Climate Change, Soil water and Soil Organic Carbon Content

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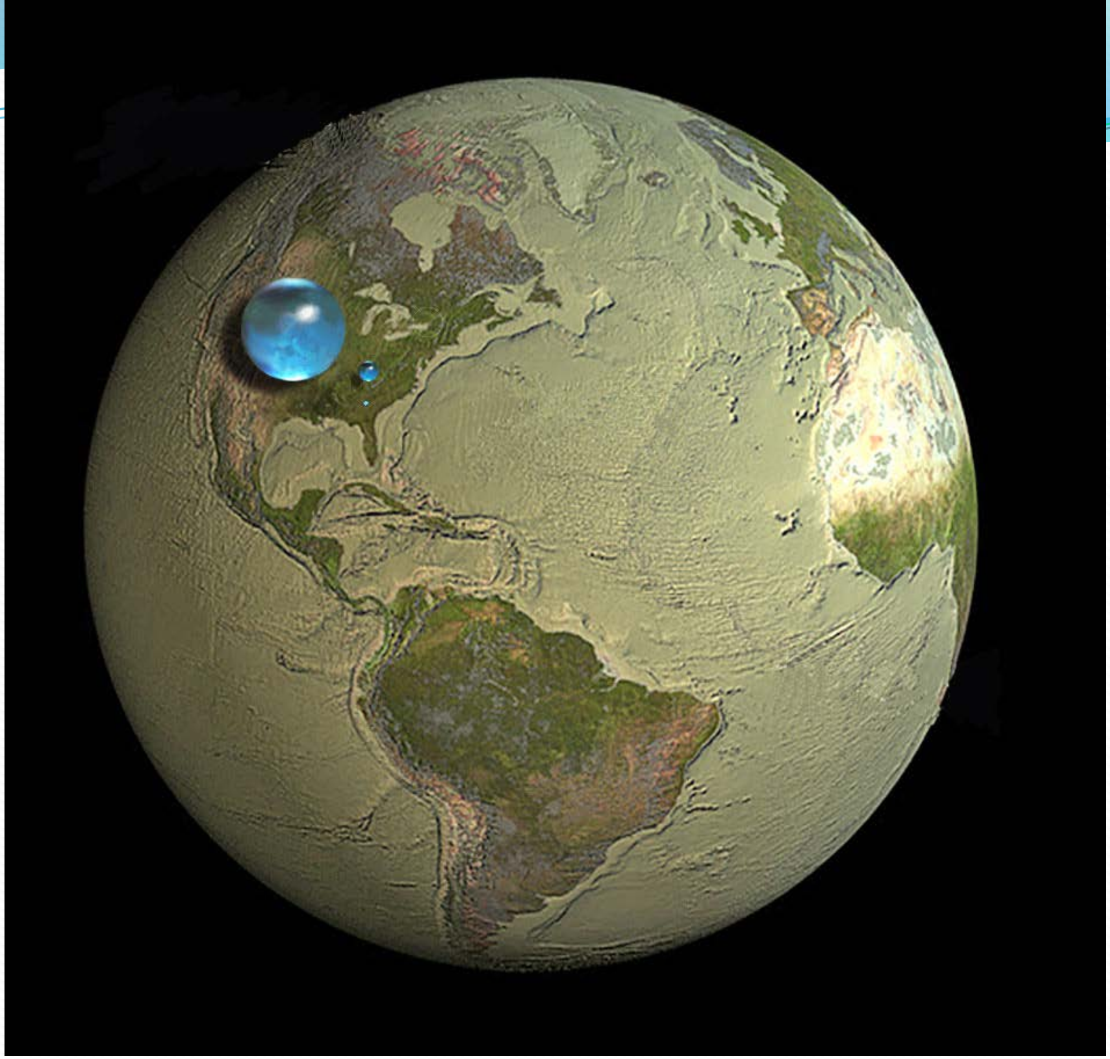
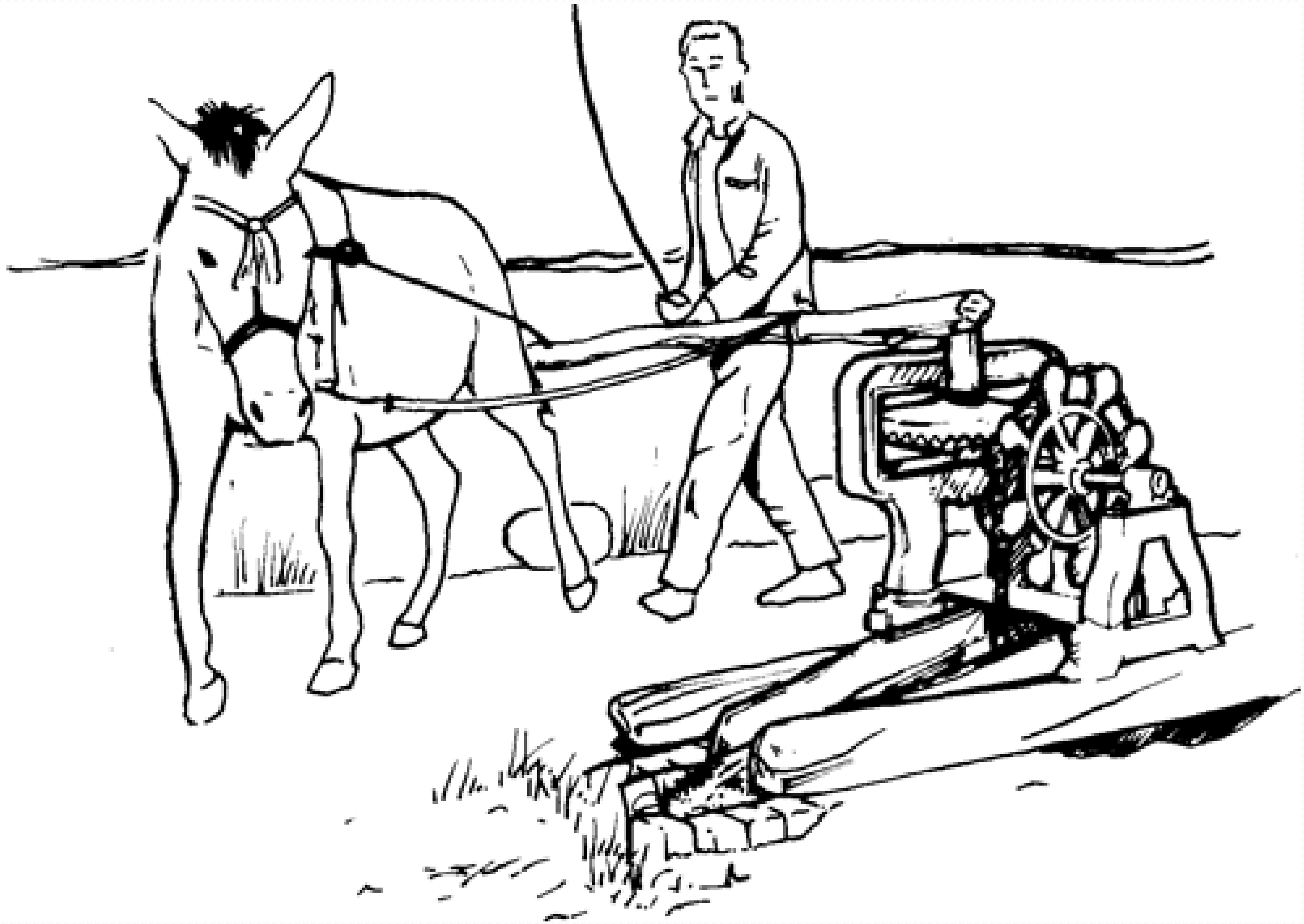
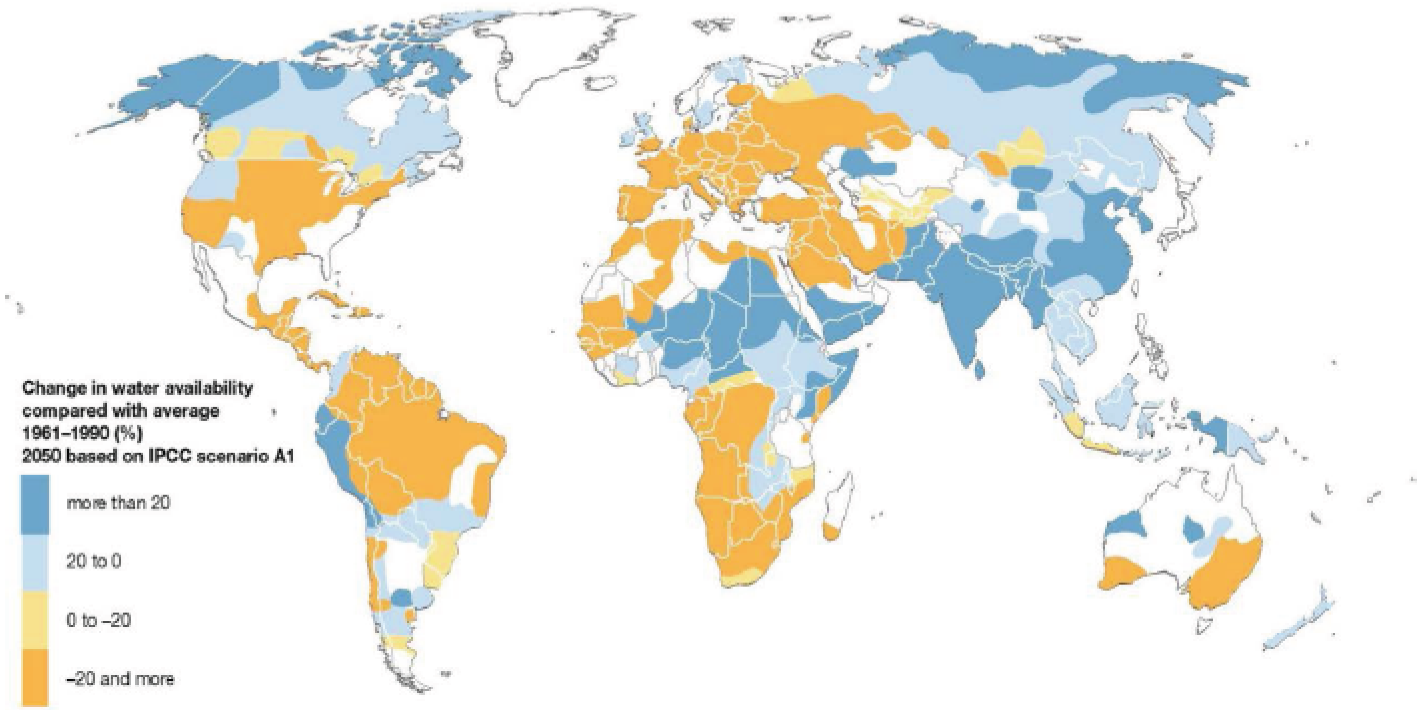


All water on the planet (sphere over western U.S., 1384 Km in diameter)
Fresh liquid water in the ground, lakes, swamps, and rivers
(sphere over Kentucky, 273 Km in diameter), and
Fresh-water lakes and rivers (the Tiny sphere over Georgia, 56 Km in diameter).

Where and When Did We Lose Our Sight on the Scope and Scale of Things?



Climate is changing and so does hydrology:
natural availability is declining



source: Arnell, 2004

Change in water natural availability, not considering production technology, access to water, etc
2050 vs [1961-90]

FAO GSP Plan to Encounter major Threats to Our Soils

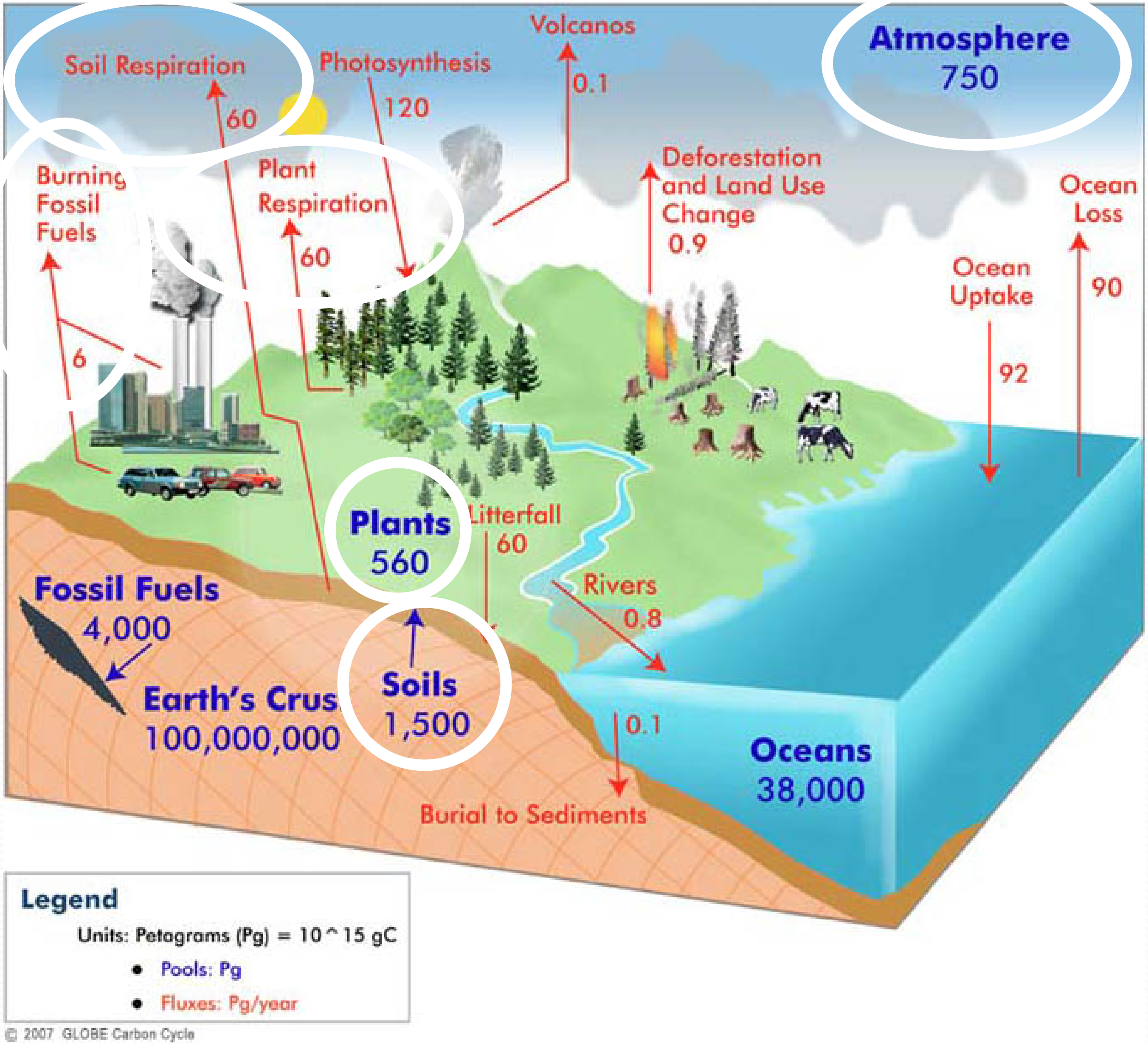
- 1. Minimal rates of soil erosion by water and wind;
  2. The soil structure is not degraded (e.g. soil compaction) and provides a stable physical context for movement of air, water, and heat, as well as root growth;
  3. Sufficient surface cover (e.g. from growing plants, plant residues, etc.) is present to protect the soil;
  4. The store of soil organic matter is stable or increasing and ideally close to the optimal level for the local environment;
  5. Availability and flows of nutrients are appropriate to maintain or improve soil fertility and productivity, and to reduce their losses to the environment;
  6. Soil salinization, sodification and alkalinization are minimal;

Threats to Our Soils

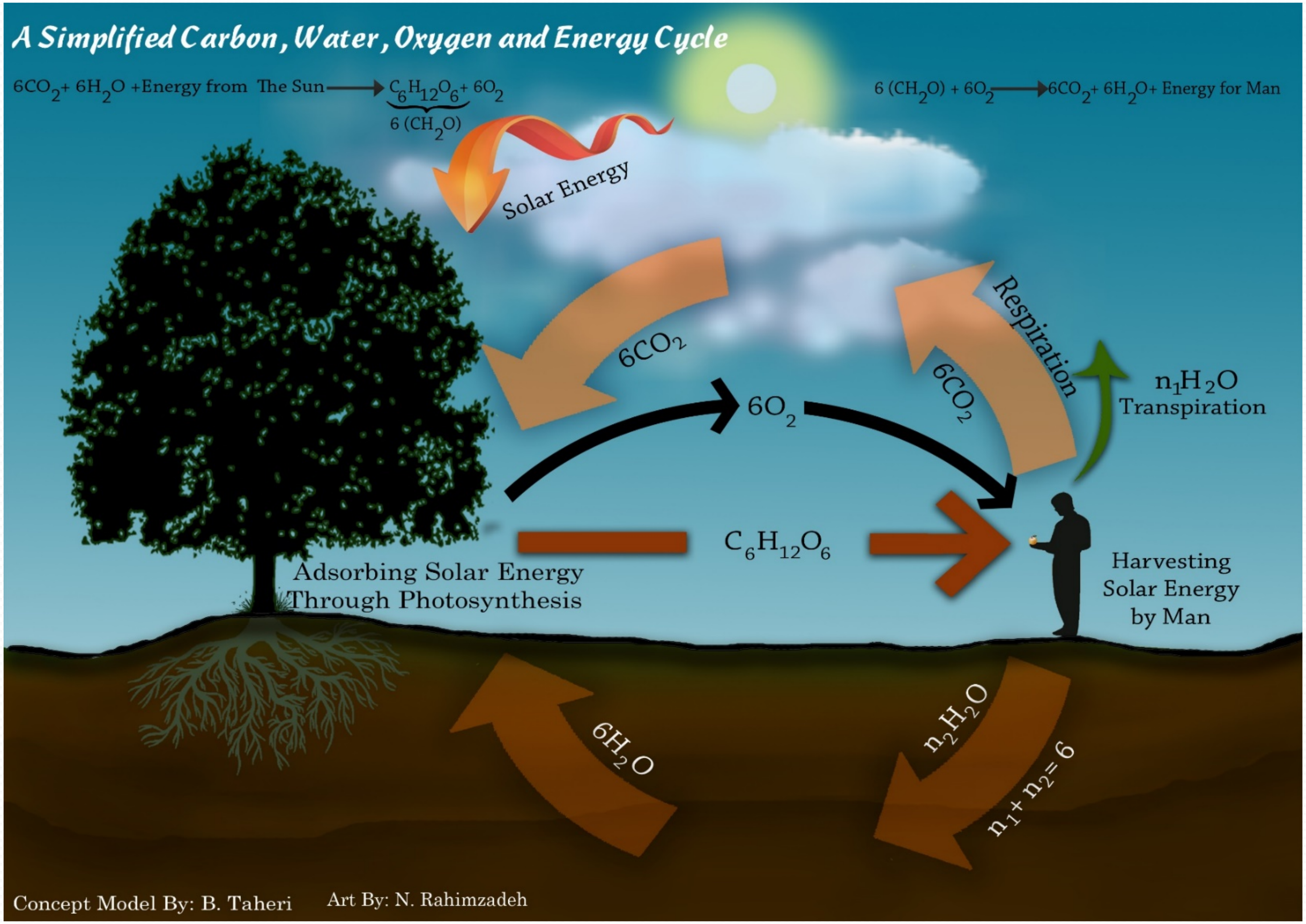
- 7. Water (e.g. from precipitation and supplementary water sources such as irrigation) is efciently infiltrated and stored to meet the requirements of plants and ensure the drainage of any excess;
  8. Contaminants are below toxic levels, i.e. those which would cause harm to plants, animals, humans and the environment;
  9. Soil biodiversity provides a full range of biological functions;
  10. The soil management systems for producing food, feed, fuel, timber, and fibre rely on optimized and safe use of inputs; and
  11. Soil sealing is minimized through responsible land use planning

380 ppm

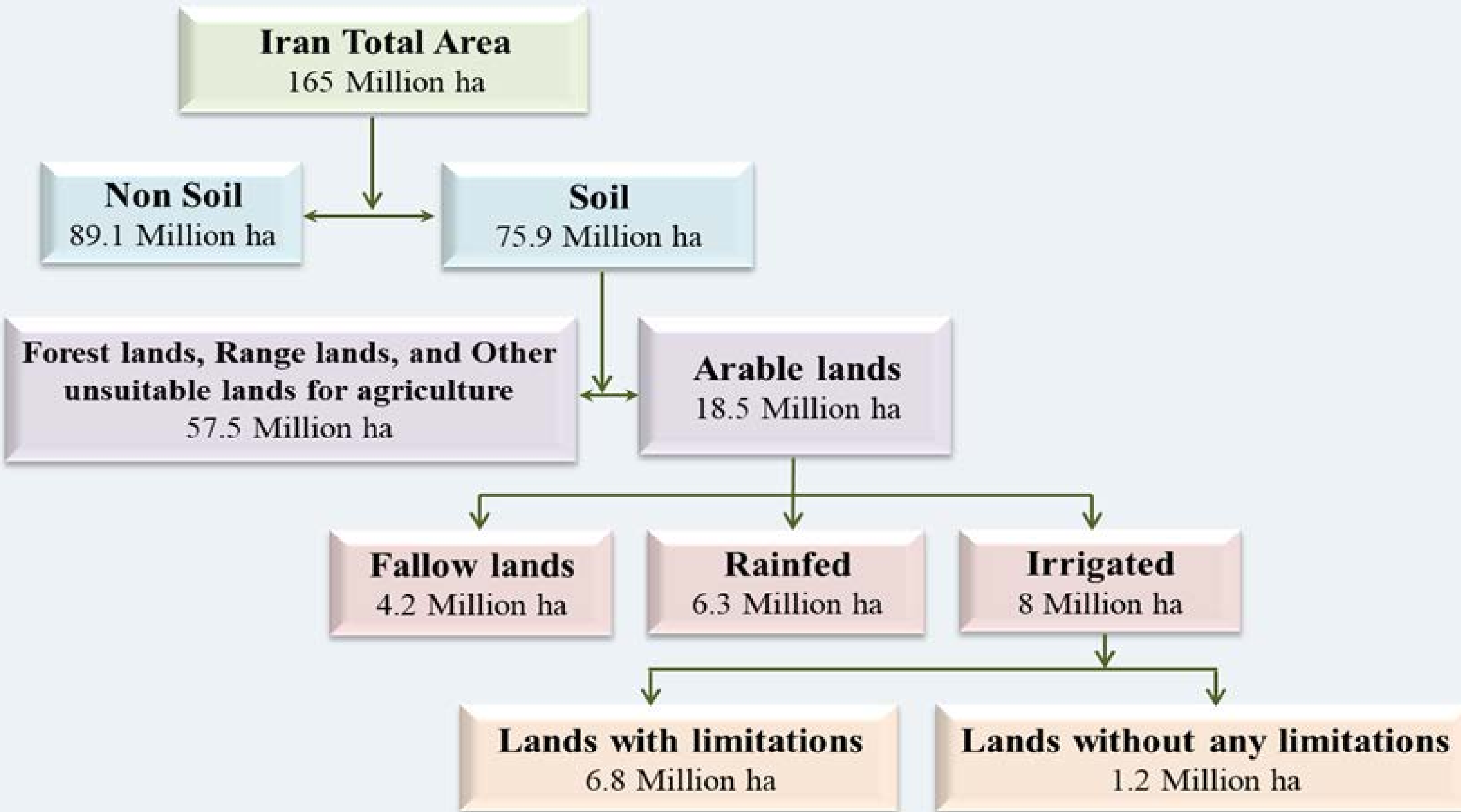
Carbon Balance and Transfer within the Planet's Elements



