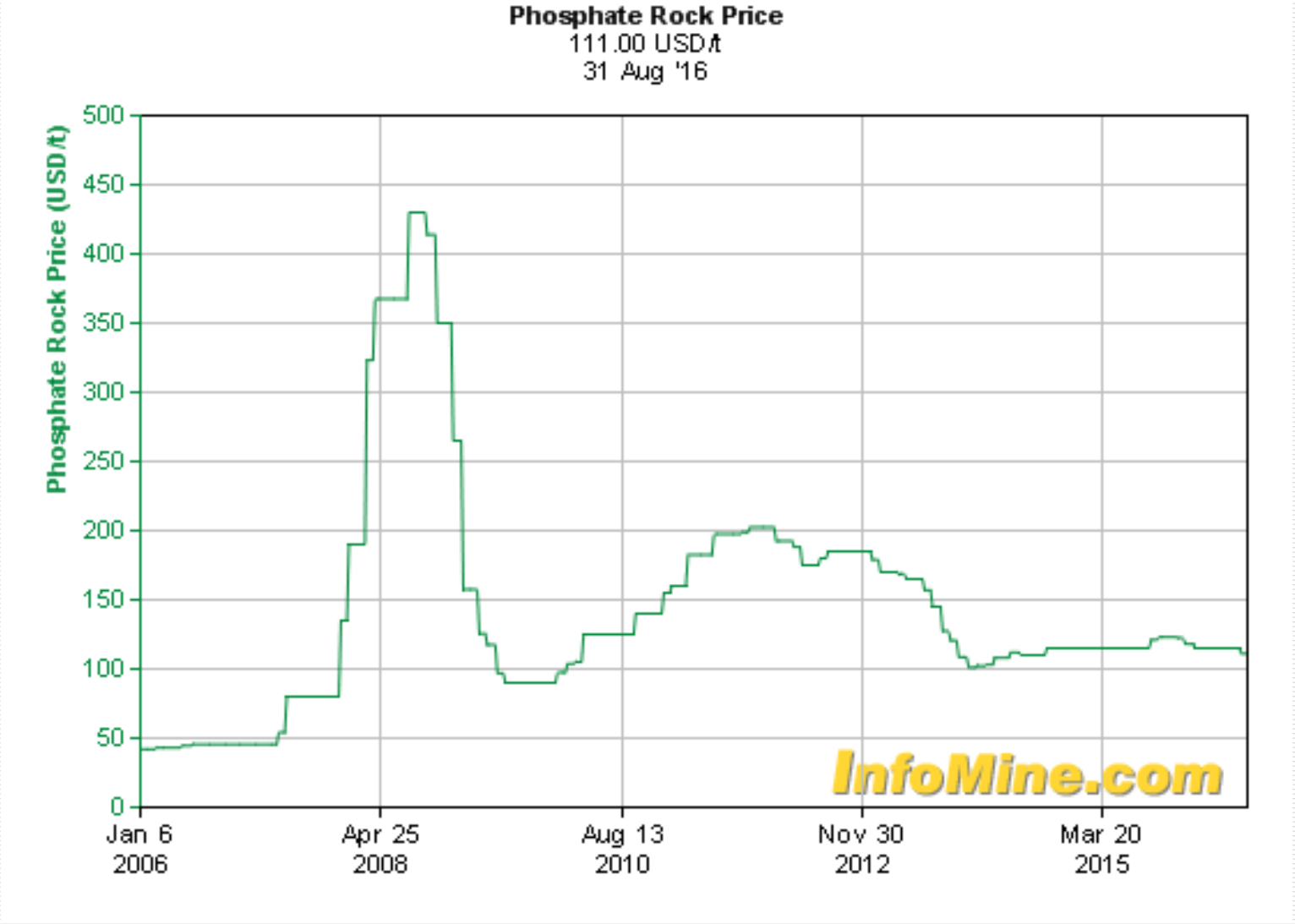
