THE OHIO STATE UNIVERSITY

Evolution of Conservation Agriculture

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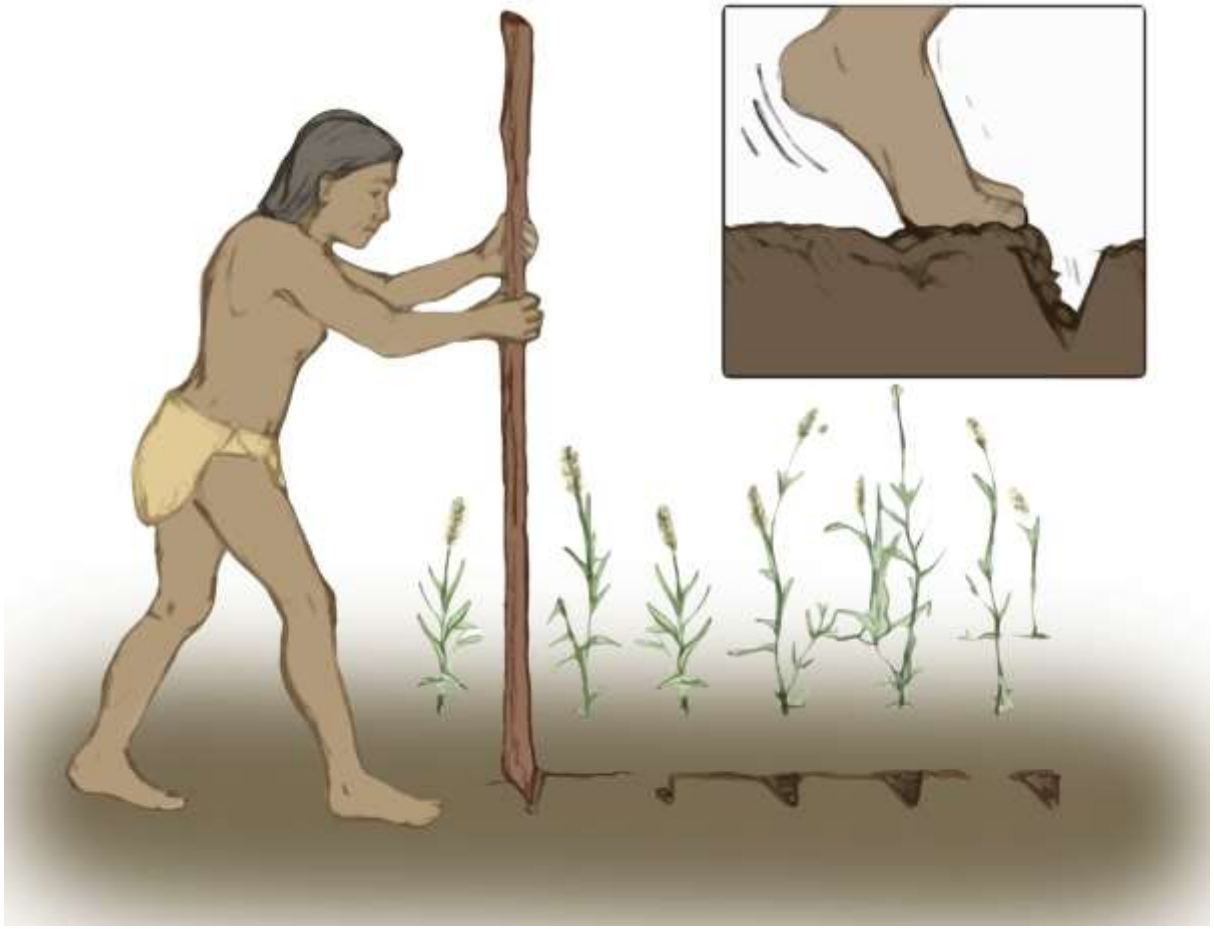
Evolution of Agriculture

10 to 12 Millennia B.P.

Planting stick to cover the seed



10 to 12 Millennia B.P.