Soil, Water, Carbon, Food

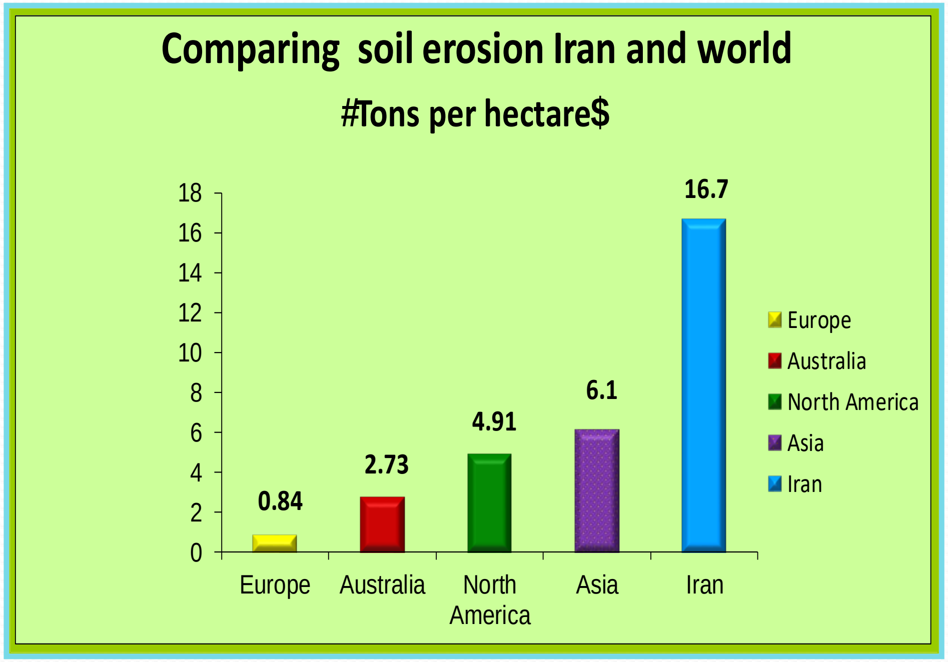


Soil Resources Status of Iran



1.Rates of soil erosion by water and wind;

- **Watershed area in the territory of water erosion: 125 m ha**
- **Water erosion average: 16.7 ton/ha/year**
- **economical losses from soil erosion: >10 billion dollars/year**



Some factors affecting soil fertility and non-optimized plant nutrition in Iran

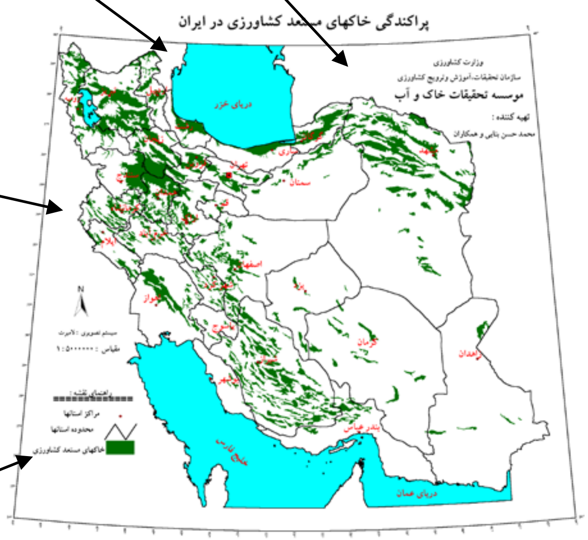
Nutrient deficiency in soils

Unbalanced nutrition of plants

Low efficiency of nutrient use

Low content of SOC

Non-compliance of plant nutrition with biotic and abiotic stresses



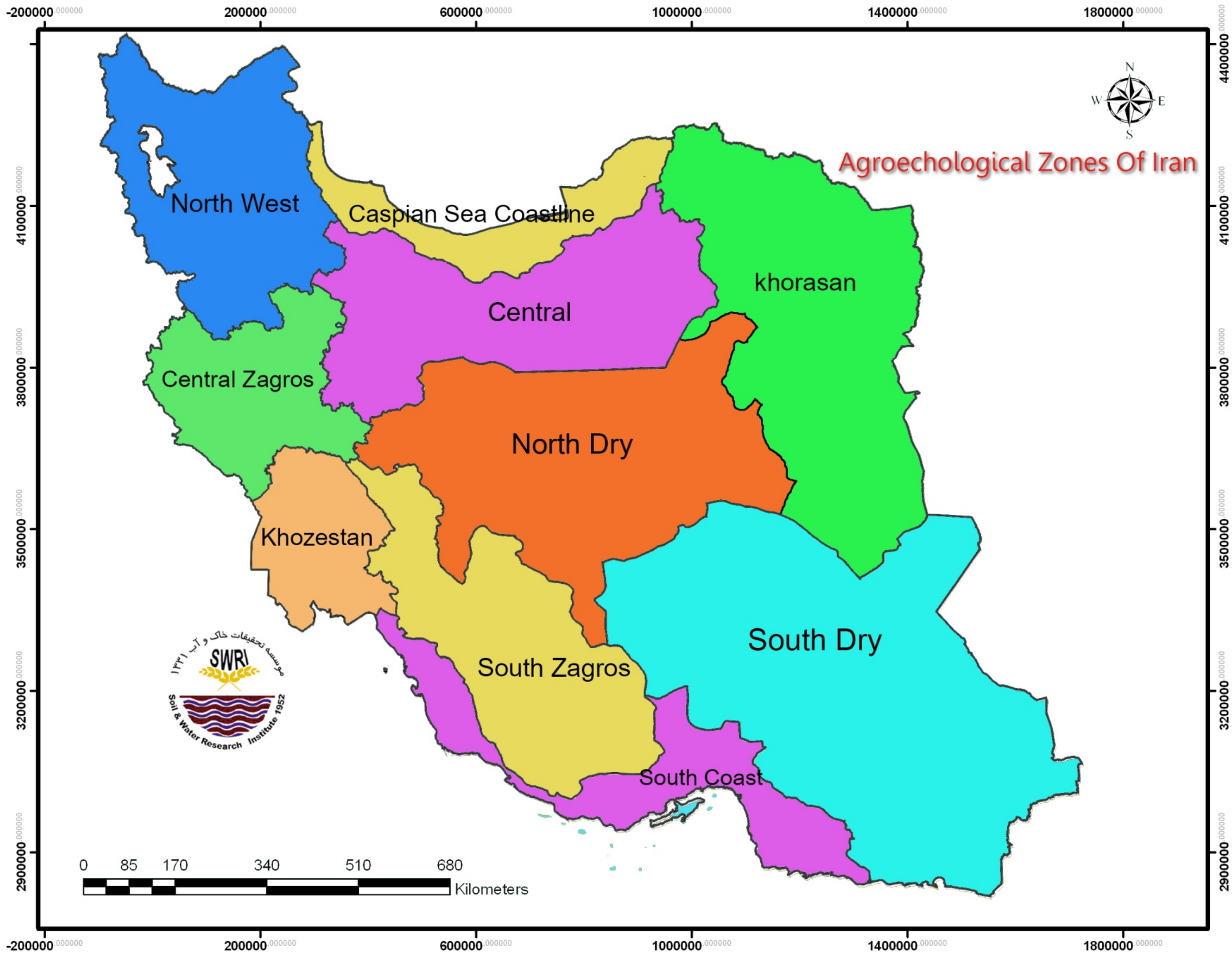
Inefficiency of fertilizer system (estimation, supply, distribution, consumption and standardization of fertilizer)

Low quality of some fertilizers

Insufficient attention to the education and promotion system

Lack of sufficient capacity and ability of the private sector in the fertility system

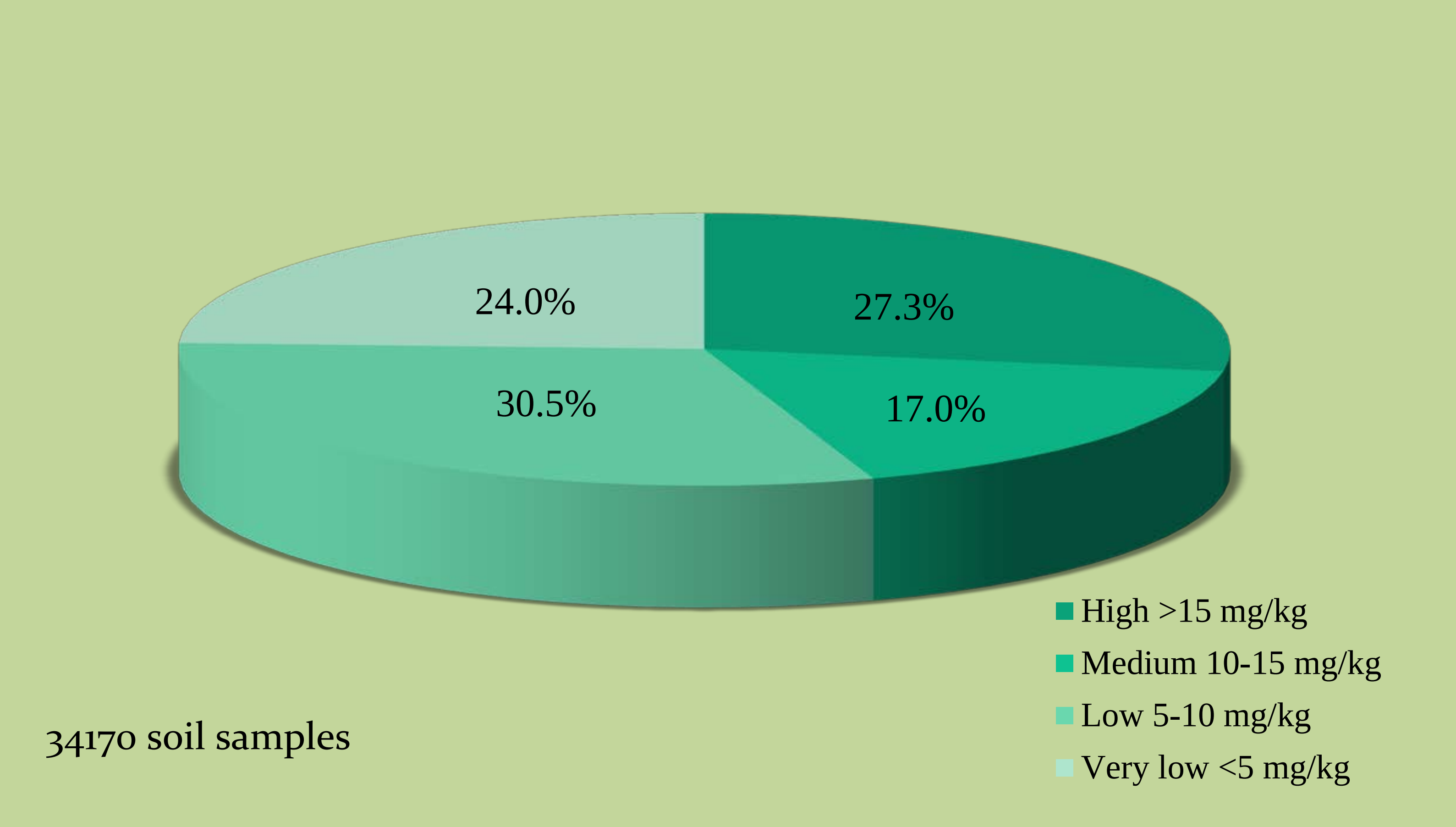
AgroEcological Zones in Iran



Distribution of nutrient deficit in soils of different AEZ

Zone	Nutrients (critical level mg/kg)					
	P (<15)	K (<200)	Fe (7.5)	Zn (<1.0)	Mn (<6.0)	Cu (<1.0)
Central	68.1*	17.9	61.3	59.2	17.9	18.3
Caspian Sea Coastline	61.2	48.6	16	59.8	36.4	6.6
North West	77.3	12.5	79.1	76.2	32.4	22.9
Central Zagros	72.9	17.5	76.4	75.7	41.5	33
Khuzestan	88.1	59.9	79.8	62.8	83.5	47.6
North Dry	69	40	45.9	39.9	29.3	22
South Zagros	61.1	26.6	48.7	77.2	17.8	24.7
South Coast	85.2	74.4	100	34.8	17.4	95.7
South Dry	74.5	48	75.5	70.3	31.9	38.4
Khorasan	73.7	25.1	85.3	65.7	23.3	39.9
Average	72.1	30.3	67.6	71.6	37.6	30.5

Range of Available Phosphorus in agricultural soils of Iran

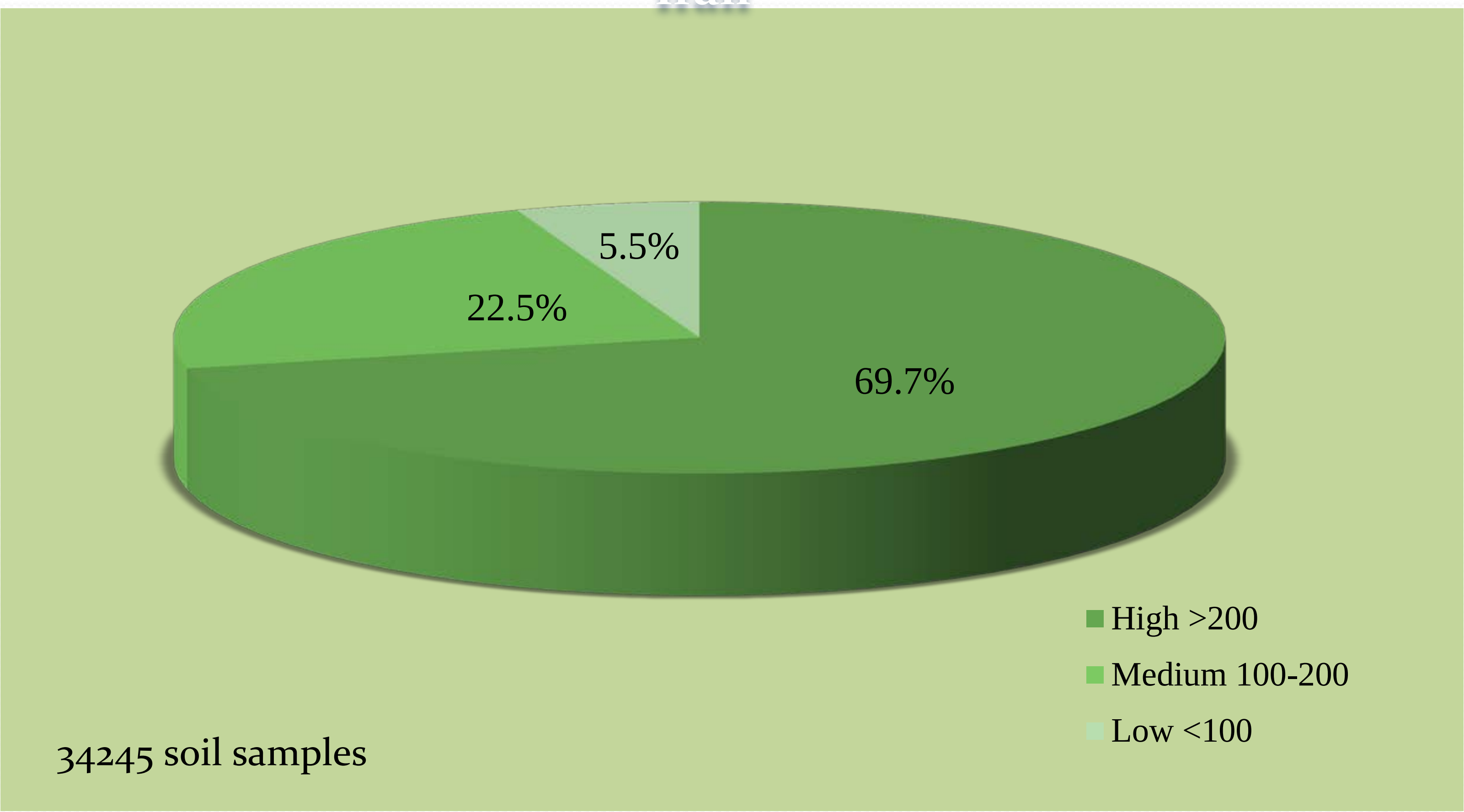


Changes of soil Available phosphorus in several regions

Region	Number of Samples	mean Available P (1966) *	Number of Samples	mean Available P (2017) **
Gilan	231	10.7	1968	23.9
Mazandaran	188	12.0	5945	22.7
Golestan	85	9.4	2740	11.1
Central Fars	570	15.3	410	17.2
Isfahan	111	9.9	695	12.2
Urmia	171	8.9	2125	15.5
Qazvin	122	7.9	180	14.5
Khorasan	387	9.2	1387	13.3

*FAO report (1966)
** Soil nutrient databank (2017)

Range of Available Potassium in agricultural soils of Iran

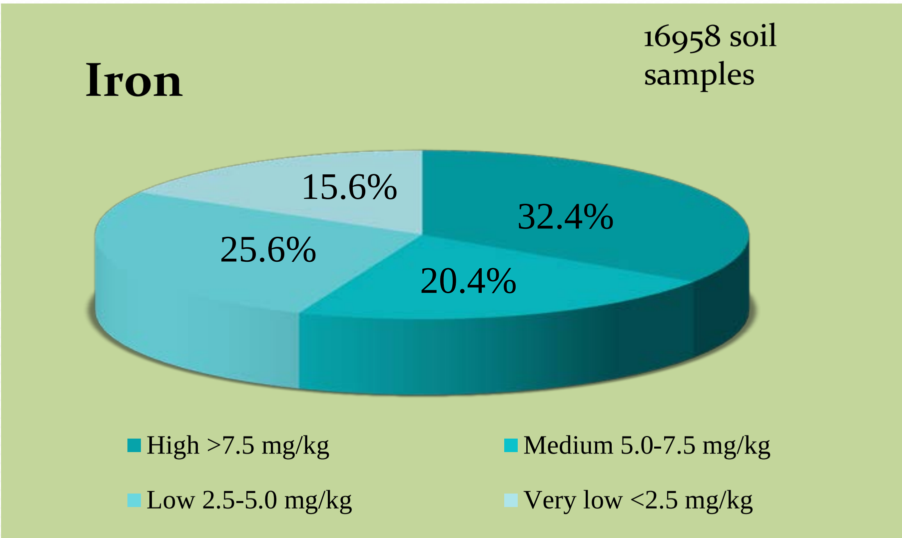


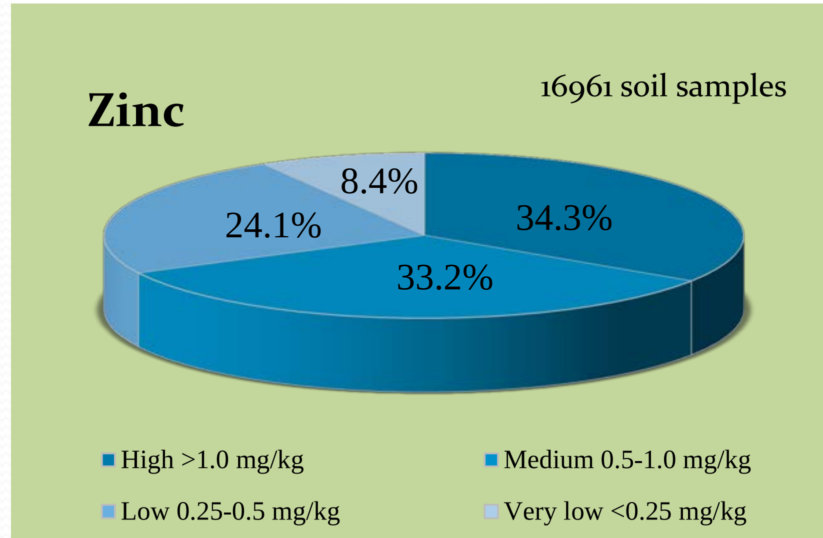
Changes of soil Available potassium in several regions

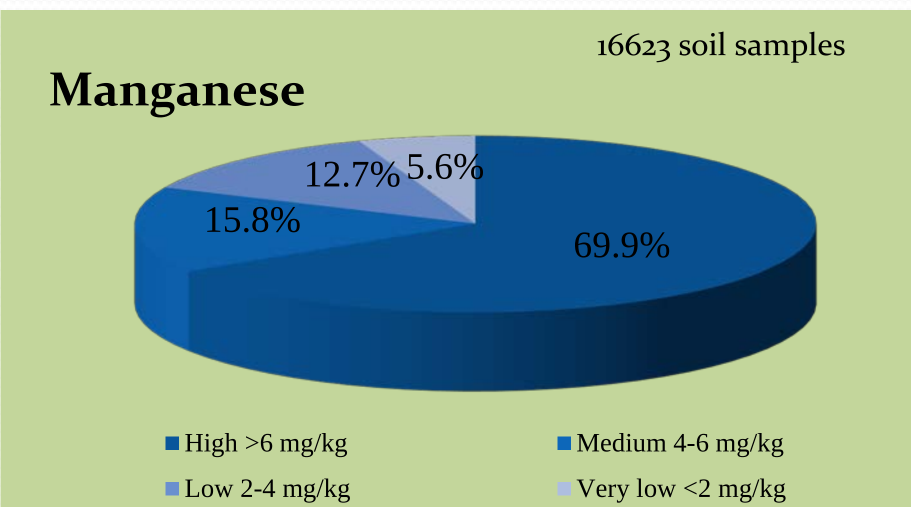
Region	Number of Samples	Mean available K (1966) *	Number of Samples	Mean available K (2017) **
Gilan	231	193	1973	184.4
Mazandaran	188	342	5692	254.7
Golestan	85	292	2747	257.9
Central Fars	570	387	420	335
Isfahan	111	366	760	260.1
Urmia	171	425	2139	360.9
Qazvin	122	390	180	373.8
Khorasan	387	275	1400	288