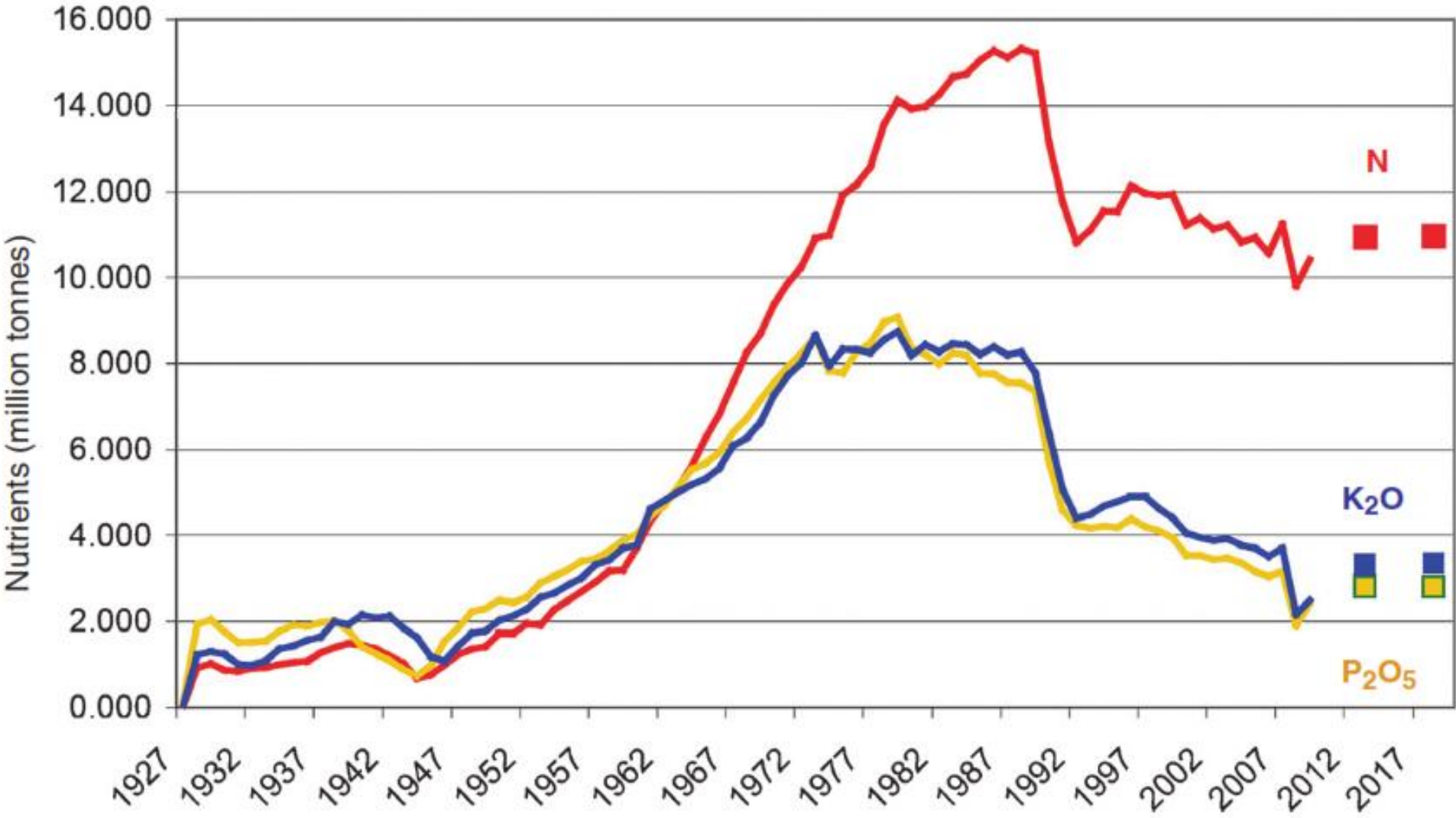
Phosphate Rock Price Trend



market since 2008 was disrupted and “scarcity priced”;
now more stable and dropping with oil prices

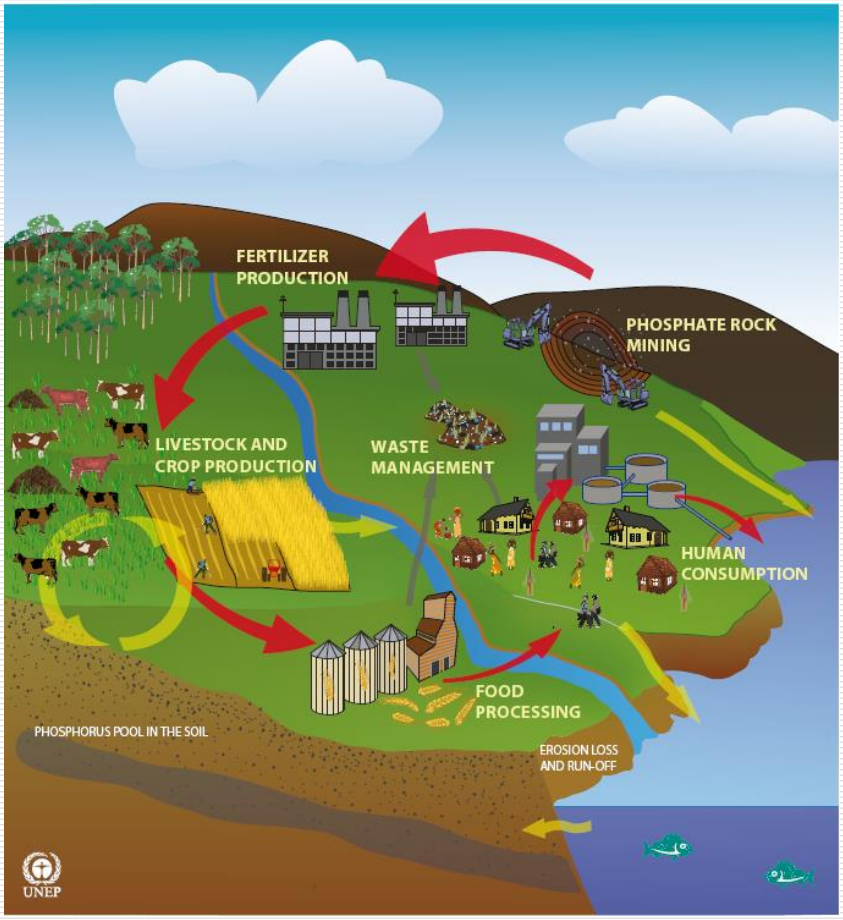
Consumption of fertilizer in EU-27



Sharp drop due to fall of the Soviet Union. The relative importance of organic sources like manure and sludge are increasing.

P value chain – multiple components to be managed

- Rock phosphorus (apatite)
- Sulfuric acid - 5 parts H_2SO_4 give 3 parts H_3PO_4 in the wet extraction process
- Phosphorus products (MAP, DAP, SP, etc)
- Agro and food system - soil, food and animal feed
- Manure, excreta, solid waste



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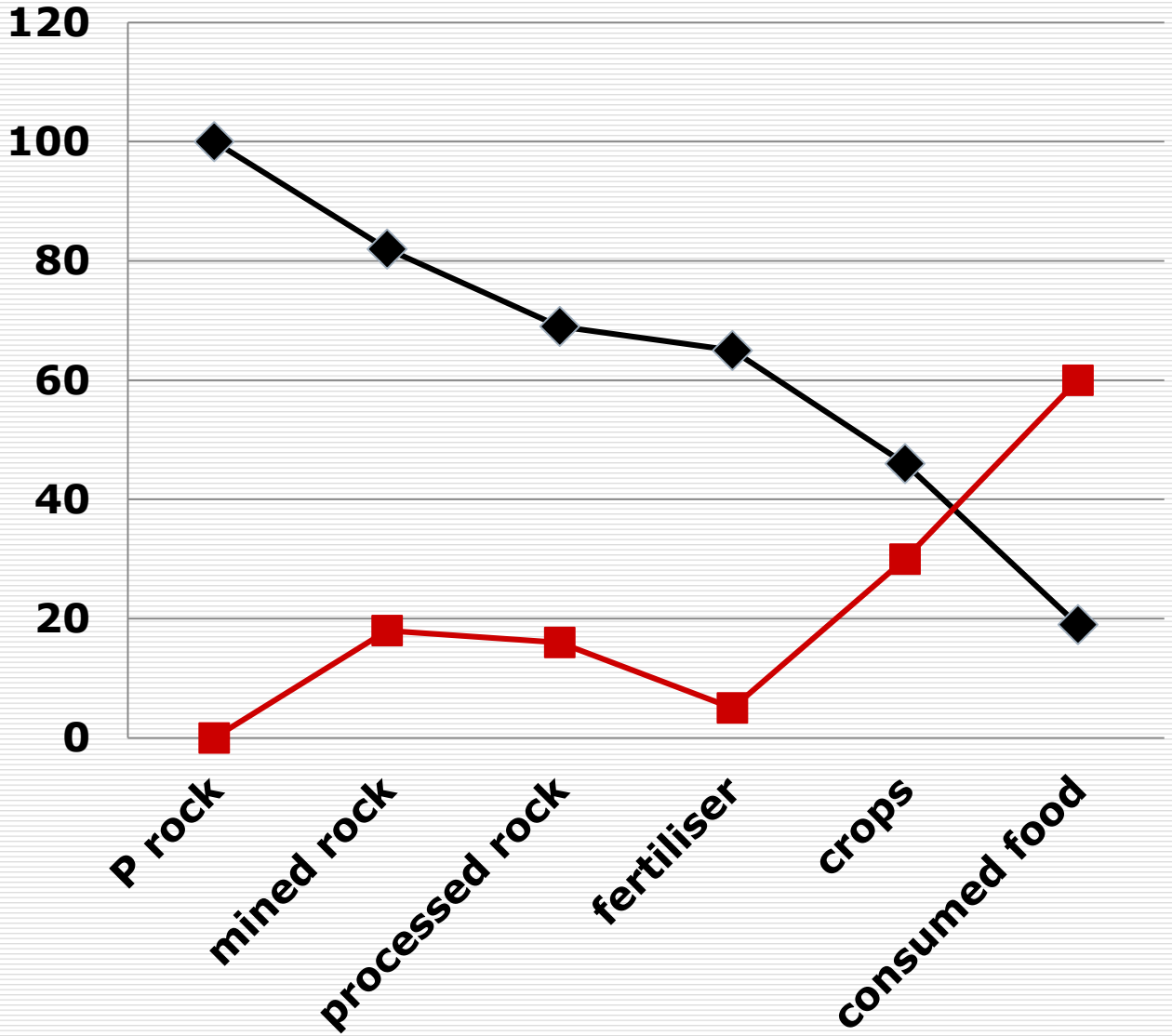
Global supply chain losses of phosphorus from mine to meal are significant