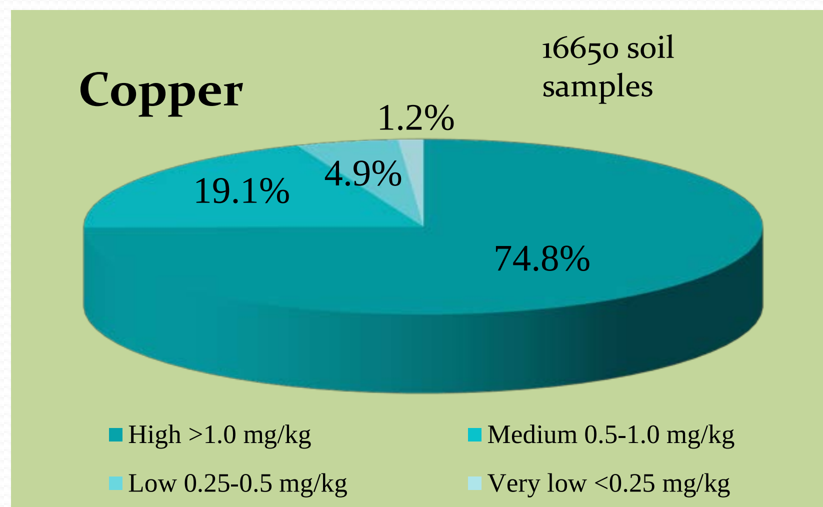
*FAO report (1966)
** Soil nutrient databank (2017)

Range of micronutrients concentration in agricultural soils of Iran







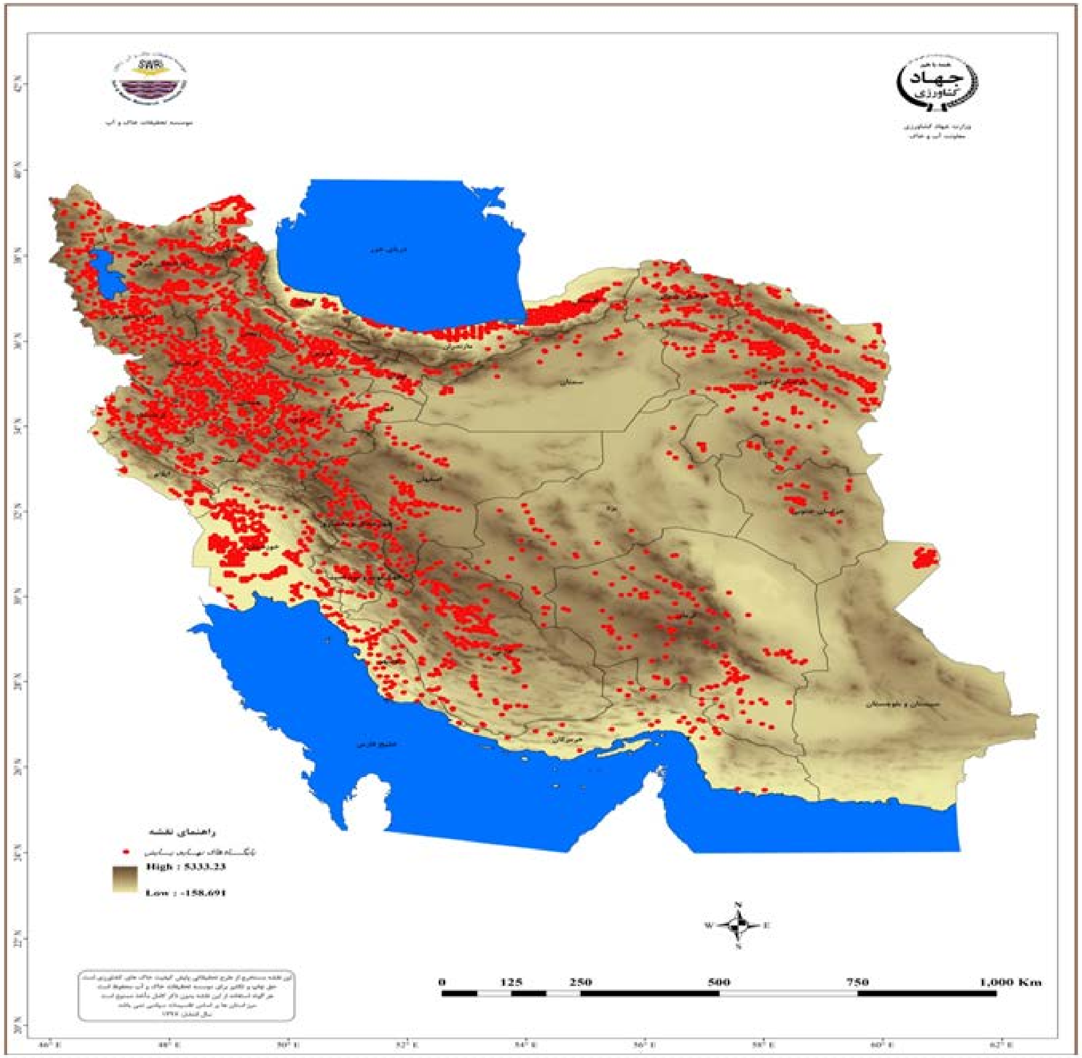


Soil Quality and Nutrient Cycling Assessment

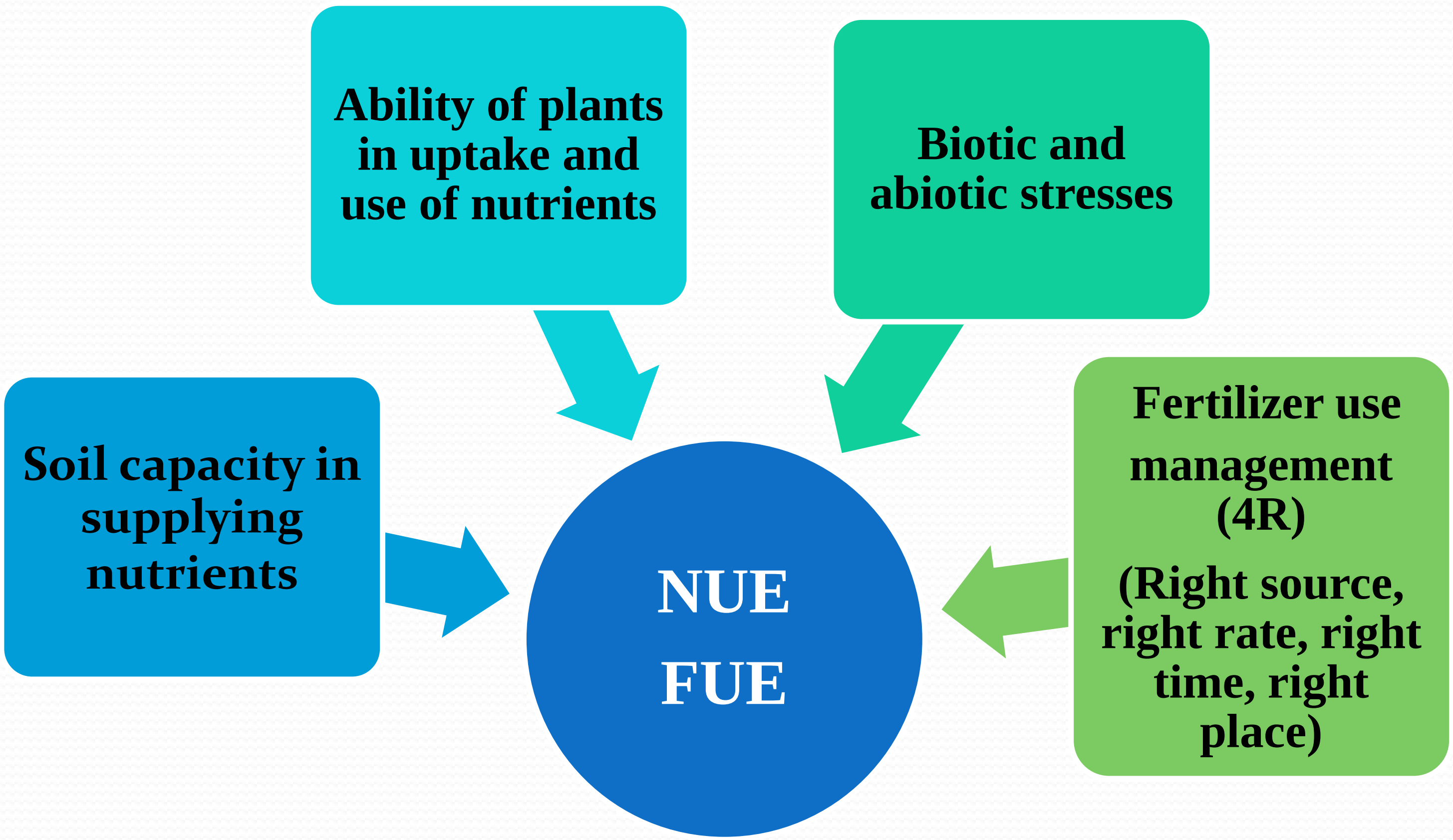
Benchmarks: 3200

Phase (I): 2010-2016

Phase (II): start in 2019



Major factors affecting the nutrient use efficiency



Nutrient balance and cycle in plot experiments

Phosphorus balance after 11 years (1991-2002) establishment of wheat-corn-suger beet cropping system in Zarghan station, Fars province

P_2O_5 application rate (kg/ha)	Total P applied (kg/ha)	Total P removal (Kg/ha)	Partial budget (kg/kg)	Initial available P (mg/kg)	Final available P (mg/kg)
0	0	136.2	-136.2	9.3	4
45	174.15	181	-6.85	10.8	13
90	348.3	191.8	156.5	9.6	34
135	522.45	203	319.45	11.5	37
180	696.6	191.8	504.8	10.7	56

Khogar, 2005

Nutrient balance and cycle in plot experiments

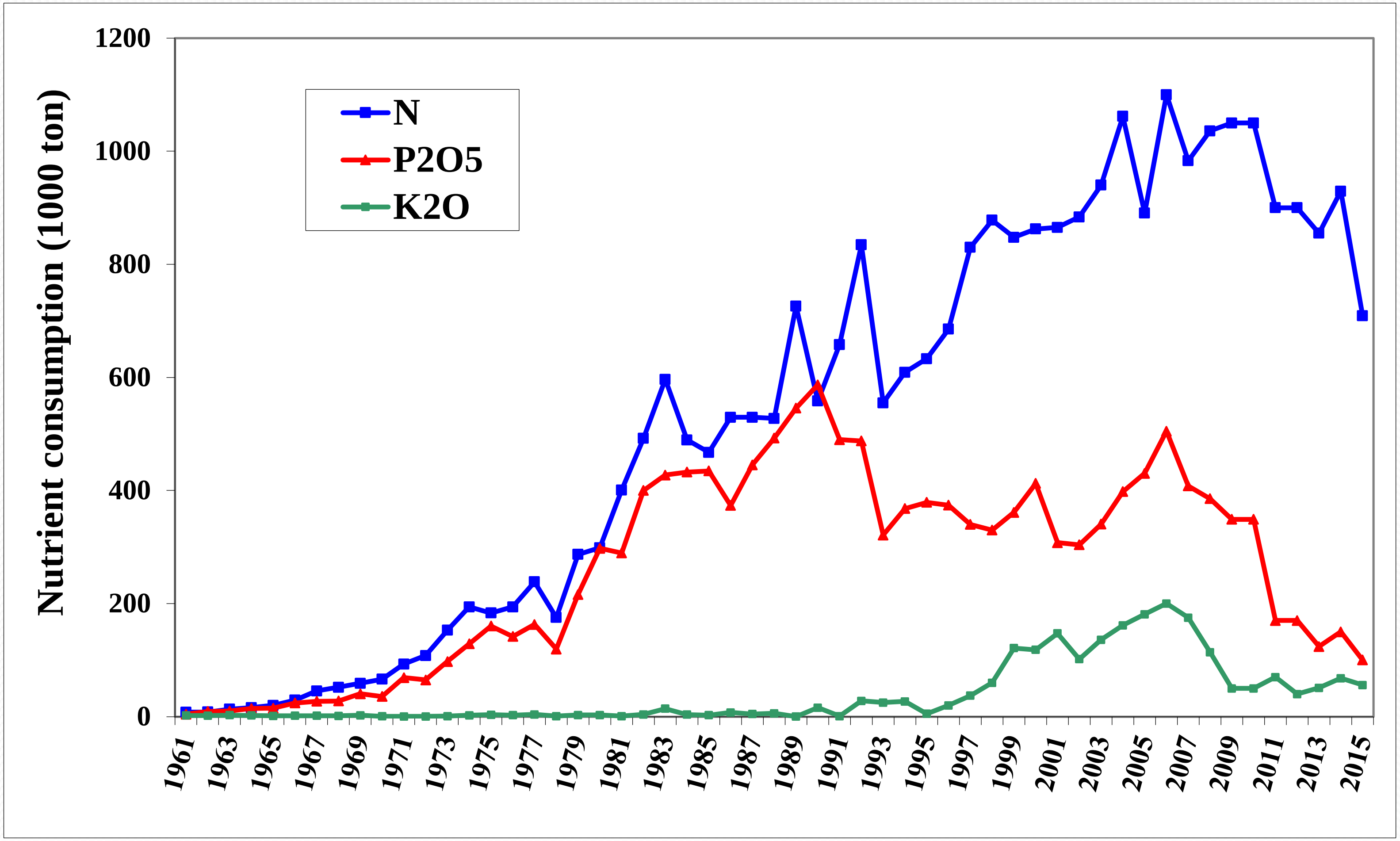
Phosphorus balance after two years establishment of wheat-maize cropping system

Location	System production (ton/ha) *	P applied (kg/ha)**	P removal (Kg/ha) ***	Partial budget (kg/kg)	Initial available P (mg/kg)	Final available P (mg/kg)
Isfahan	23.2	80.4	105.6	-25.2	10.8	11.2
Khorasan	20.2	120.6	138.3	-17.7	6.0	12.5
Fars (Darab)	25.0	160.8	68.7	+92.1	3.6	-
Fars (Zarghan)	29.3	160.8	173.1	-12.3	8.5	10.7
Alborz	24.4	120.6	158.6	-38.0	7.3	10.5
W. Azerbaijan	26.0	120.6	154.0	-33.4	6.8	14.7
Khuzestan	18.6	160.8	63.3	+97.5	4.4	8.0
Lorestan	24.6	160.8	83.8	+77.0	5.0	9.1
Mazandaran	24.7	70.4	135.2	-64.8	9.9	40.7
Golestan	23.7	110.6	205.1	-94.5	5.4	11.1

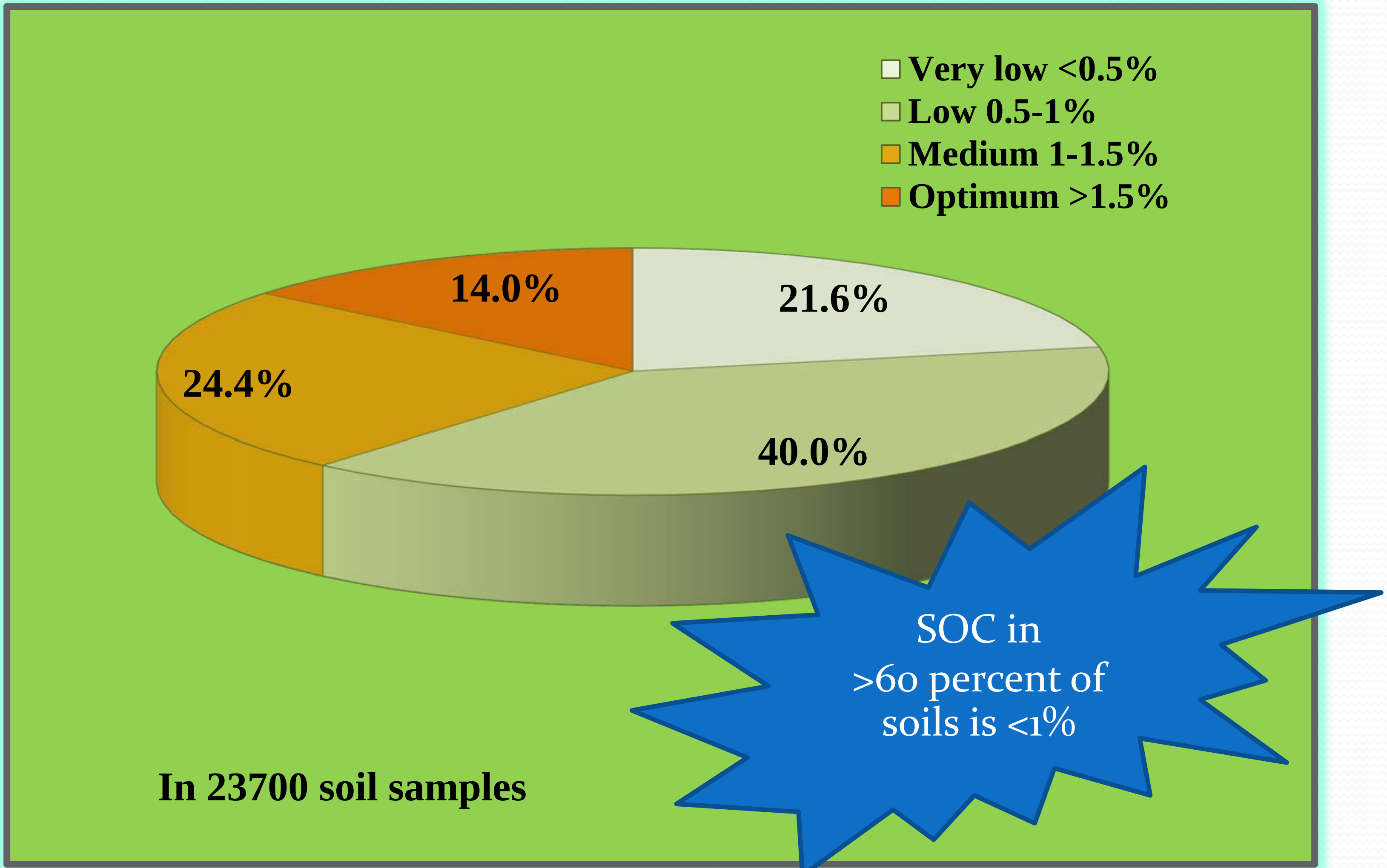
* Wheat-based system production
**Sum of the phosphorus added at recommendation level for each crop
*** Sum of the phosphorus removed at recommendation level for each crop

Moshiri, 2017

Trend of fertilizer consumption in Iran (1961-2015)



Range of organic carbon content in agricultural soils of Iran



Balali et al. (2014)

Changes of soil Organic carbon in several regions

Region	Number of Sample	SOC (1966) *	Number of Sample	SOC (2017) **
Gilan	231	3.63	1162	2.10
Mazandaran	188	2.29	1904	1.90
Golestan	85	1.97	2730	1.30
Central Fars	570	1.06	540	0.9
Isfahan	111	1.01	1056	0.50
Urmia	171	0.97	1953	1.20
Qazvin	122	0.58	184	0.70
Khorasan	387	0.98	325	0.7

*FAO report (1966)
** Soil nutrient databank (2017)

Changes in SOC in Dezful, Southern Iran

The relative amounts of soil samples contained less than one percent of SOC (%)	Time period	Number of soil samples
79.5	1960's	150
68.3	1990's	100
88.0	2000's	200
100.0	2010-2014	120
Mirzashahi (2016)		

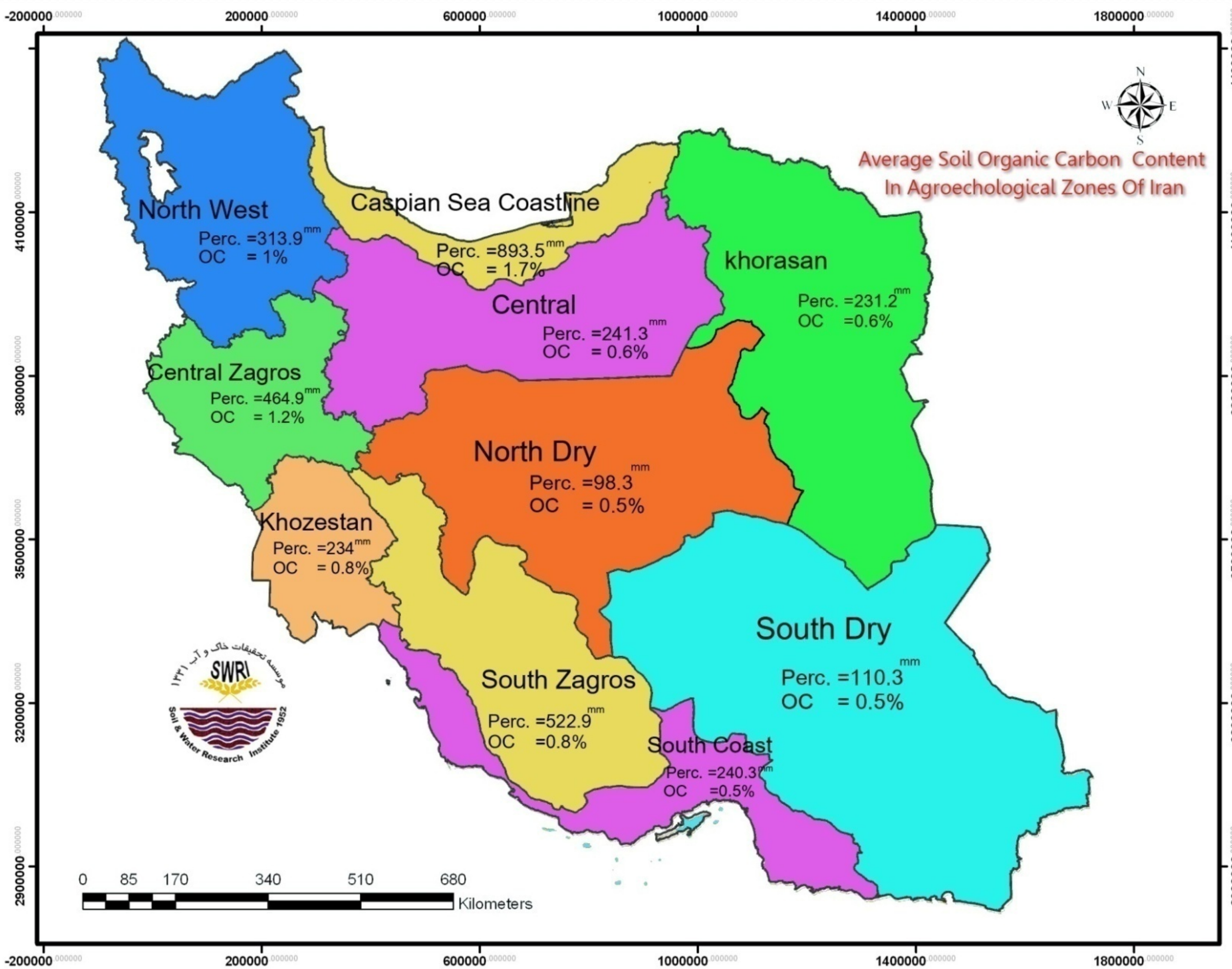
This trend also observed in Northern Iran (moist-subhumid to humid) which in 1960's average amount of SOC was 3.2 percent (Dewan and Famouri, 1964) and now is reduced to 1.7 percent (Balali, et al 2014).