40% lost from mine to fertilizer

40% lost from fertilizer to consumer

20% to the consumer; for the EU it is 25%

(Schröder et al 2010)

Phosphorus sustainability to be managed

- **Reduce**
  - Improved efficiency in mining and extraction
  - Improved fertilizer use and technology
  - Less consumption of meat and dairy products
- **Recycle**
  - Improved recycling of food & food production wastes, sludge, manure, struvite, etc.
- **Economic instruments and flexible fees**
  - Large users to pay more tax fees than smaller users

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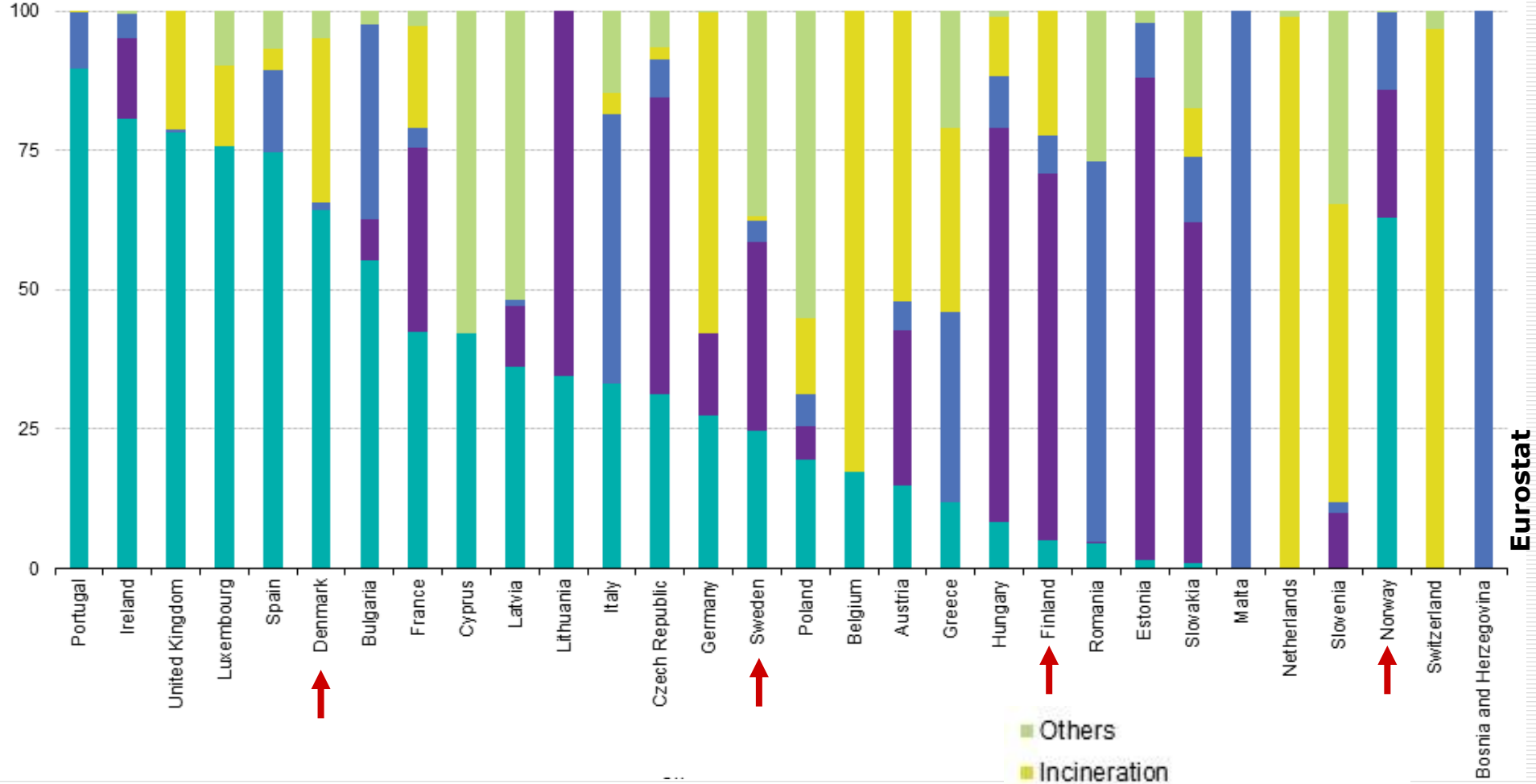
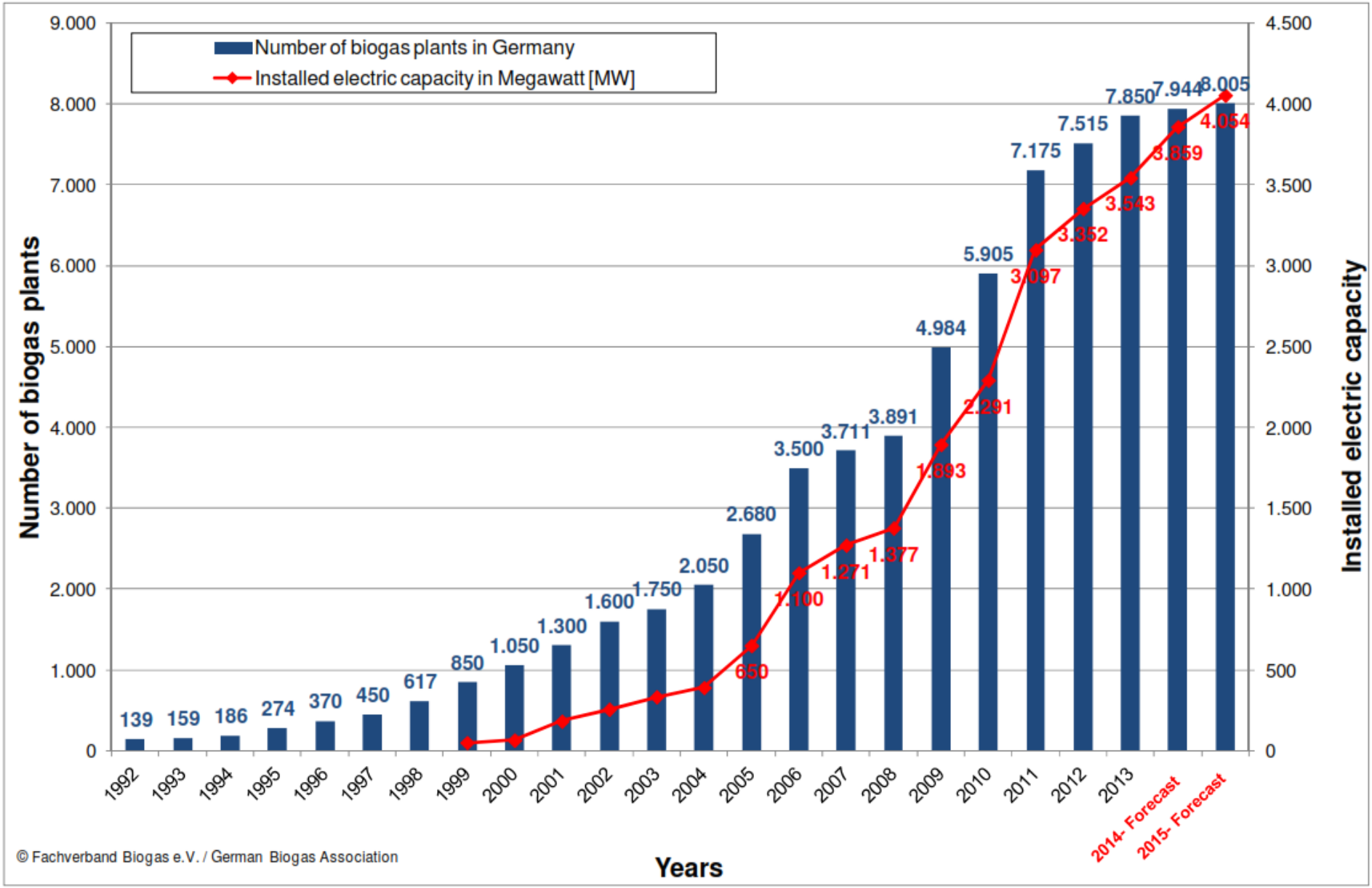
Sewage sludge disposal from urban wastewater treatment 2013 (% total mass)

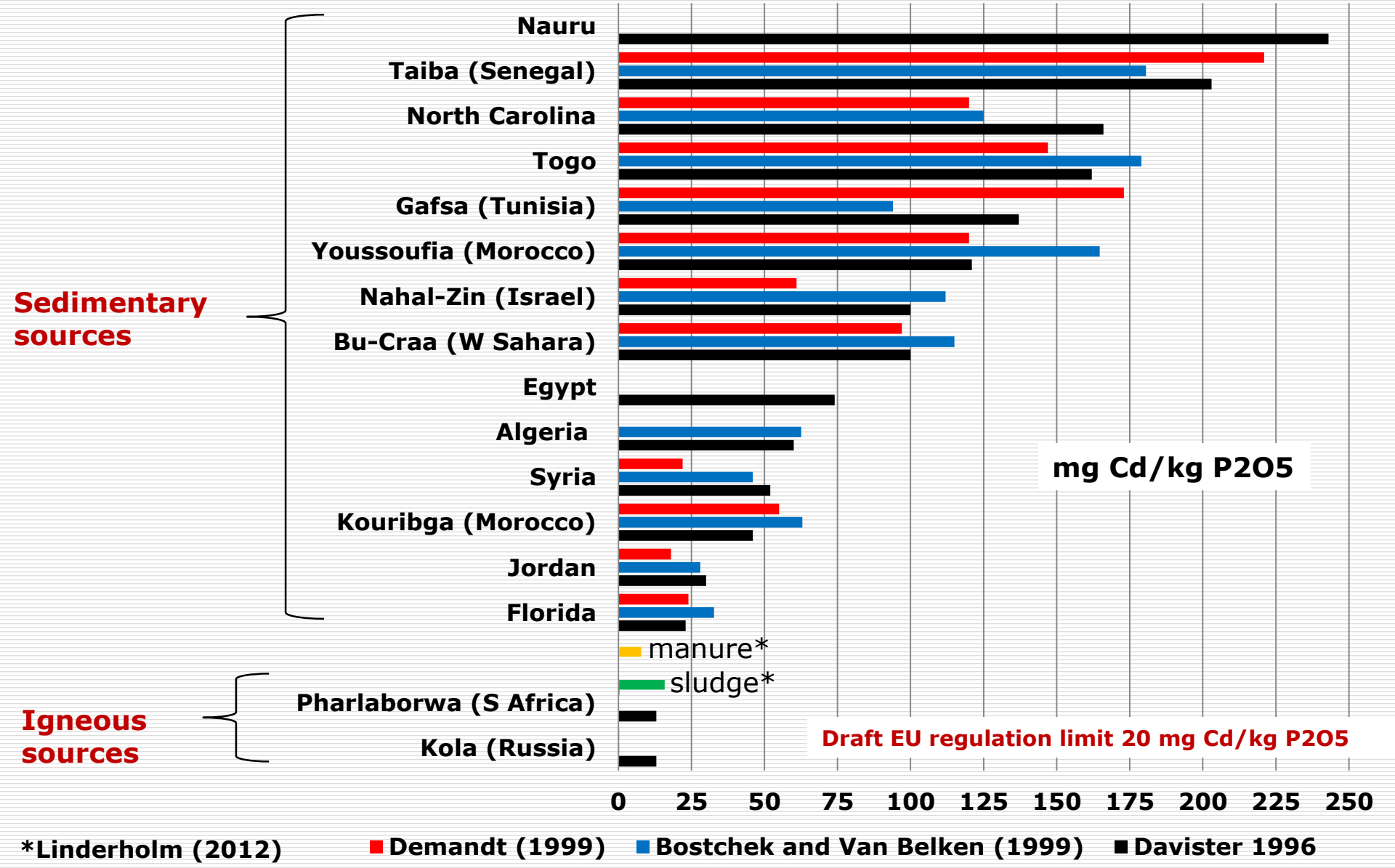


Ranked in terms of agro reuse:
Norway (57%), Denmark (58%),
Sweden (25%), Finland (5%)