It is necessary to monitor Soil OC content systematically in 3000 existing benchmarks in agricultural soils of Iran

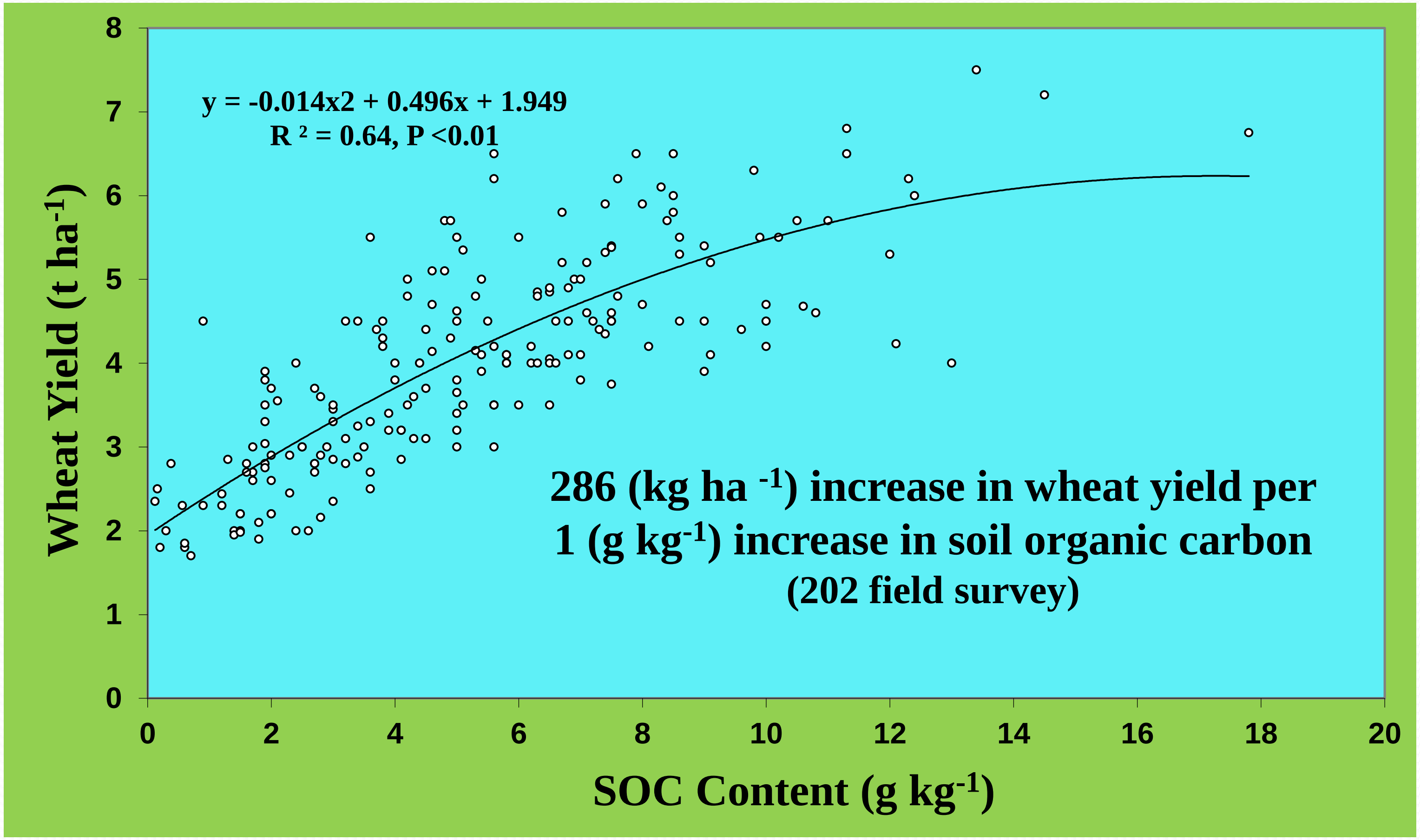
Three major reasons for lack and reduction of OC in soils of Iran

- **Climatic condition**
  - With the exception of north and some western regions of the country, conditions are not suitable for the accumulation of organic carbon in soils due to the dry and semi-dry condition.
- **Undeveloped soils**
  - Unsuitability of soil quality (shallow depth, salinity and alkalinity, water logging, low fertility of soils) affects the growth and development of plants and afterwards the low amount of SOC storage
- **Improper soil and crop management**
  - Limited use of organic fertilizers,
  - Burning crop residues,
  - Inappropriate crop rotation and cropping system (e.g. monoculture),
  - Land use change (23 to 58 percent drop in SOC content because of the rangeland change to dryland farming in western regions of Iran),
  - Irregular and deep tillage

Average SOC in agro-ecological zones of Iran in relation to annual precipitation



Soil organic carbon effects on wheat production sustainability



Keshavarz et al. (2013)

Effect of different organic materials application on organic carbon content in top soil

	Location	Source	Application rate (ton ha^{-1})	Cropping system	Native SOC (gr kg^{-1})	SOC after Treatment (gr kg^{-1})	SOC change (%)
Gholchin (1998)	Zanjan	Animal manure	40	Wheat (monoculture)	5.6	5.9	5.0
Zolfi (2006)	Bushehr	Sheep manure	30*	Onion-Canola-Favabean-Spinach	3.5	7.2	105.7
Mirzashahi (2006)	Safi-Abad	Animal manure	20	Maize	7.3	7.6	4.1
Saadat (2005)	Kohgolooyeh	Cow manure	10	Wheat (monoculture)	6.4	8.2	28.5
	Semnan	Poultry manure	10*	Wheat-Potato (4 years)	2.0	4.1	105.0
	Khozestan	Sugarcane bagasse	15*	Wheat-Potato-Wheat-Canola-Maize	4.6	9.3	102.1
Khogar (2010)	Fars	Green manure	-	Wheat	7.1	9.9	39.4
Ardabili (2011)	Khorasan	Cow manure	60	Wheat (monoculture)	3.1	6.0	93.5

* Every year before each crop

Effect of organic matter application on sustainability of soil quality and nutrient balances

Soil Quality

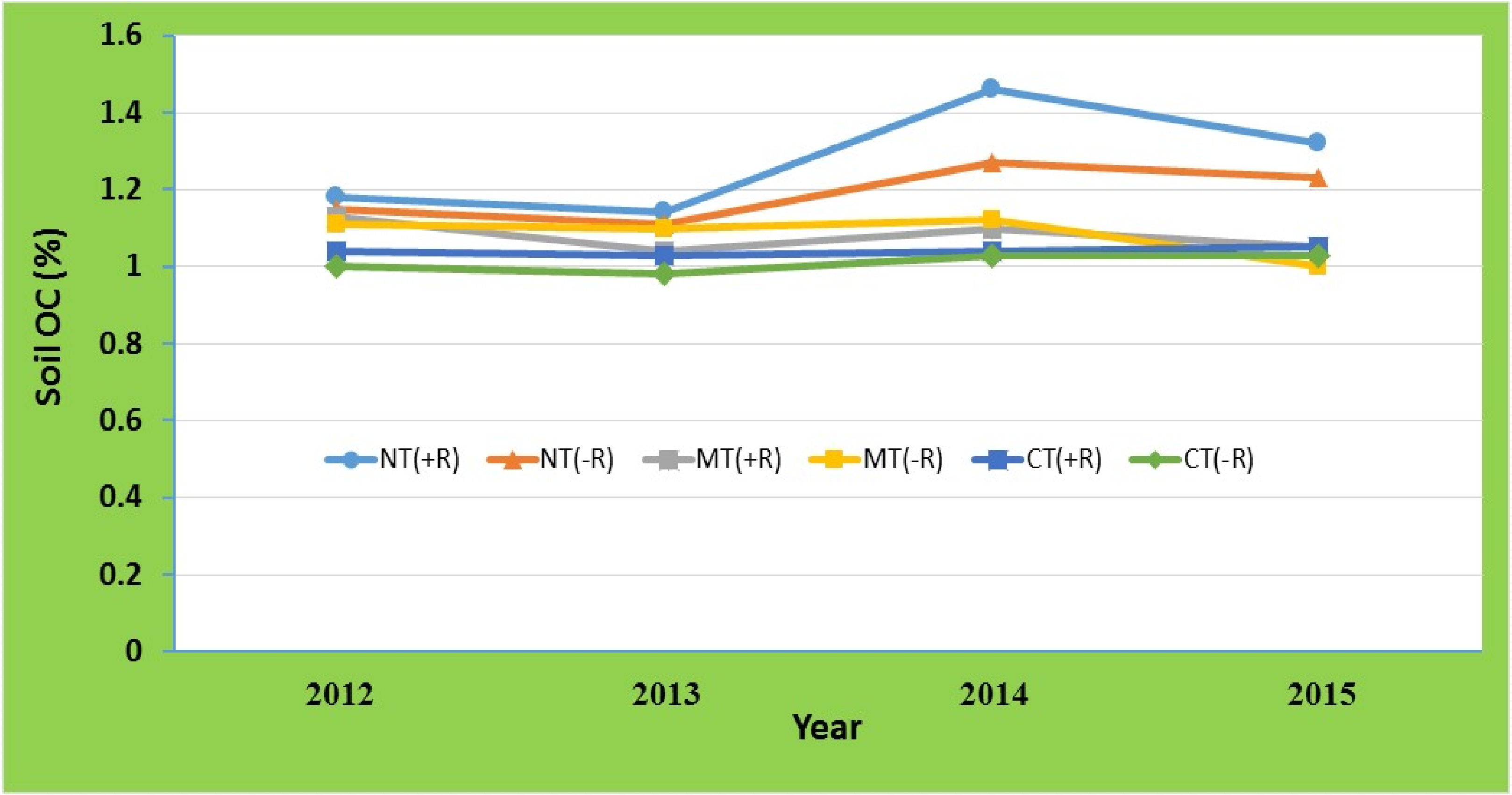
- **Physical Properties**
  - Aggregates mean weight diameter : 20-70 % ↑
  - Available water: 5-10 % ↑
- **Chemical Properties**
  - Available P: 20-50% ↑
  - Available K: 30-100 % ↑
- **Biological properties**
  - Urease activity: 30-50% ↑
  - Phosphatase activity: 40-80% ↑
  - Phosphate solubilizing bacteria:100 times ↑
  - Microbial respiration: 40-100% ↑

Samavat (2017)

Source and amount of compostable organic materials available in Iran

Source	Total gross amount ('000 tons)	Compostable net amount ('000 tons)	Conversion Factor %	Marketable compost ('000 tons)
Poultry manure	3500	3000	80	2400
Cow Manure	12000	10000	50	5000
Municipal solid waste	6000	4000	15	600
Sugarcane bagasse	2400	500	80	400
Palm waste	1200	500	80	400
Pistachio green peel	250	100	15	15
Tea waste	200	150	50	75
mushroom bed	300	200	80	160
Other cellulosic waste	150	100	75	75
Total	26000	18540		9117

SOC content in top soil layer after 4 years establishment of conservation agriculture in wheat-maize rotation

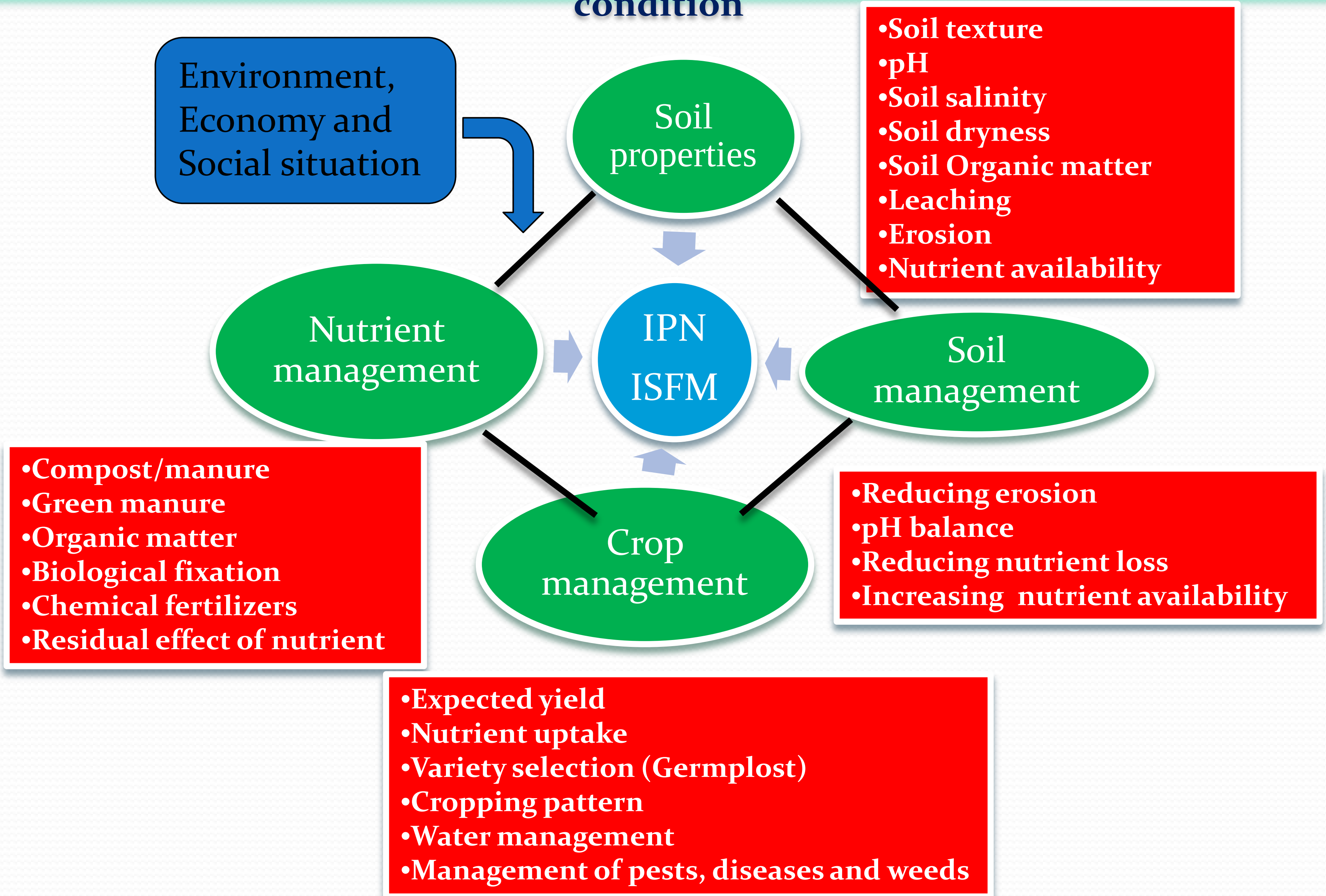


(NT): No till, (MT): Minimum till, (CT): Conventional till, (-R): Without residue, (+R): With residue

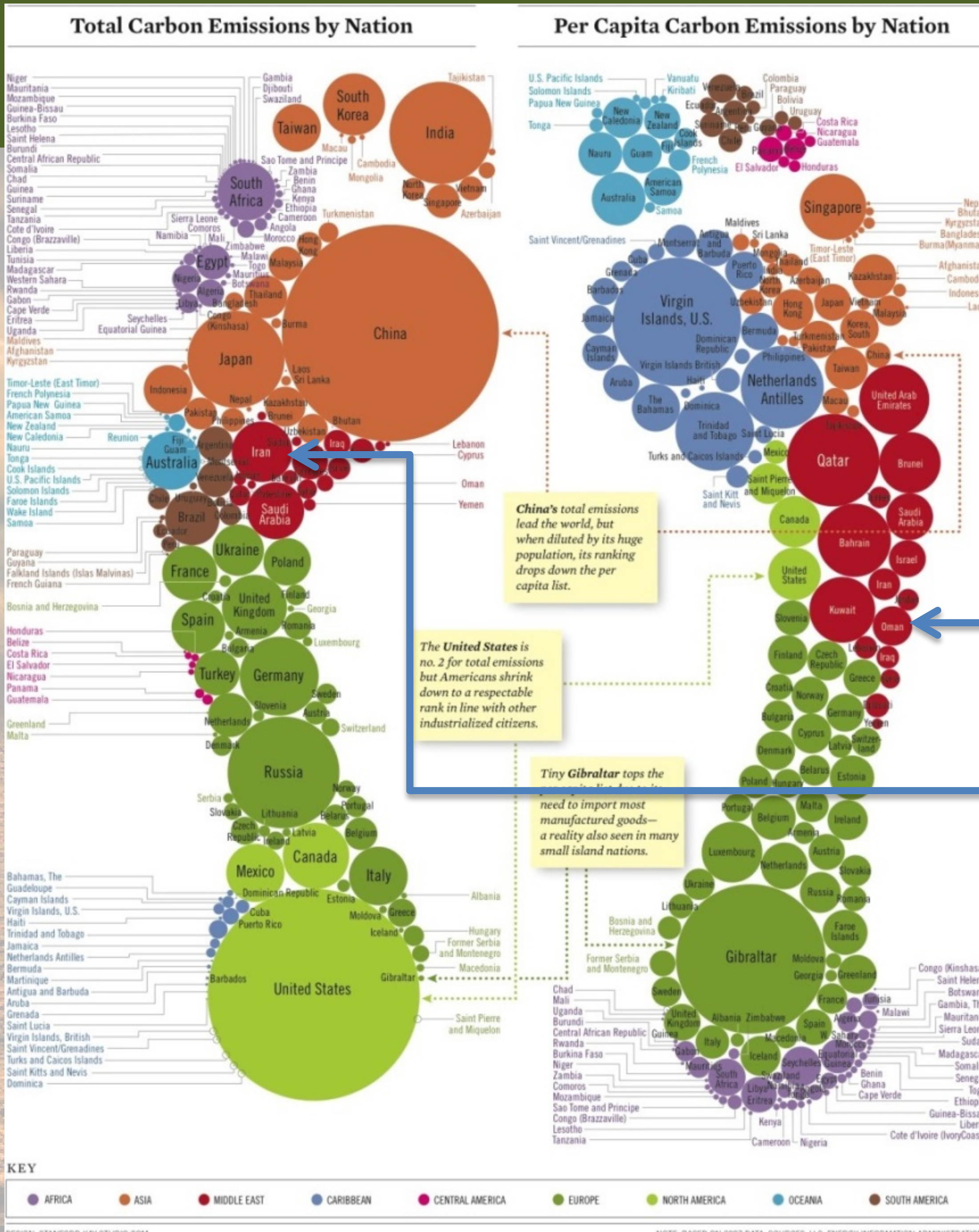
Mirzavand (2015)

Integrated soil fertility and plant nutrition management

(Applying chemical, organic and/or biological fertilizers to meet the plant nutrient needs and embracing the climate, environment and Socio-economic condition