Biogas plants in Germany 1992–2015

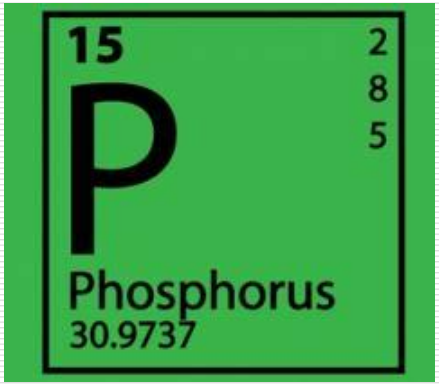


Cadmium levels in P-rock



Challenges surrounding P governance

- Common perception: Food & fertilizer have no limits – just water is limiting
- EU's mammoth agro-subsidy (1 billion Euros/wk) creates false security – now fragile
- No government will lead the dialogue – food price increases would be a political disaster
- Industry has taken a very low profile
- UN is not pro-active (P-rock)
- No geopolitical crisis yet like 1972 oil
- Duncan Brown's empty gas tank analogy still prevails – no action until we run out



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ICIS pricing
fertilizer

International Fertilizer Industry Association

Trammo®

Global fertilizer trade map

Produced by ICIS in partnership with IFA

For more information please visit www.icis.com/fertilizers

Map produced in December 2015

WORLD MAJOR PRODUCING COUNTRIES OF FERTILIZERS AND RAW MATERIALS 2014

AMMONIA**

'000 metric tonnes products	
China	56,400
Russia	14,650
India	13,100
US	11,330
Indonesia	5,450
Trinidad	5,150
World	168,500

UREA**

'000 metric tonnes products	
China	74,100
India	23,000
Indonesia	6,800
US	6,800
Russia	6,200
Qatar	5,450
World	166,050

PHOSPHATE ROCK**

'000 metric tonnes products	
China	80,000
US	27,400
Morocco	26,950
Russia	10,800
Brazil	7,100
Jordan	5,800
World	196,900

DAP**

'000 metric tonnes products	
China	15,450
US	4,550
India	3,300
Saudi Arabia	2,350
Morocco	2,100
Russia	800
World	32,850

POTASH**

'000 metric tonnes products	
Canada	17,450
Russia	12,100
Belarus	10,350
China	7,650
Israel/Spain and UK *	5,150
Germany	5,150
World	55,100

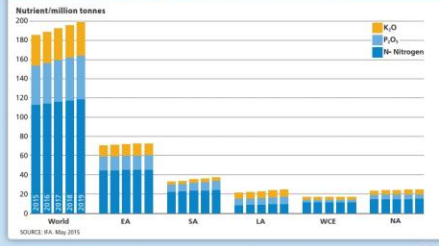
SULPHUR**

'000 metric tonnes products	
US	8,600
Russia	6,100
Canada	5,800
China	5,000
Saudi Arabia	3,900
Abu Dhabi,UAE	2,500
World	55,150

SOURCE: IFA, November 2015, for sulphur October 2014

NOTES: * No split between the three countries ** The ranking of the countries has changed over last year

FERTILIZER CONSUMPTION FROM THE MAIN CONSUMING REGIONS



SOURCE: IFA, May 2015

CONVERSION FACTORS

Nitrogen (N)	Ammonia: N / (divided by)	0,82
	Urea:N / (divided by)	0,46
Phosphate (P_2O_5)	Phosphate Rock: P_2O_5 /	0,30
	MAP: P_2O_5 /	0,52
	DAP: P_2O_5 /	0,46
Potassium (K_2O)	Potash (MOP or KCl):K_2O /	0,60

KEY

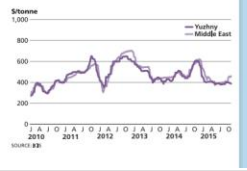
Ammonia · DAP · MAP · Phosphate Rock · Potash · Urea · Sulphur · Sulphuric Acid

The width of the arrows indicates the relative size of trade flow; the arrows' positions of origin and destination do not indicate the ports location

Cut off tonnage for trade flows is 300,000 tonnes product

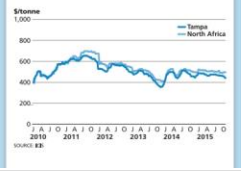
source: IFA data 2014, for sulphur 2013 and for sulphuric acid 2012

AMMONIA FOB YUZHNY AND MIDDLE EAST



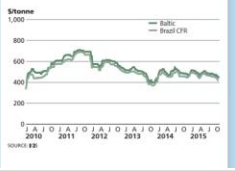
SOURCE: ICIS

DAP FOB TAMPA AND NORTH AFRICA



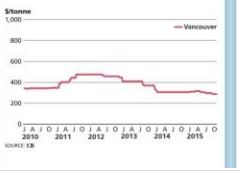
SOURCE: ICIS

MAP FOB BALTIC AND BRAZIL CFR



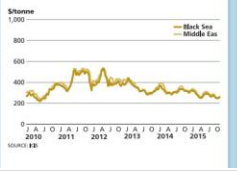
SOURCE: ICIS

STANDARD MOP VANCOUVER FOB



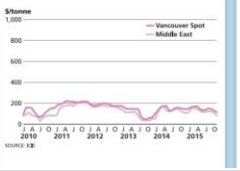
SOURCE: ICIS

UREA FOB BLACK SEA AND MIDDLE EAST



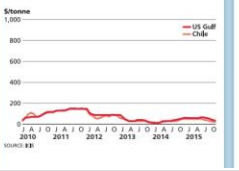
SOURCE: ICIS

SULPHUR FOB VANCOUVER AND MIDDLE EAST



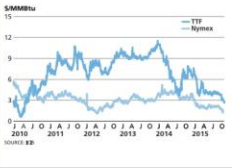
SOURCE: ICIS

SULPHURIC ACID US GULF AND CHILE

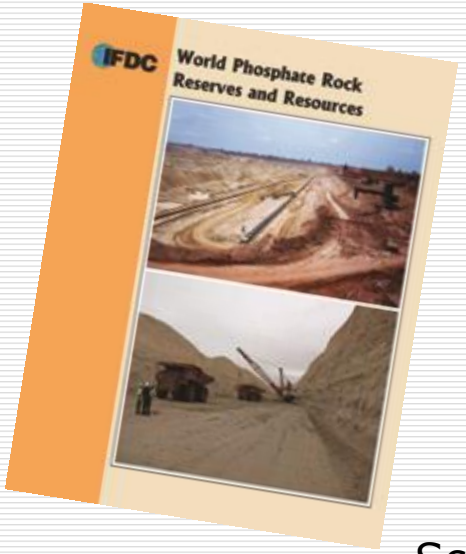


SOURCE: ICIS

TTF AND HENRY HUB GAS PRICES



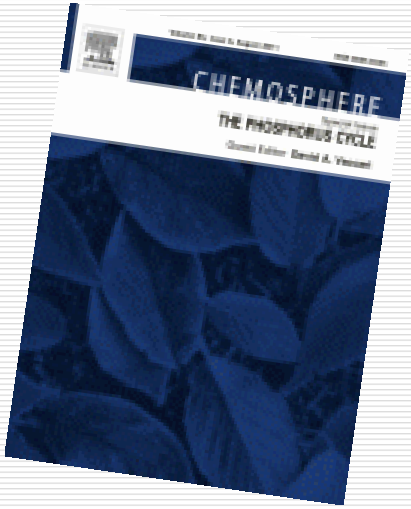
SOURCE: ICIS



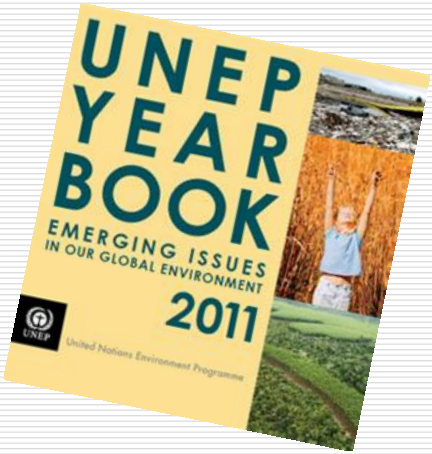
IFDC 2010

Schroder, Cordell, Smit, Rosemarin 2010

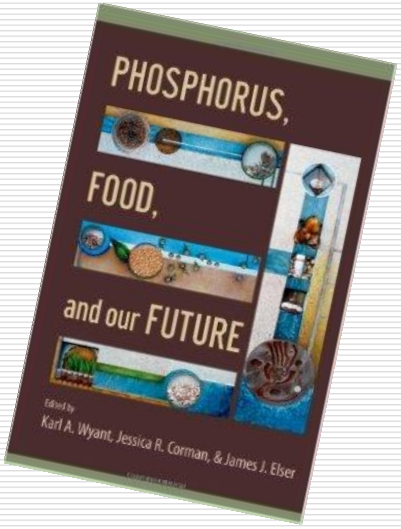
Formas 2011



Chemosphere 2011



UNEP 2011



Wyant, Corman, Elser 2013

Butusov & Jernelövs 2013

Finnson, Swedish Water 2015

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