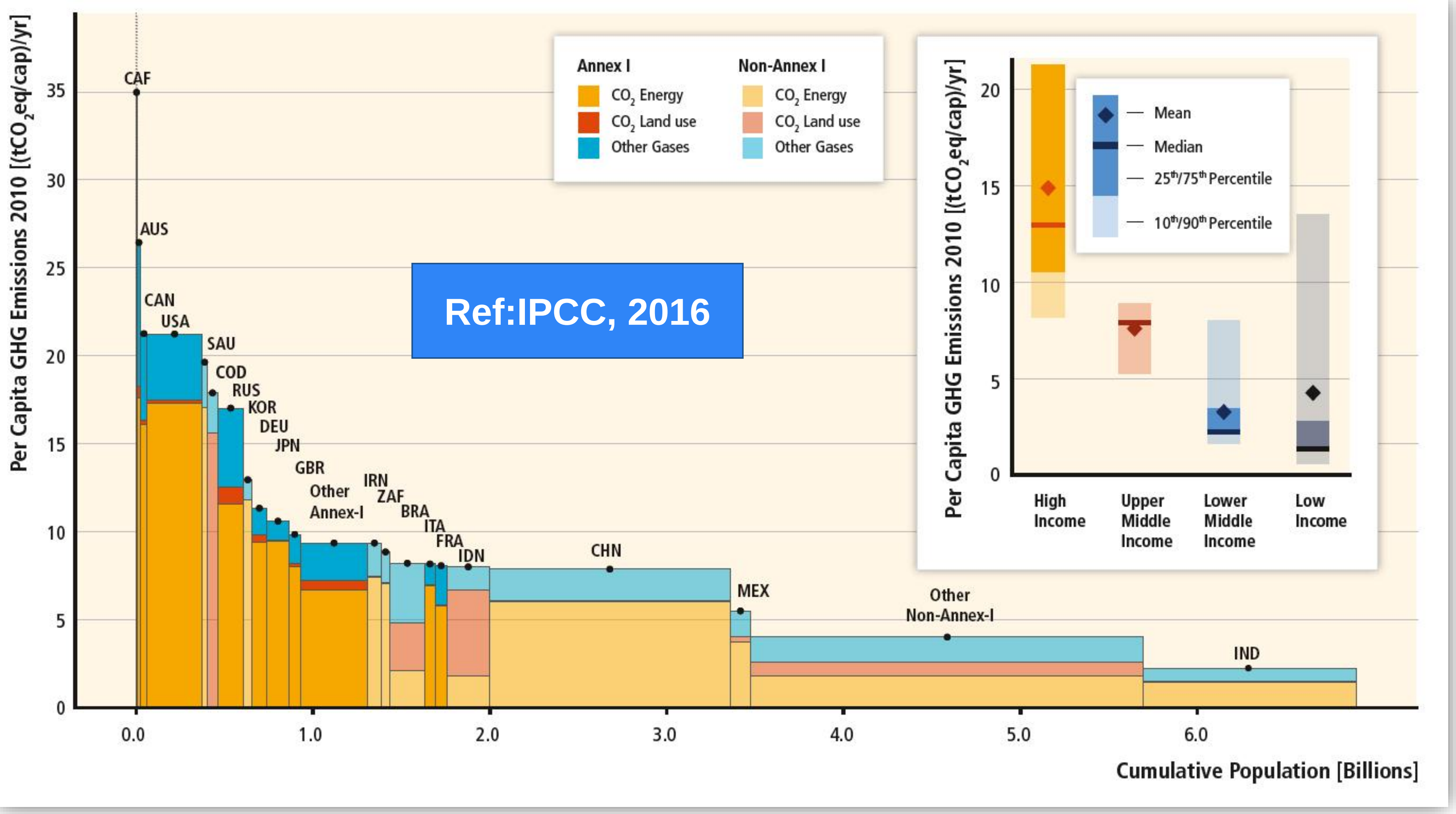


GHG Emissions



Iran

Per Capita Emissions of Different Nations



Ref:IPCC, 2016

Share of agriculture in GDP

Rank	Country	Nominal GDP	Agr. %	Industry %	Services%	Agr. Net	Ind. Net	Services Net
1	India	1,841,710	17.40%	25.80%	56.90%	320,458	475,161	1,047,933
2	Indonesia	894,854	14.30%	46.90%	38.80%	127,964	419,687	347,203
3	Iran	482,445	11.20%	40.60%	48.20%	54,034	195,873	232,538
4	China	9,181,377	10.00%	43.90%	46.10%	918,138	3,611,671	3,792,665
5	Turkey	783,064	8.90%	28.10%	63%	69,693	220,041	493,330
6	World	**71,707,302**	**5.90%**	**30.50%**	**63.60%**	**4,230,731**	**21,870,727**	**45,605,844**
21	Switzerland	622,855	1.30%	27.70%	71%	8,097	172,531	442,227
22	Japan	5,963,969	1.20%	27.50%	71.40%	71,568	1,640,091	4,258,274
23	United States	15,684,750	1.12%	19.10%	79.70%	188,217	2,995,787	12,500,746
24	Germany	3,400,579	0.80%	28.10%	71.10%	27,205	955,563	2,417,812
25	United Kingdom	2,440,505	0.70%	21%	78.30%	17,084	512,506	1,910,915
26	Belgium	513,396	0.70%	21.60%	77.70%	3,594	110,894	398,909

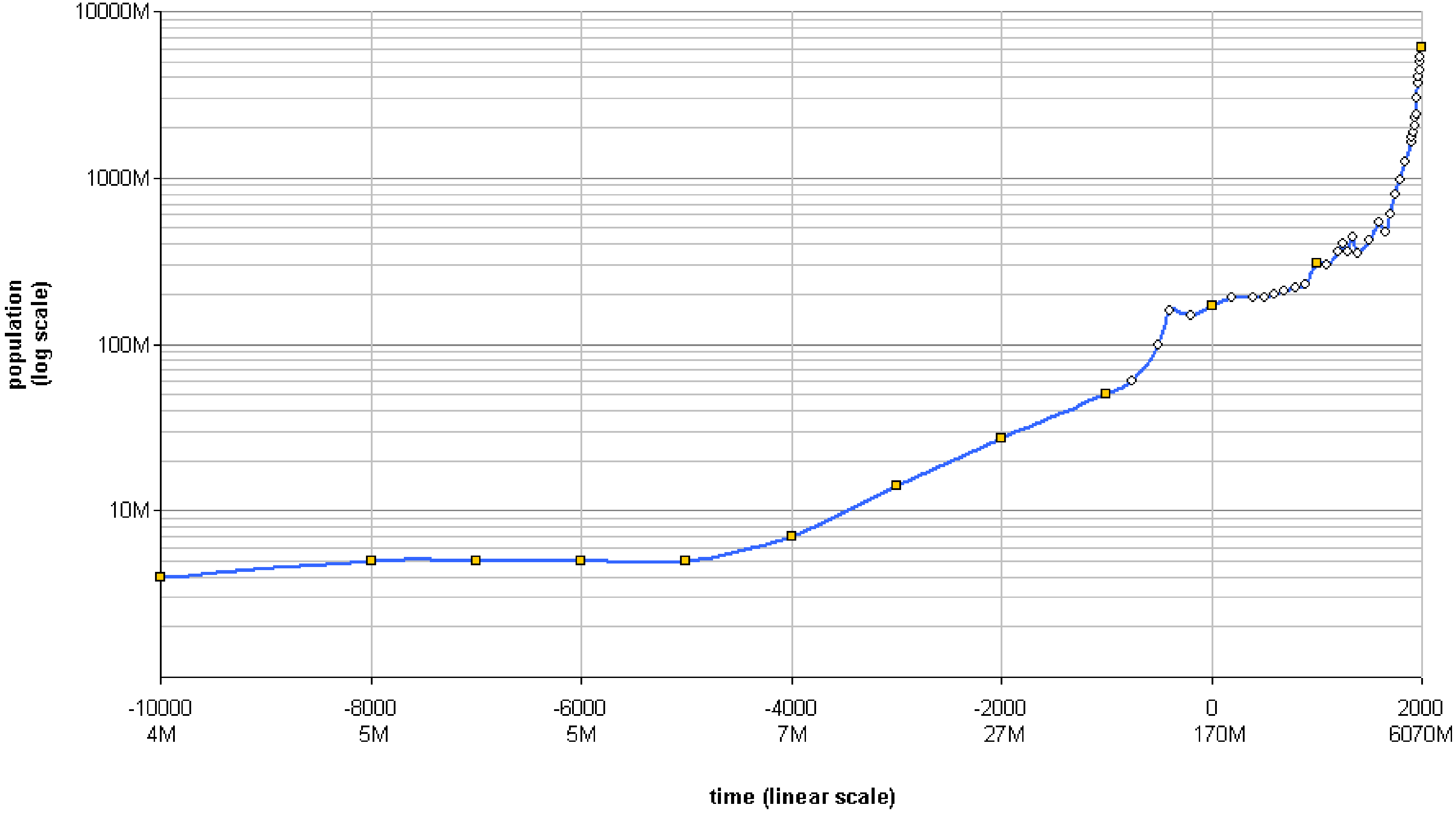
Share of industry in the GDP

Rank	Country	Nominal GDP	Agr. %	Industry %	Services%	Agr. Net	Ind. Net	Services Net
1	Saudi Arabia	657,049	2%	66.90%	31.10%	13,141	439,566	204,342
2	Indonesia	894,854	14.30%	46.90%	38.80%	127,964	419,687	347,203
3	China	9,181,377	10.00%	43.90%	46.10%	918,138	3,611,671	3,792,665
4	Iran	482,445	11.20%	40.60%	48.20%	54,034	195,873	232,538
5	South Korea	1,151,271	2.70%	39.80%	57.50%	31,084	458,206	661,981
22	Netherlands	770,224	2.80%	24.10%	73.20%	21,566	185,624	563,804
23	Belgium	513,396	0.70%	21.60%	77.70%	3,594	110,894	398,909
24	United Kingdom	2,440,505	0.70%	21%	78.30%	17,084	512,506	1,910,915
25	United States	15,684,750	1.12%	19.10%	79.70%	188,217	2,995,787	12,500,746
26	France	2,608,699	1.90%	18.30%	79.80%	49,565	477,392	2,081,742

What Happened Around 4200 B.C.

- Copper 4200 B.C.
- Silver 4000 B.C.
- Lead 3500 B.C.
- The first Gravity Dam by Egyptians 2750-2950 B.C.
- Bronze Age 2300-700 B.C.
- Nimrod Earth Dam in Mesopotamia 2000 B.C.
- Tin 1750 B.C.
- Iron 1500-1200 B.C.
- The first Qantas well, constructed by Iranians 1000 B.C.
- The oldest existing Qantas 700 B.C.
- Persian Empire starts 550 B.C.
- Alexander attacks Persian Empire 220 B.C.
- The first Roman Concrete and Mortar Dam 100 A.D.
- Bridge Dam: Band-e Qaisar 200-300 A.D.
- First Record of Windmills 1185 A.D.
- The first Arch Dam in Qom: Kebar 1280 A.D.
- Steam Engine 1712 A.D.
- Movement of large modern dams' constructions in 1849 A.D. Coal, HC, Gold Rush
- Oil discovery at Oil Creek Pennsylvania in 1859 A.D.
- The first large Dam Aswan on Nile River 1899-1902 A.D.
- The largest Concrete Dam: Hoover Arc-Gravity Dam 1931-1936 A.D.

Estimated world population figures, 10,000 BCE–2000 CE (in log y scale)



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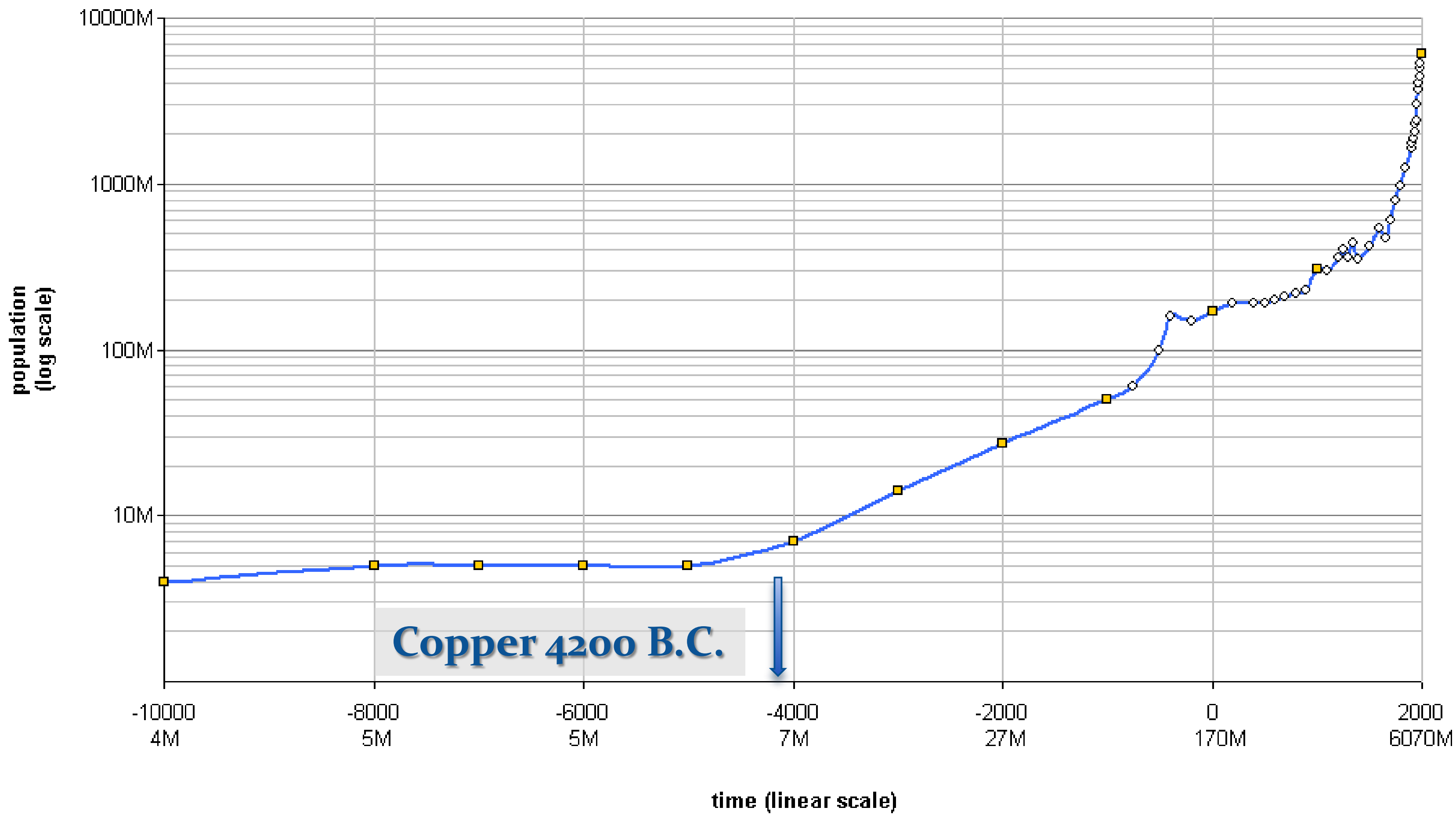

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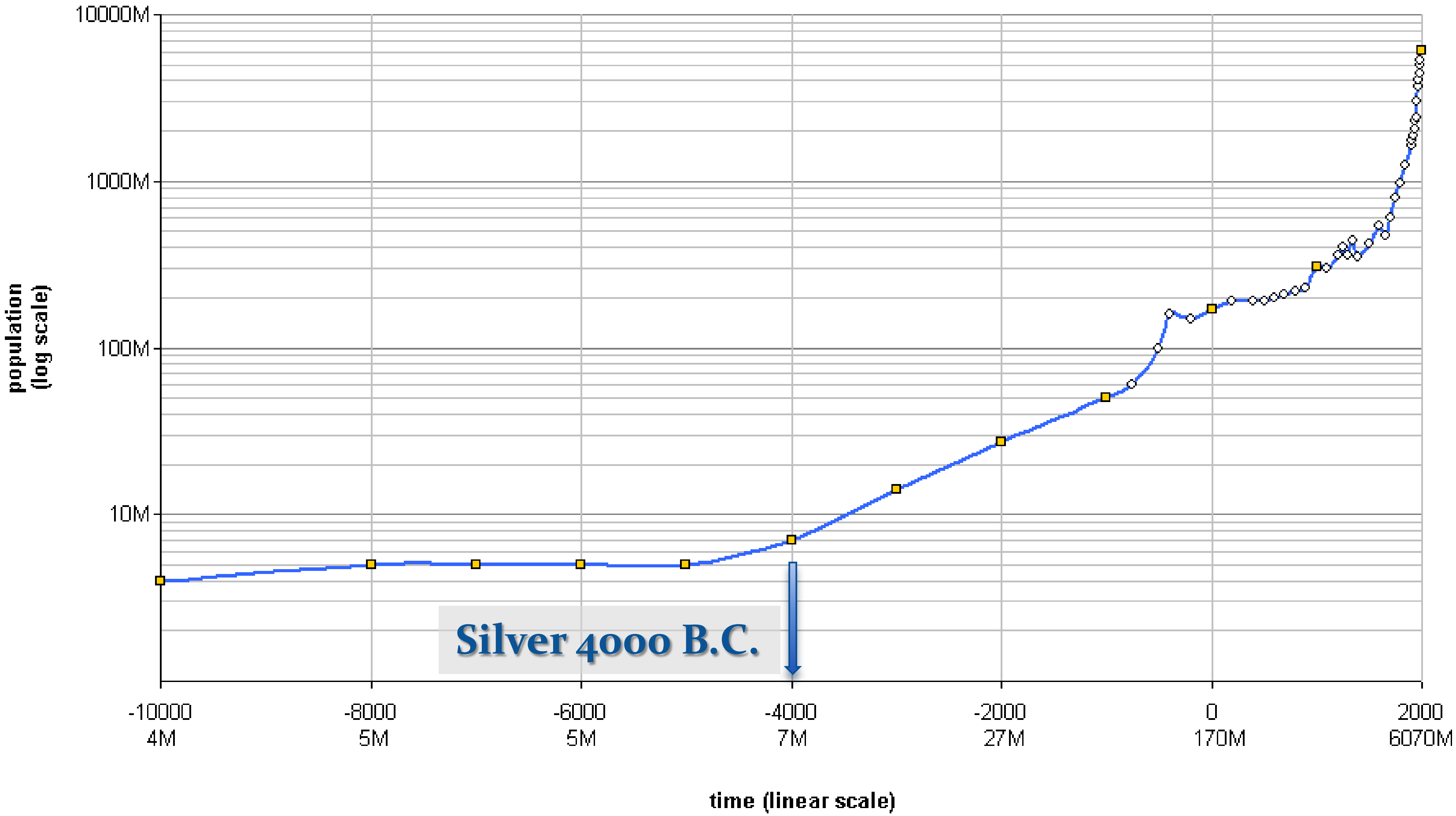
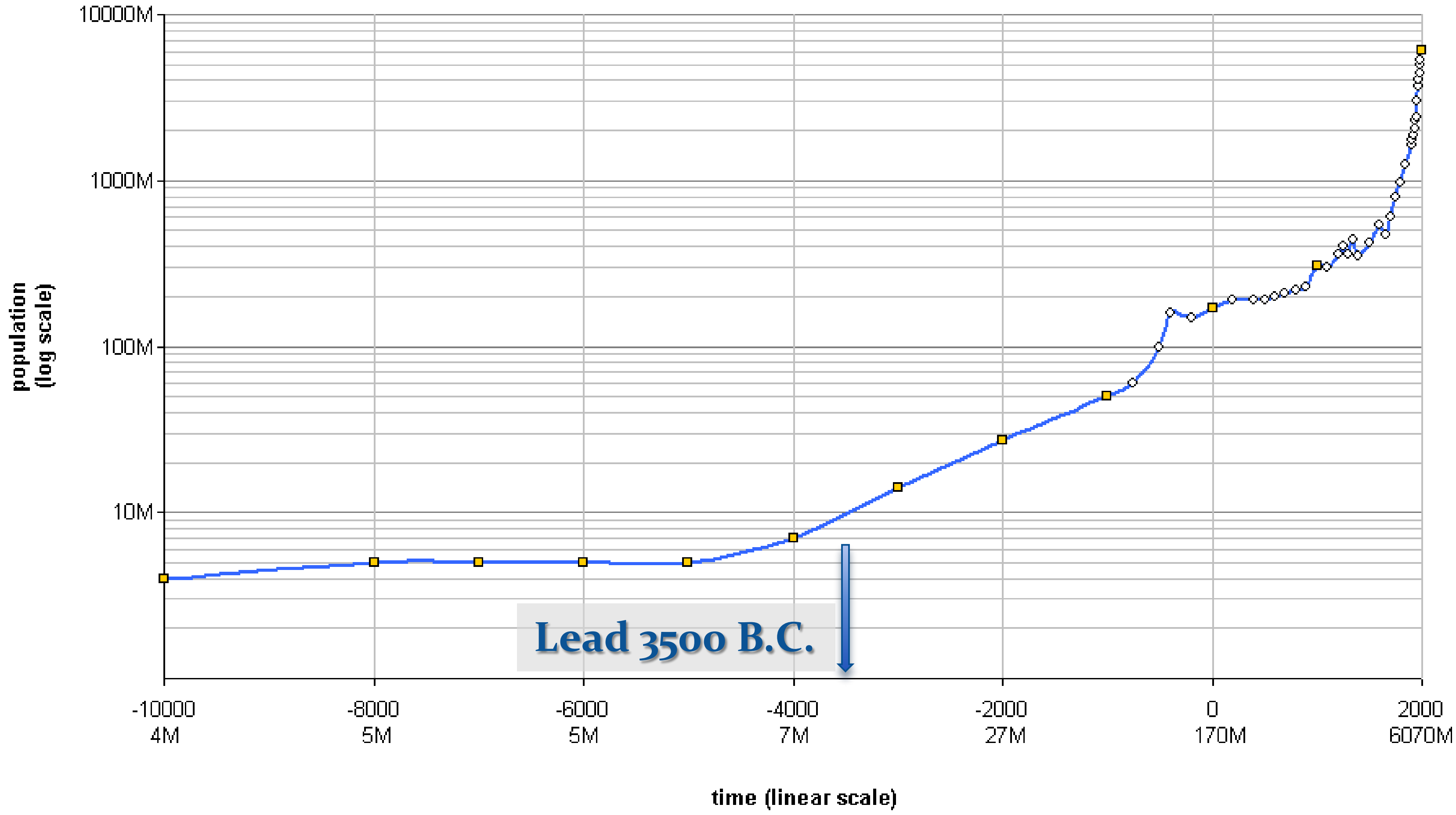


Estimated world population figures, 10,000 BCE–2000 CE (in log y scale)



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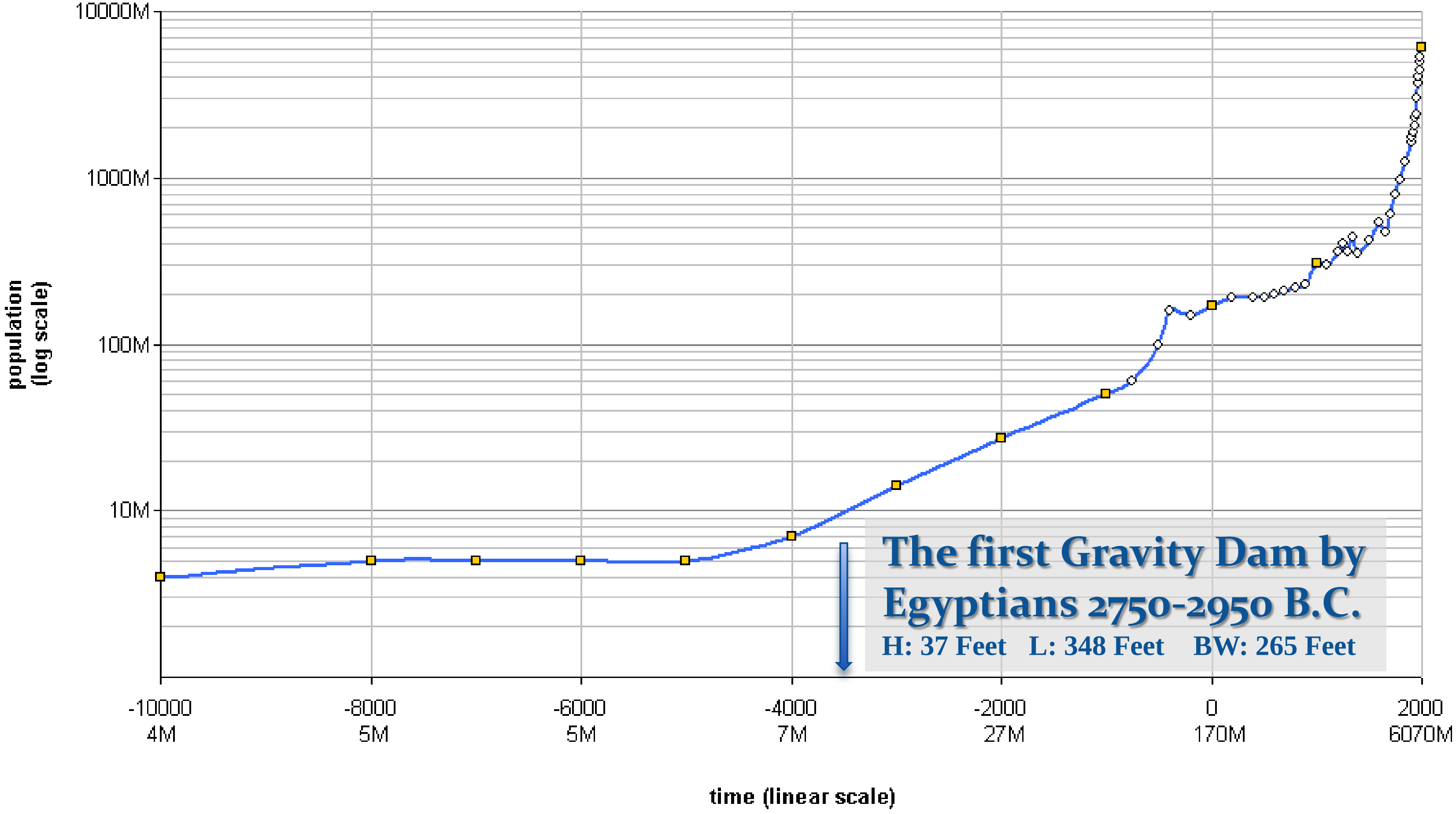

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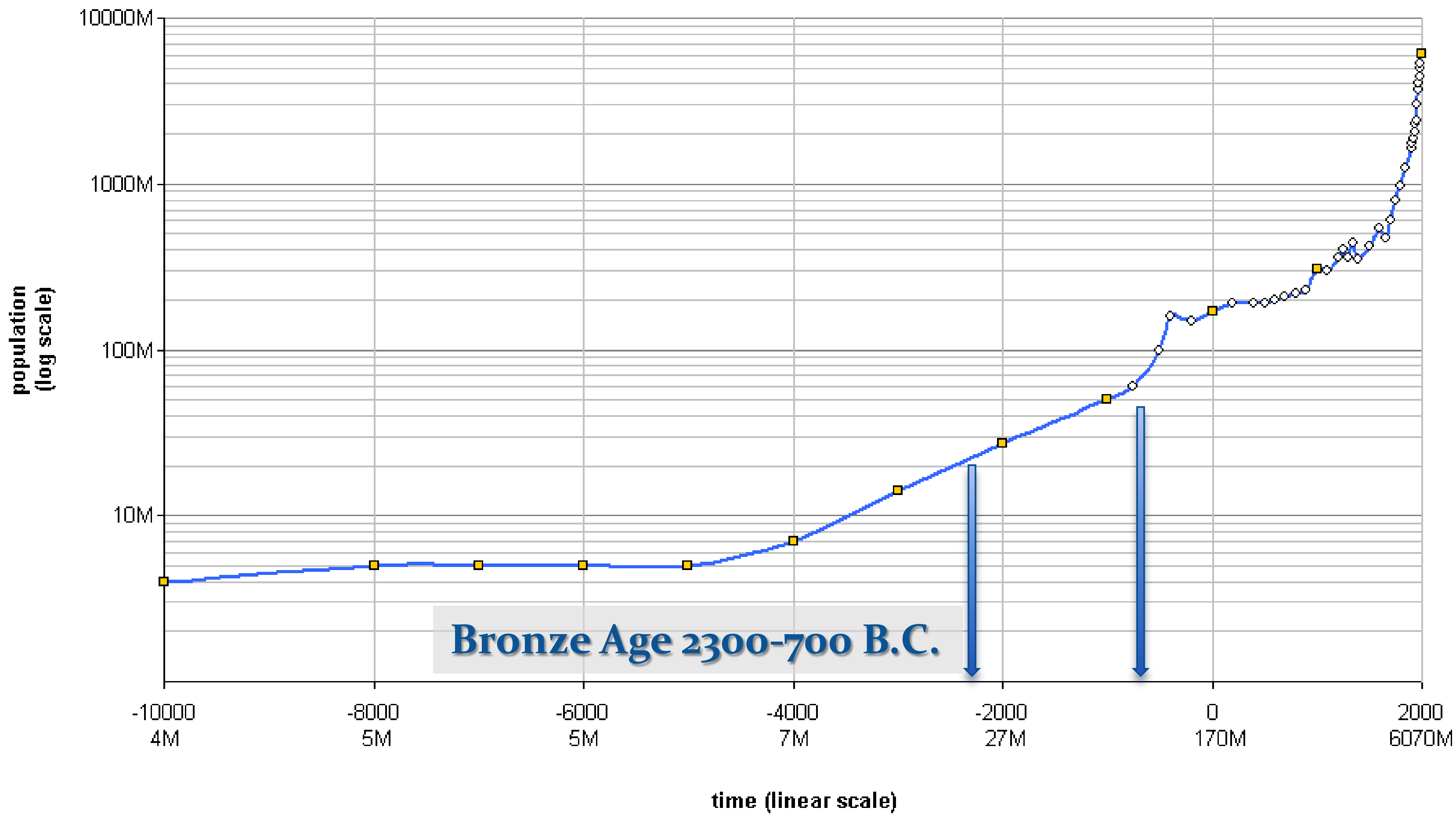

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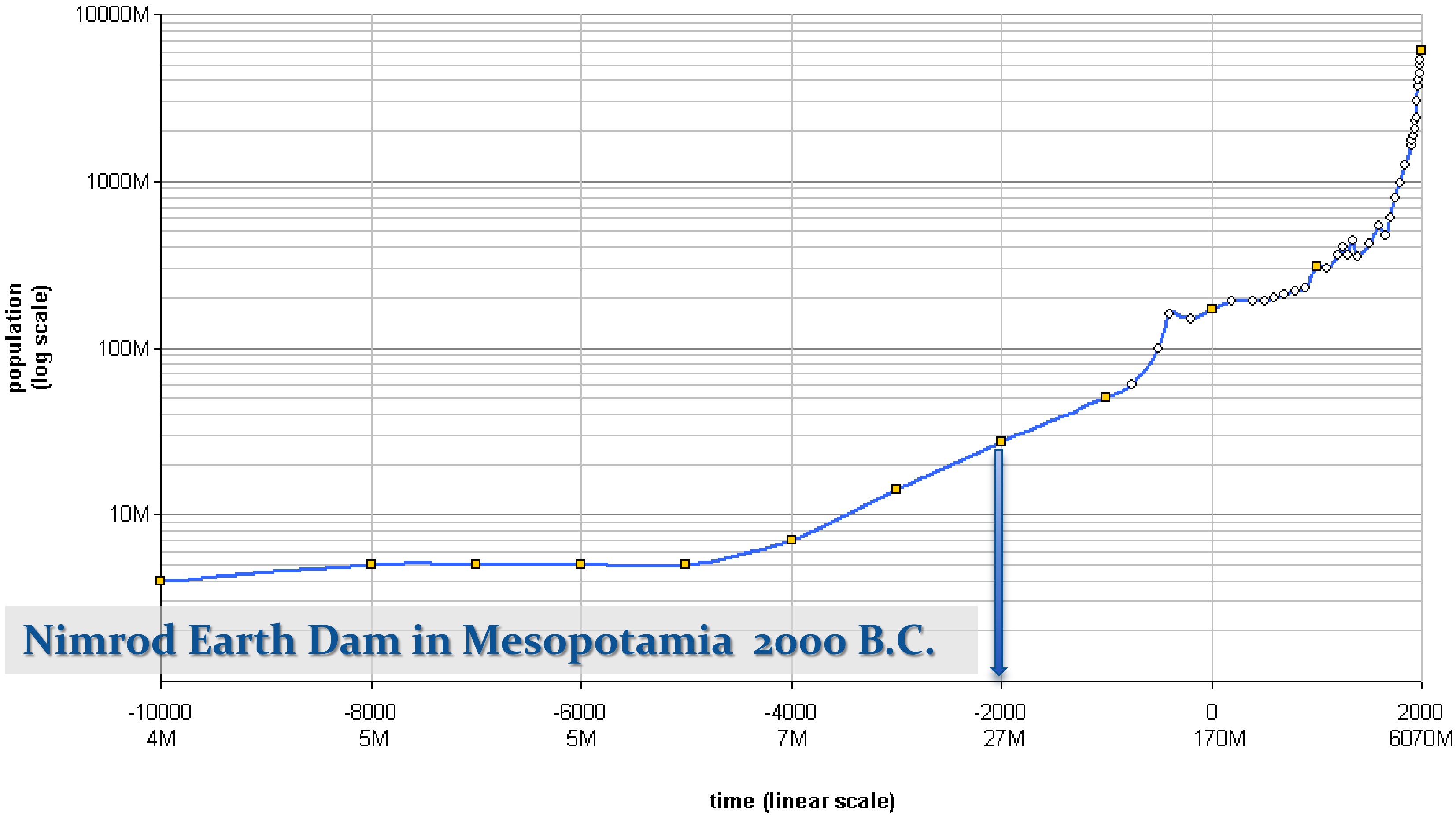

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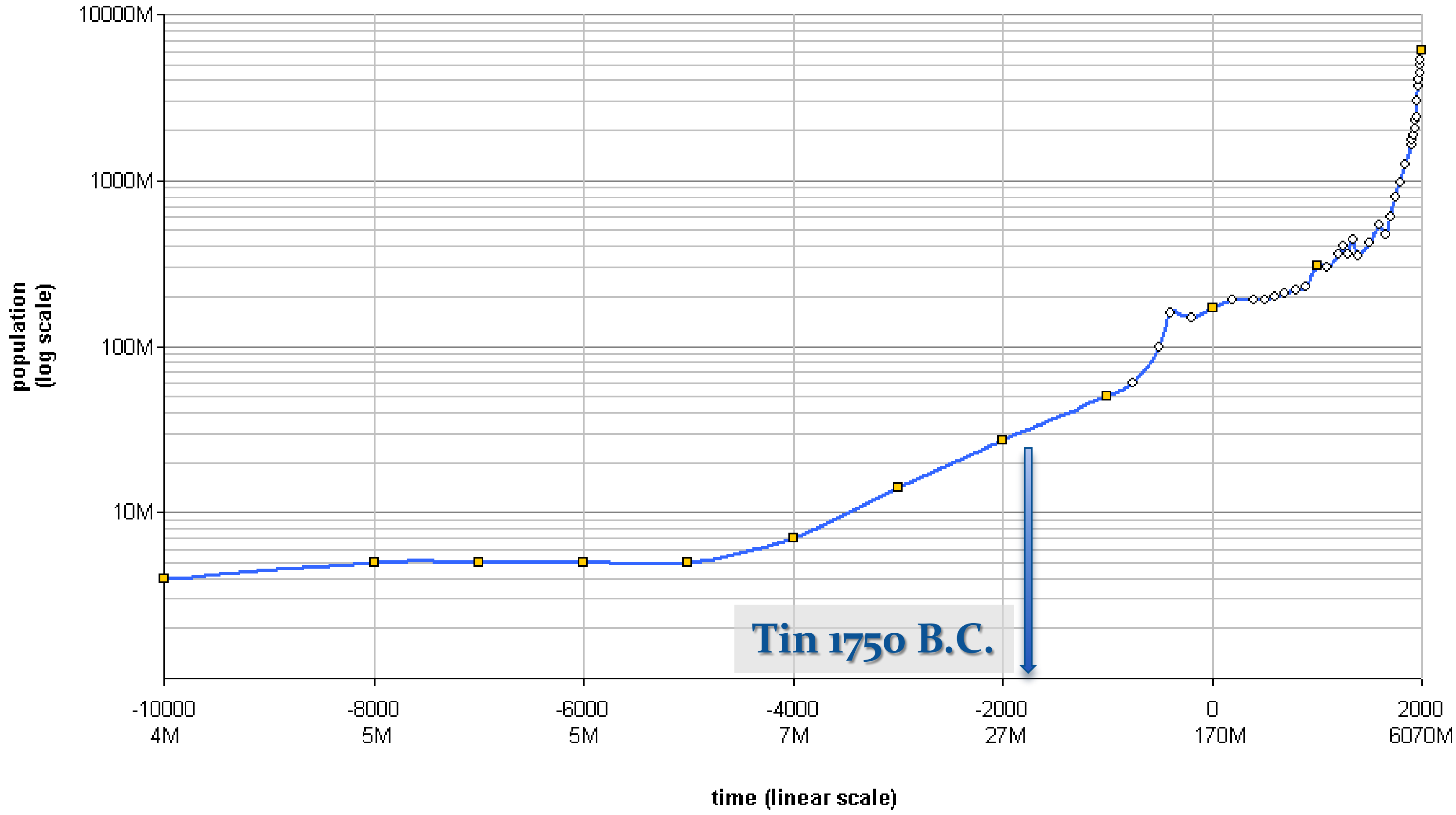

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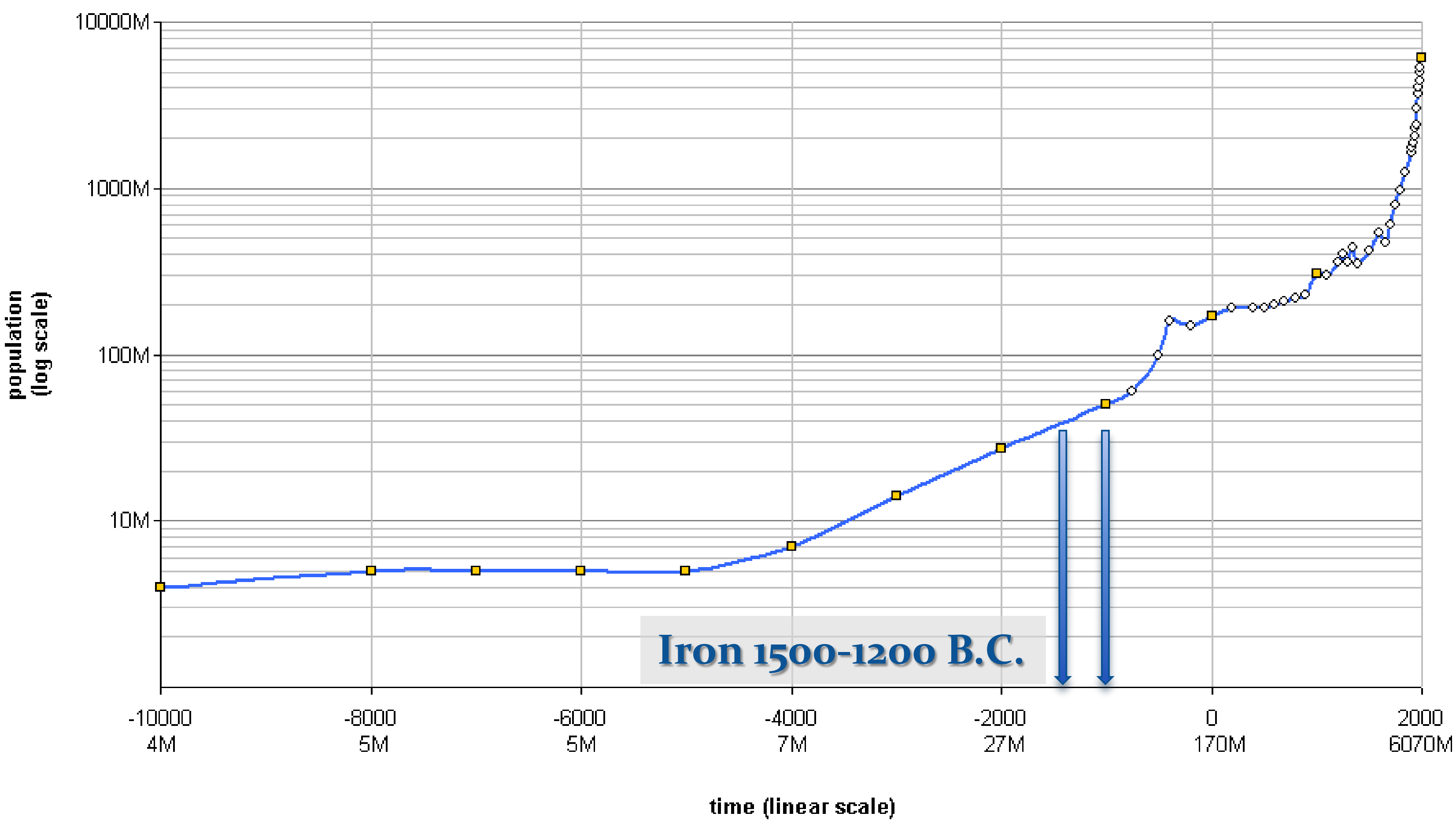

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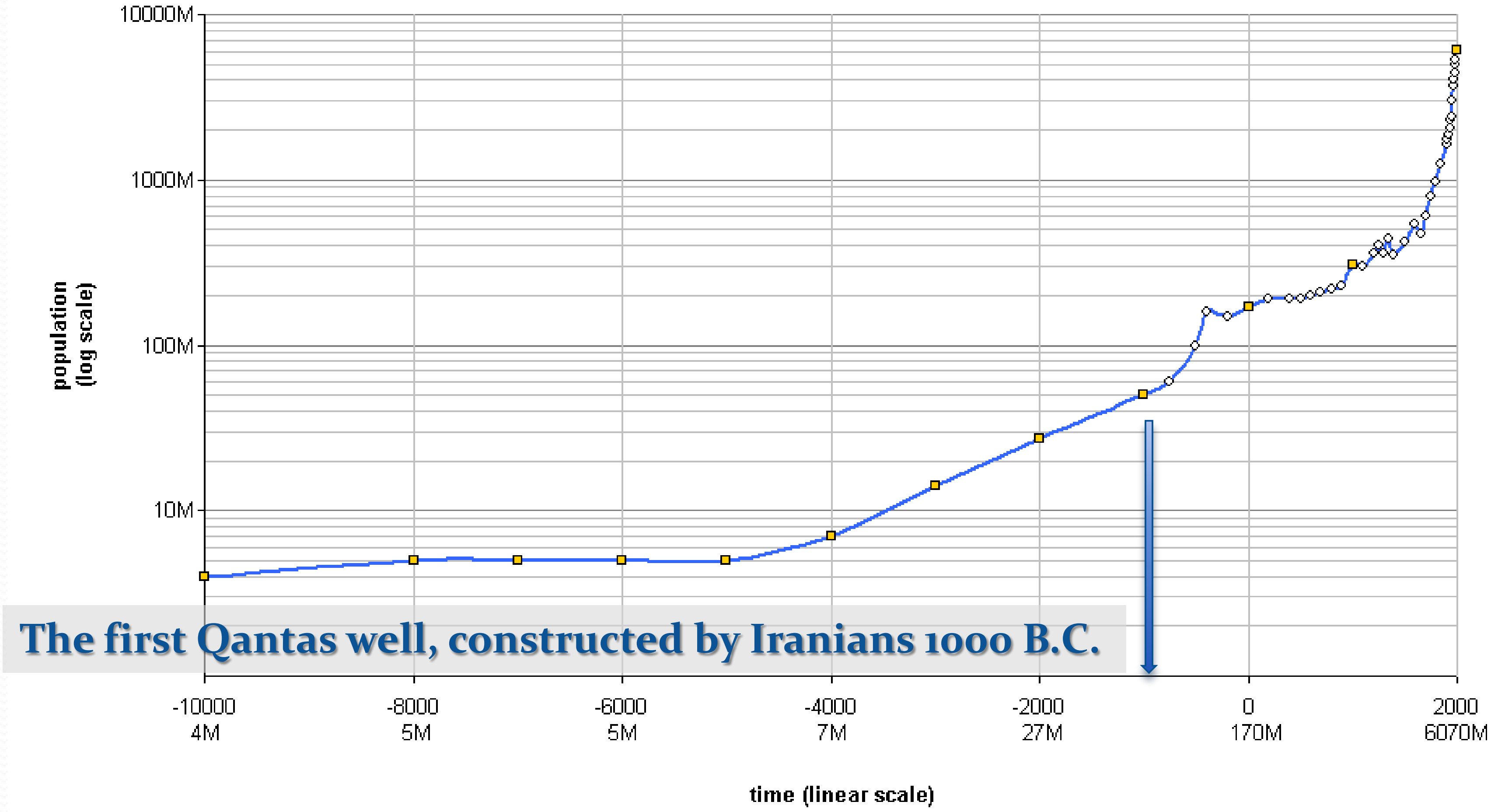

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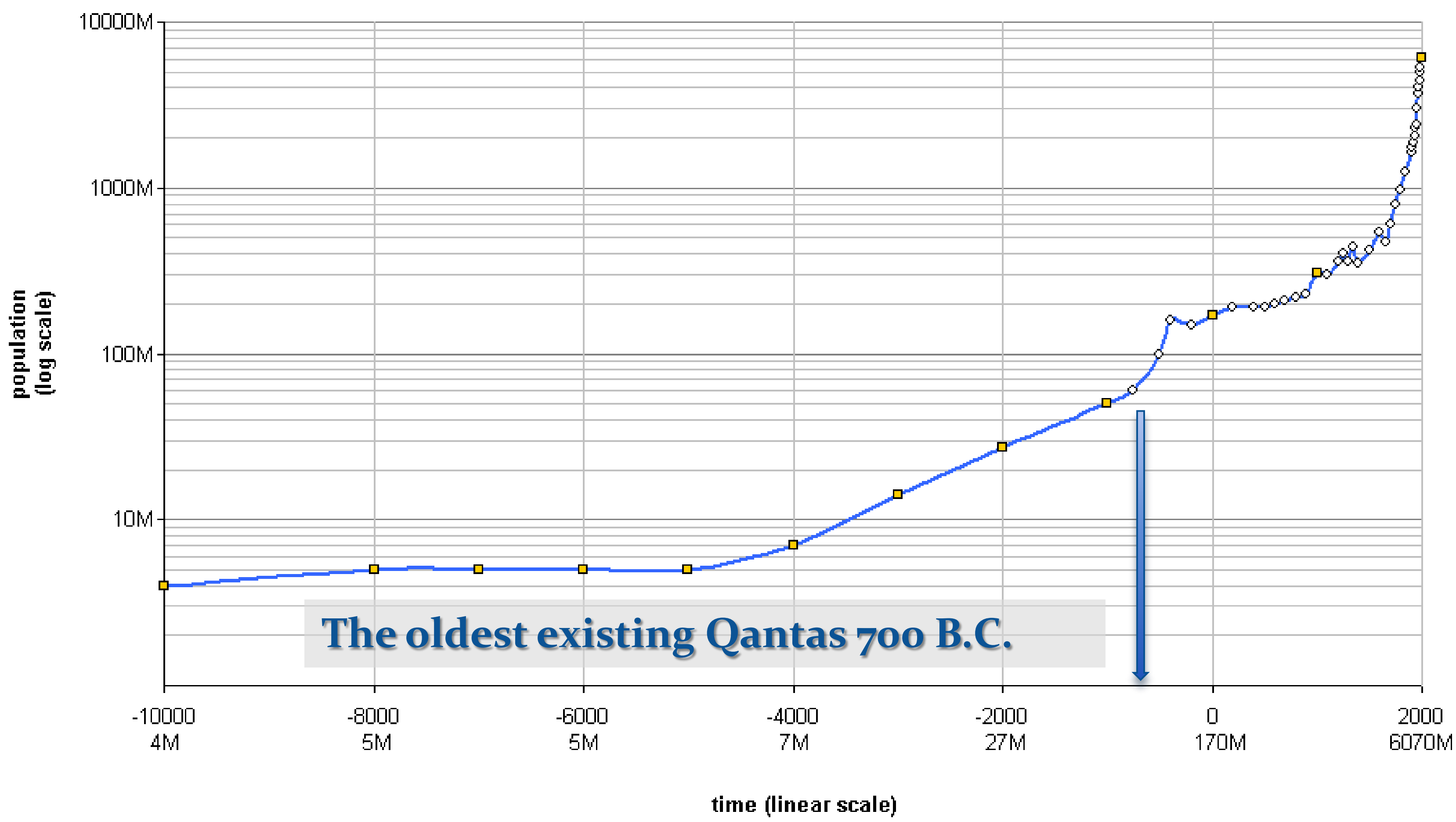

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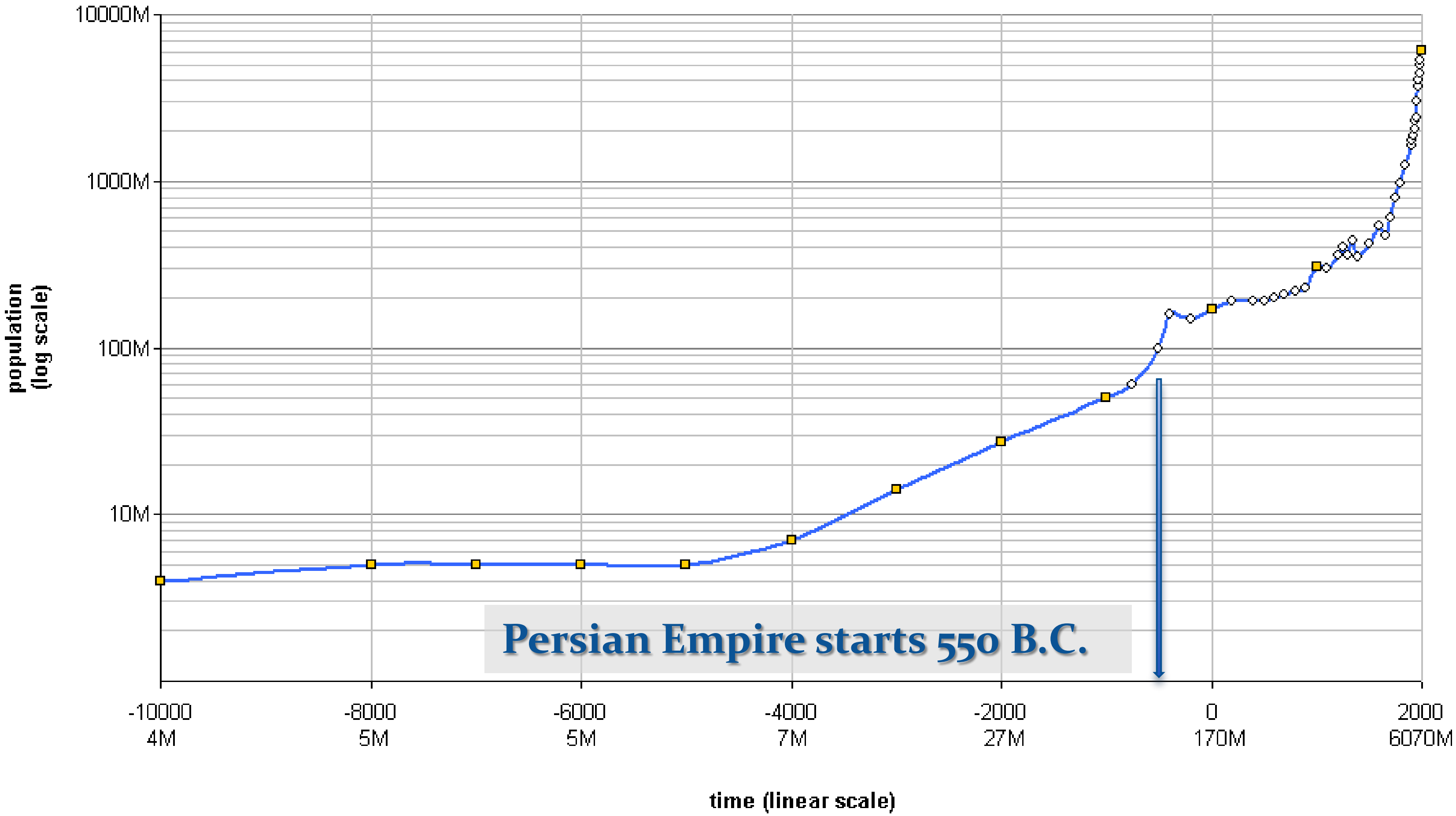

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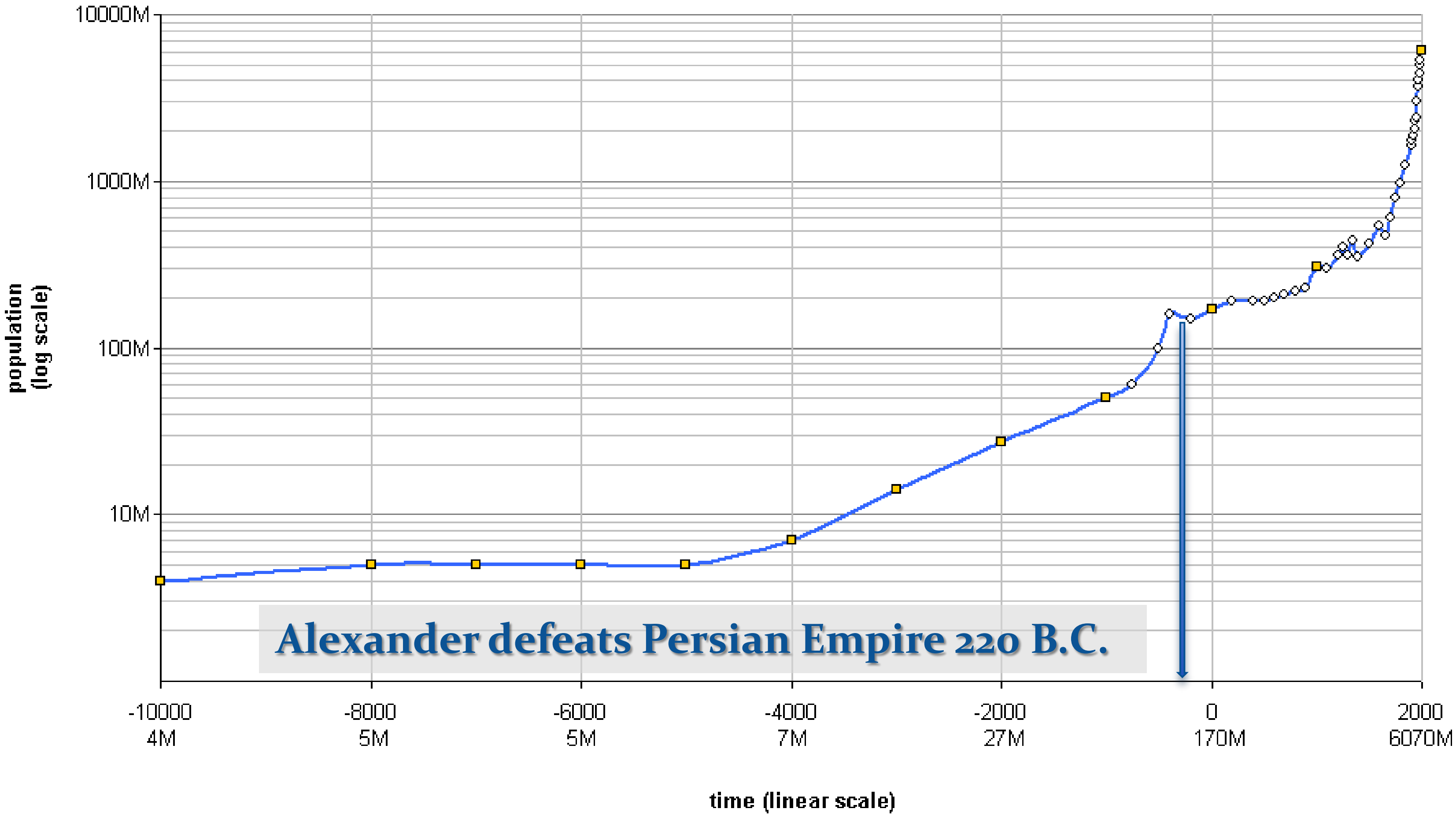

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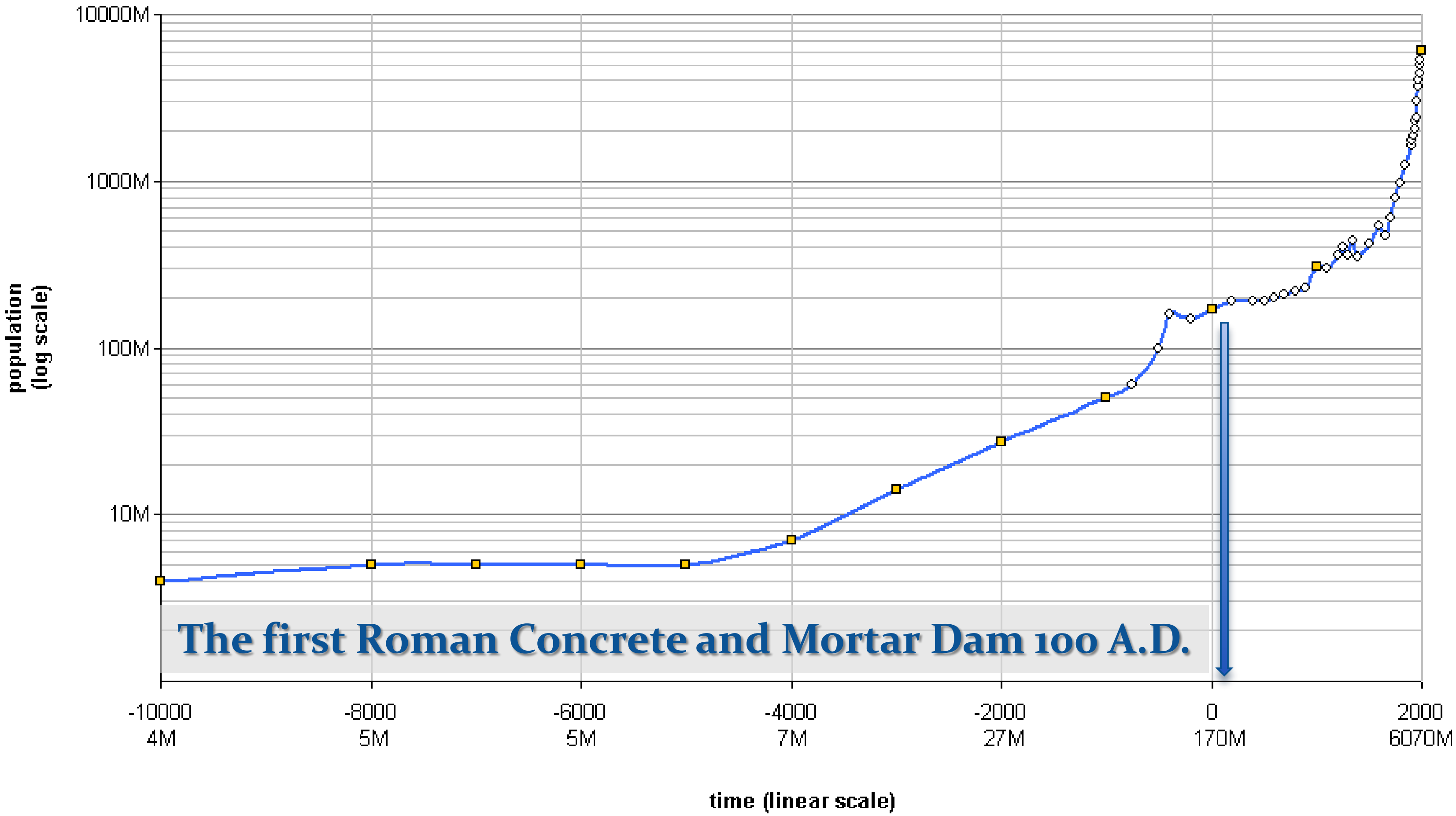

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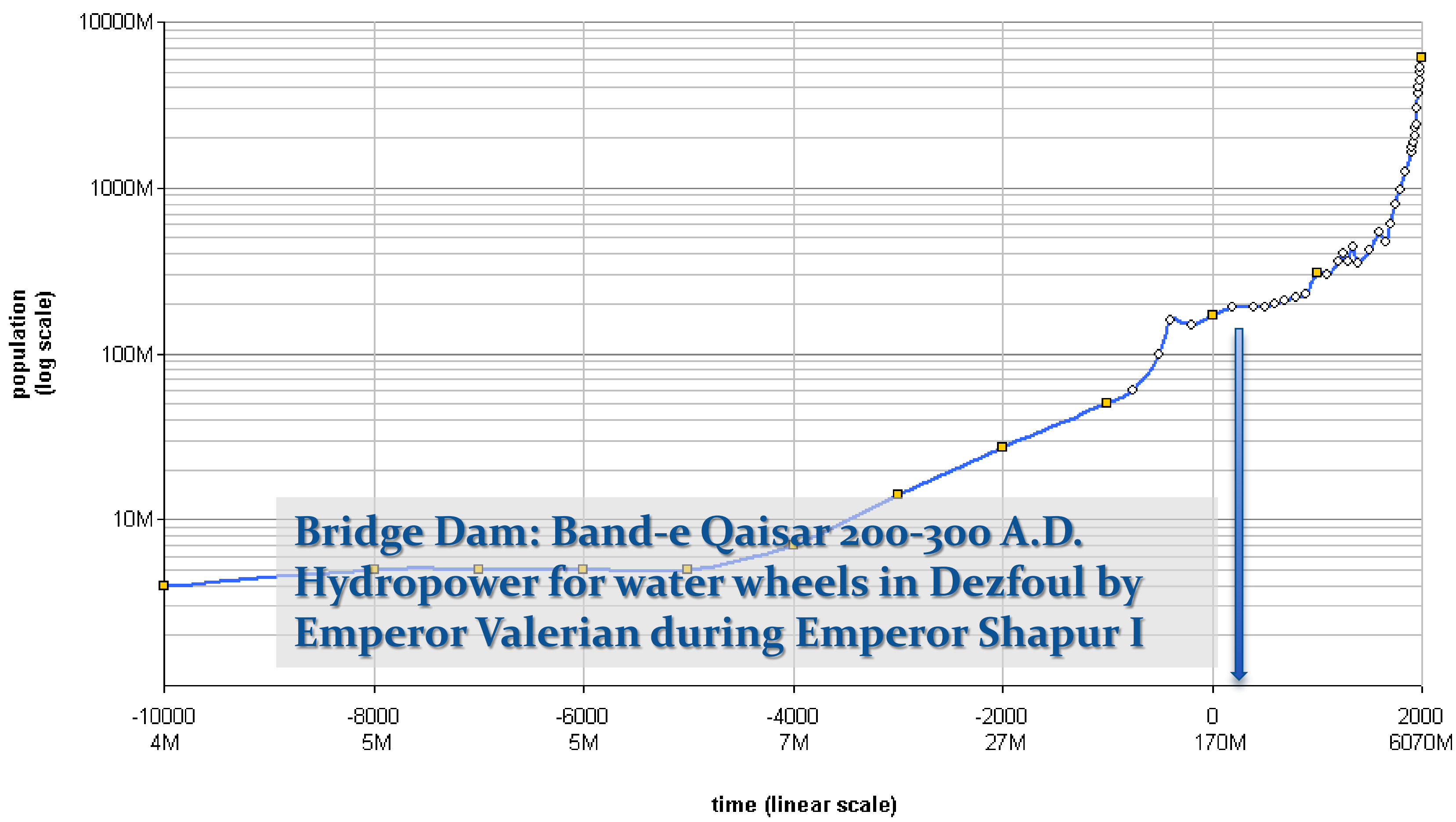

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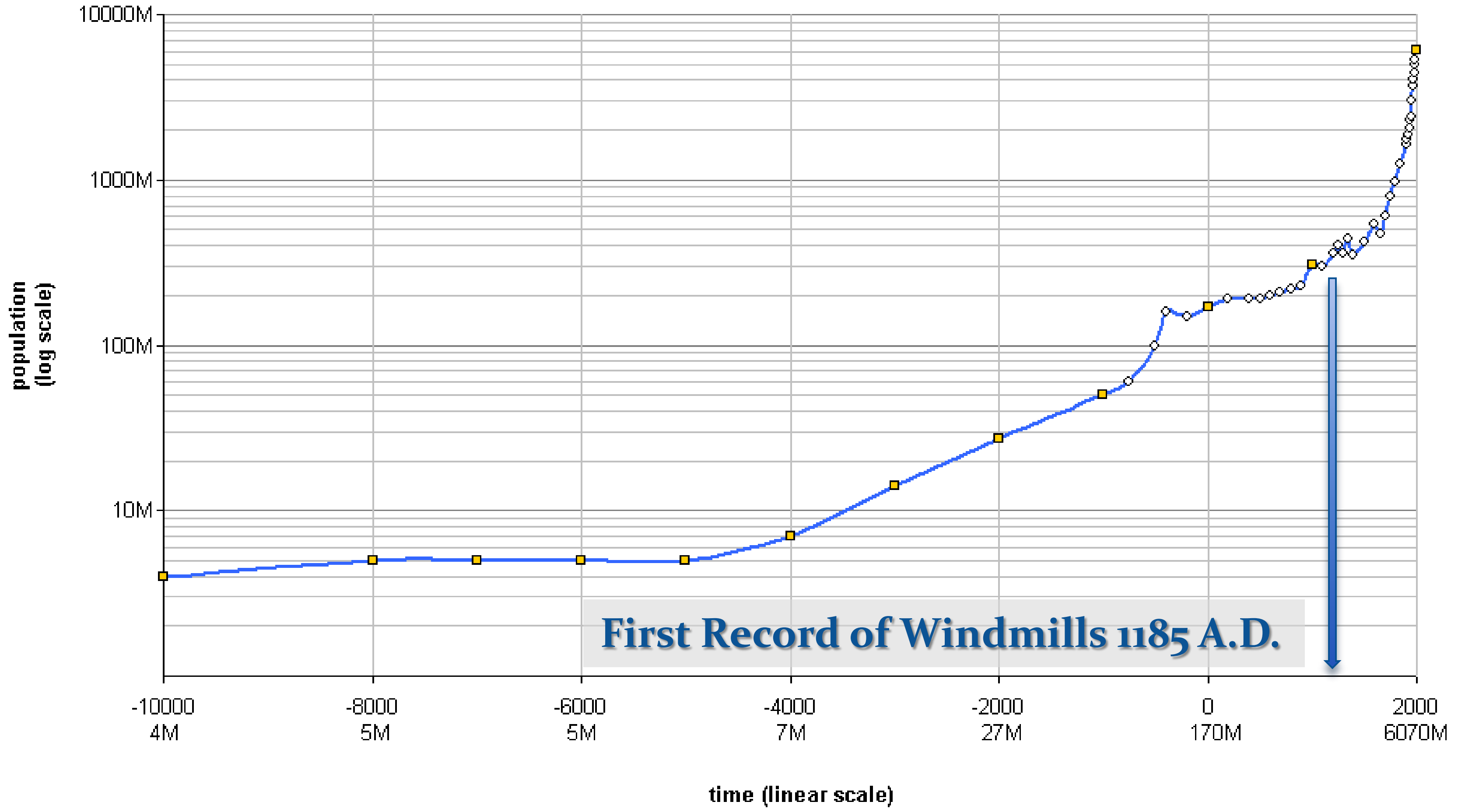

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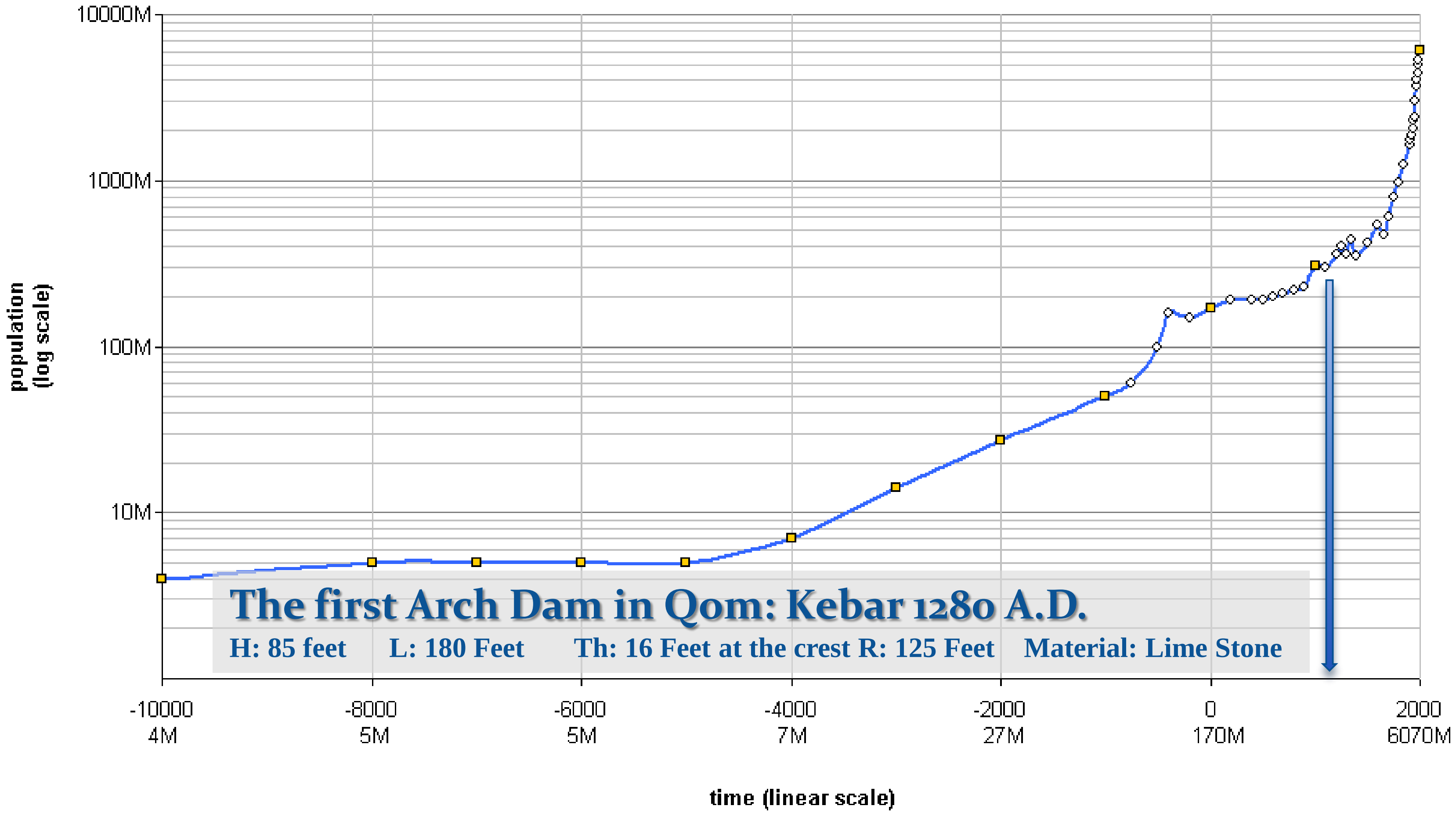

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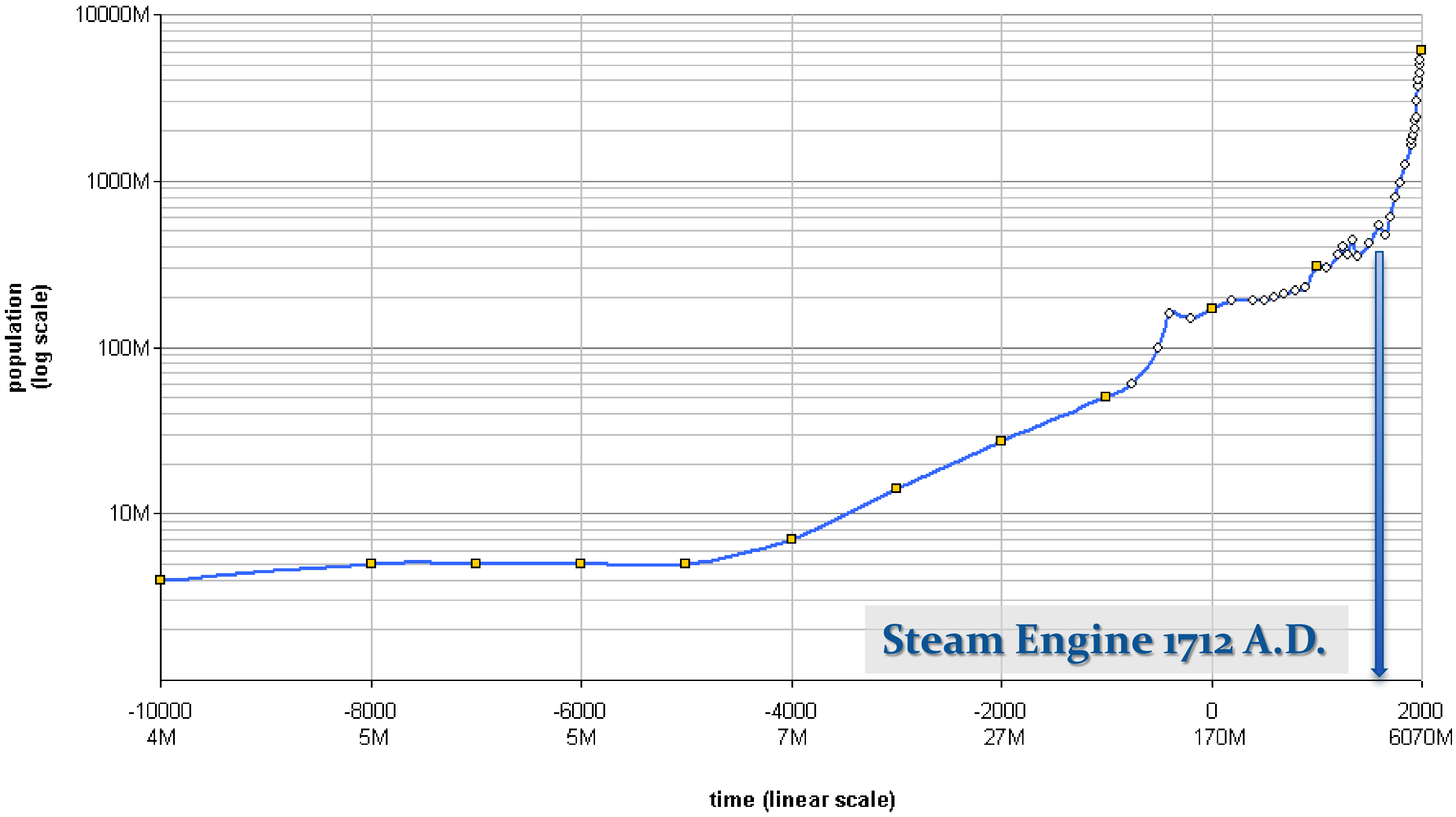

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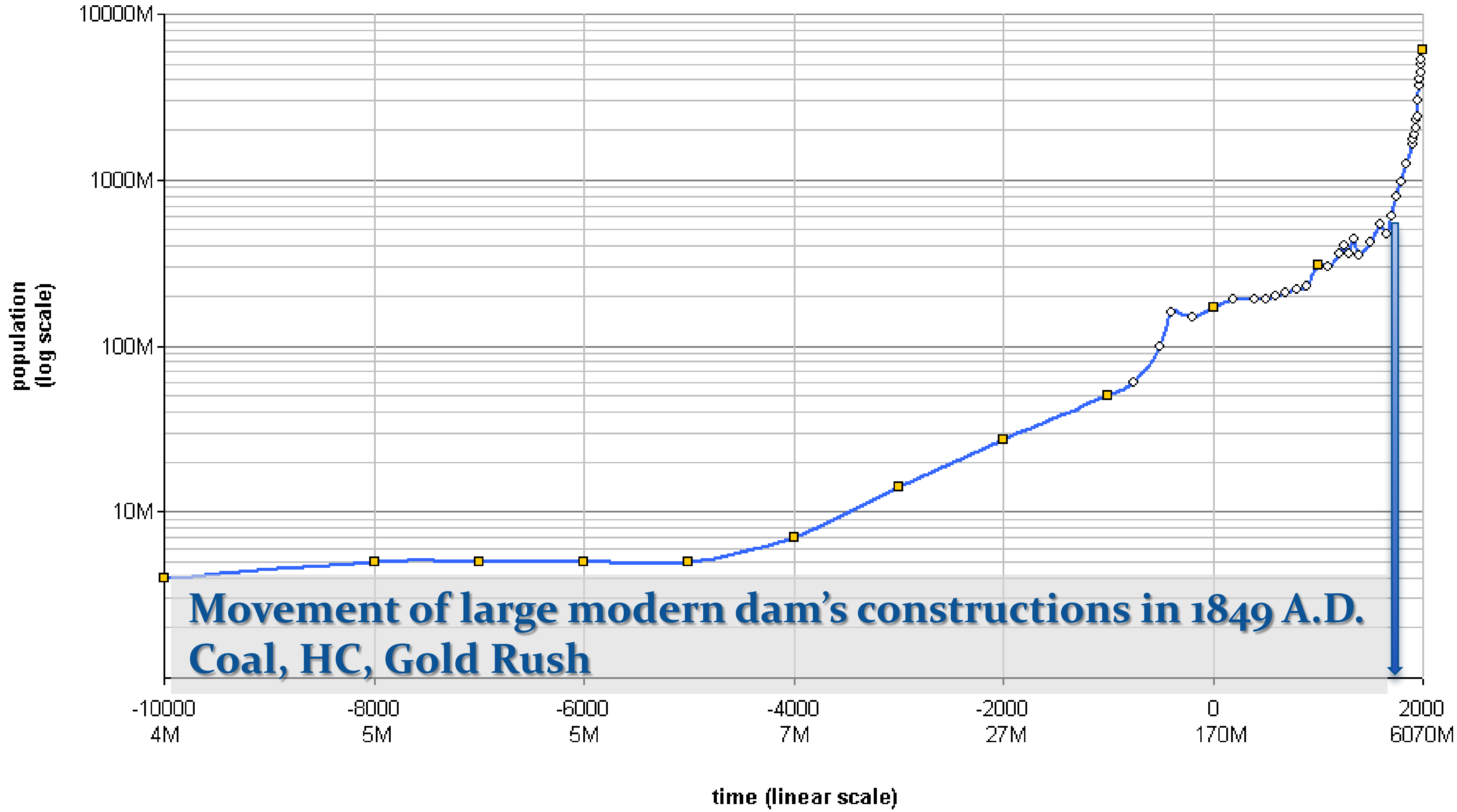

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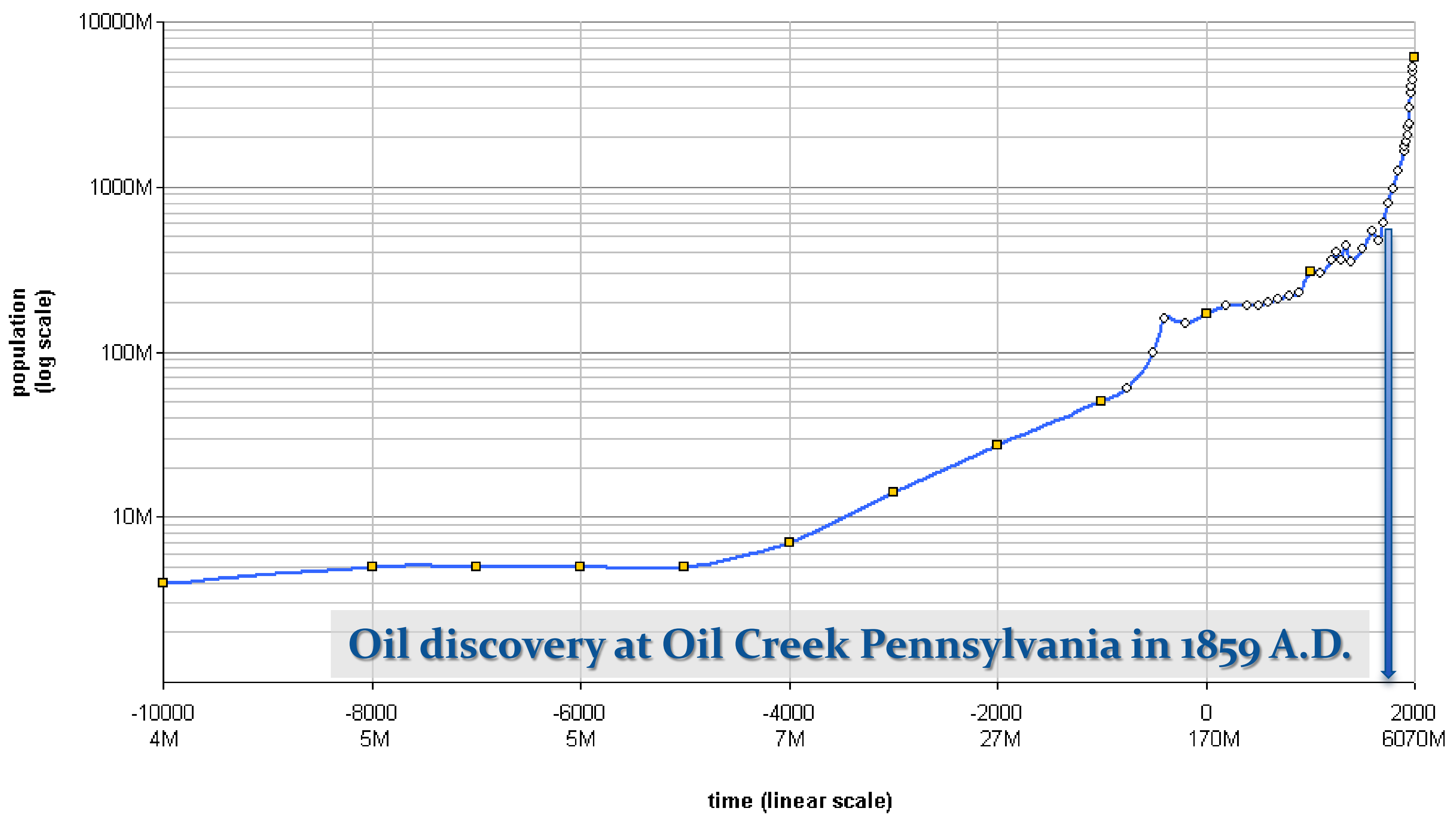

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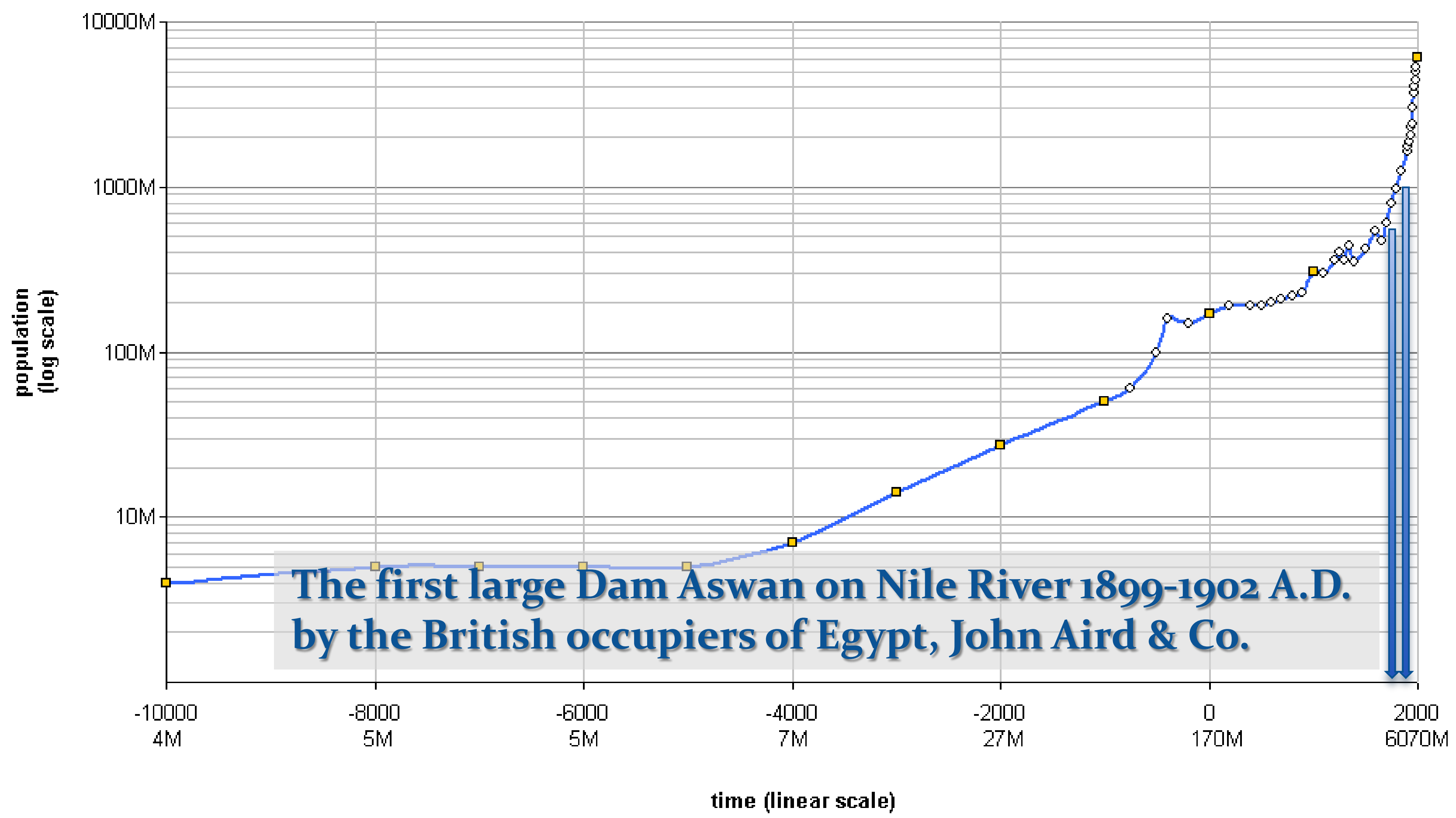

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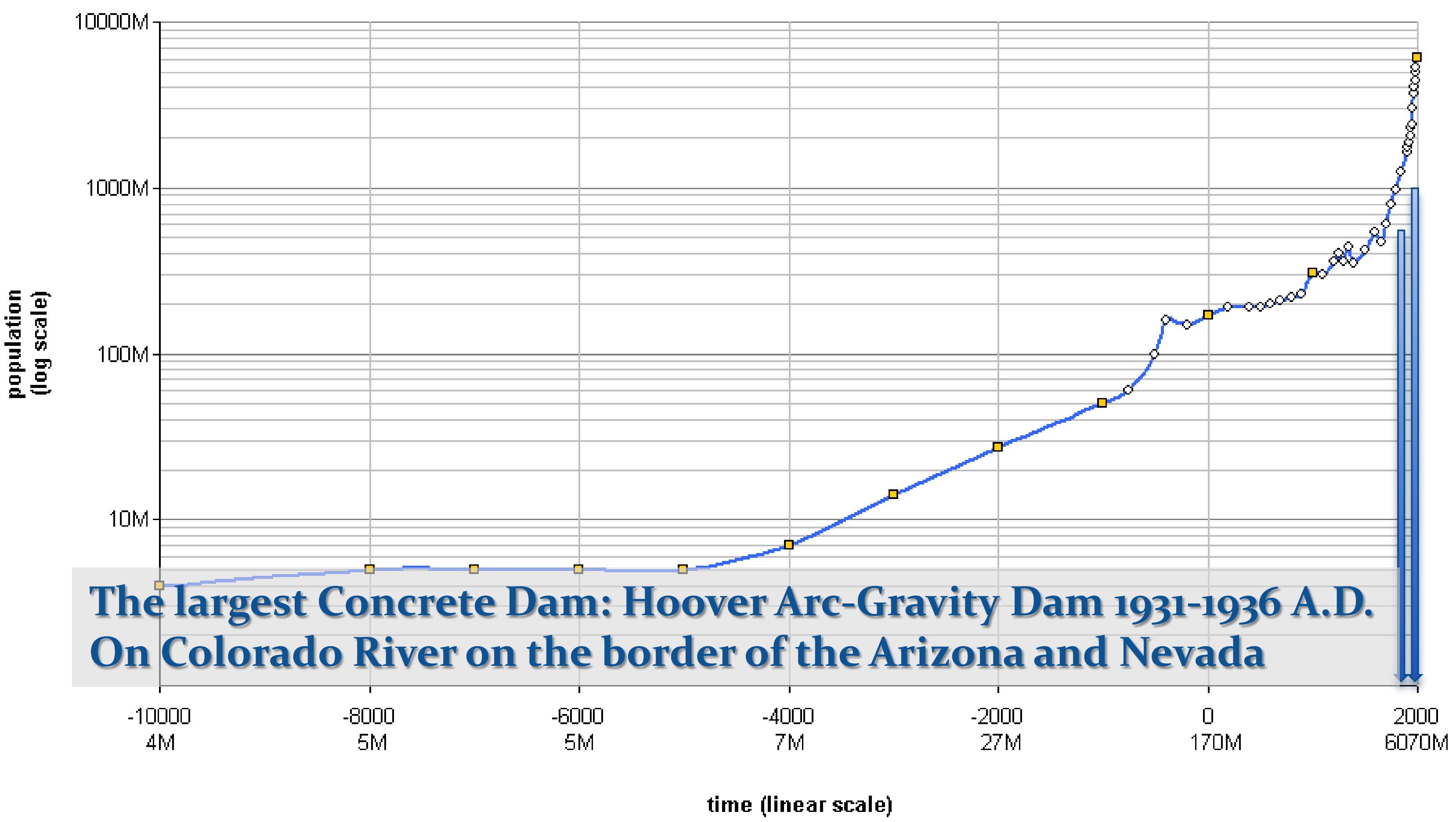

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- And, Of course very Special Thanks to Professor Lutz Mez for tirelessly continuing the Incredible Energy Forum year after year for so long!

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