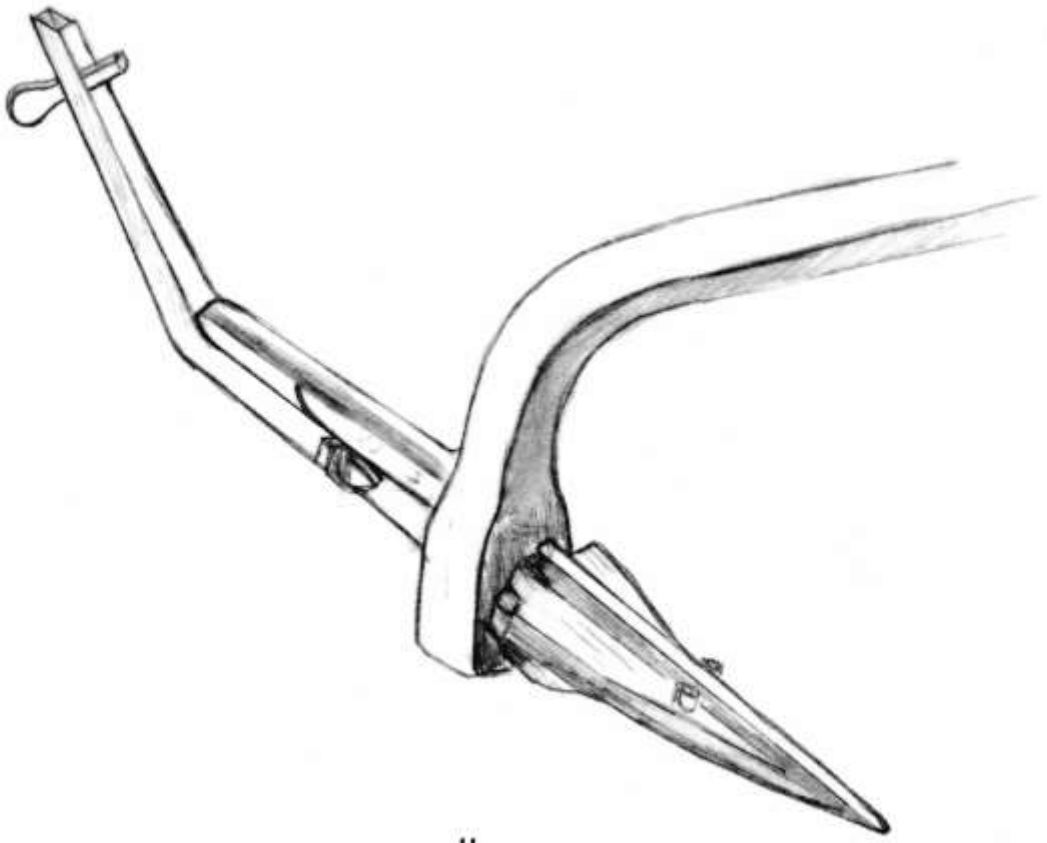
The “ard” was a paddle-shaped digging tool.

6 to 8 Millennia B.P.

Hand tools to create a loose soil laver and eradicate weeds

6 to 8 Millennia B.P.

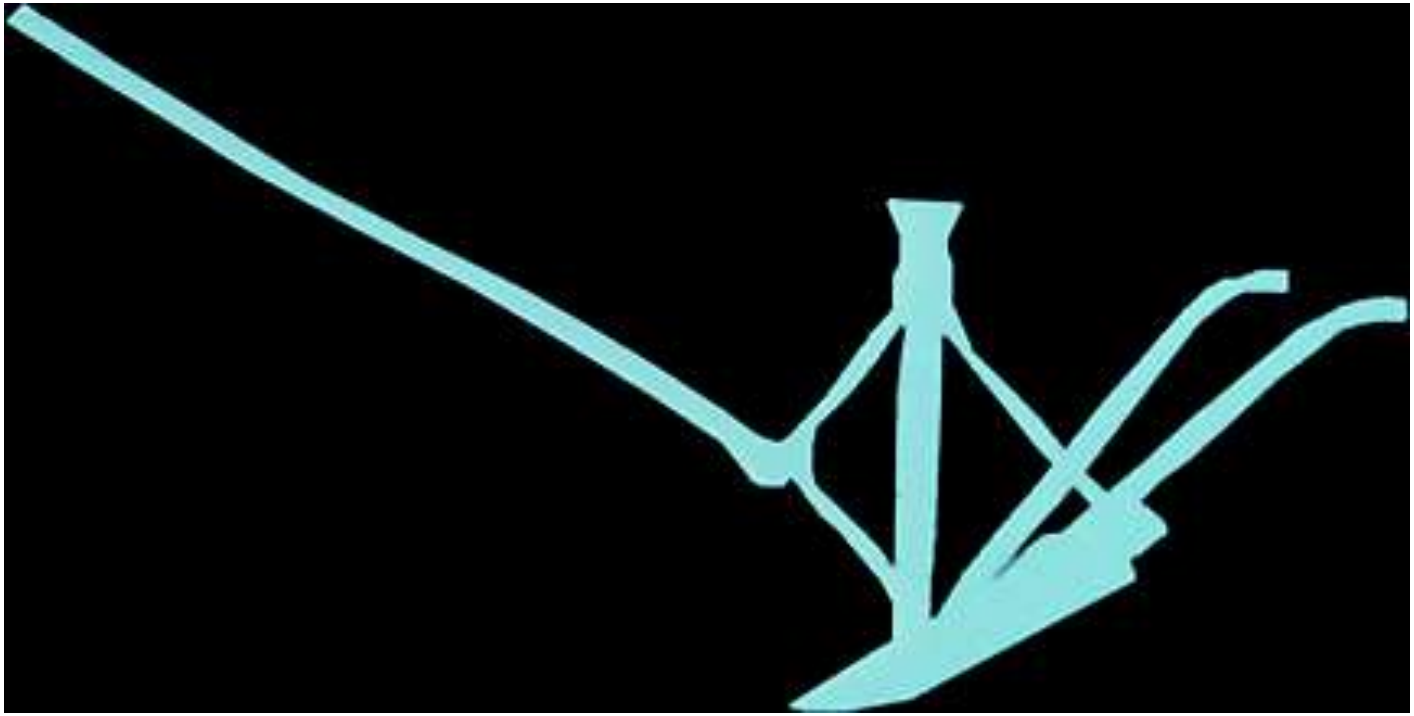
Triptolemos Ard (named after Greek god and hero)



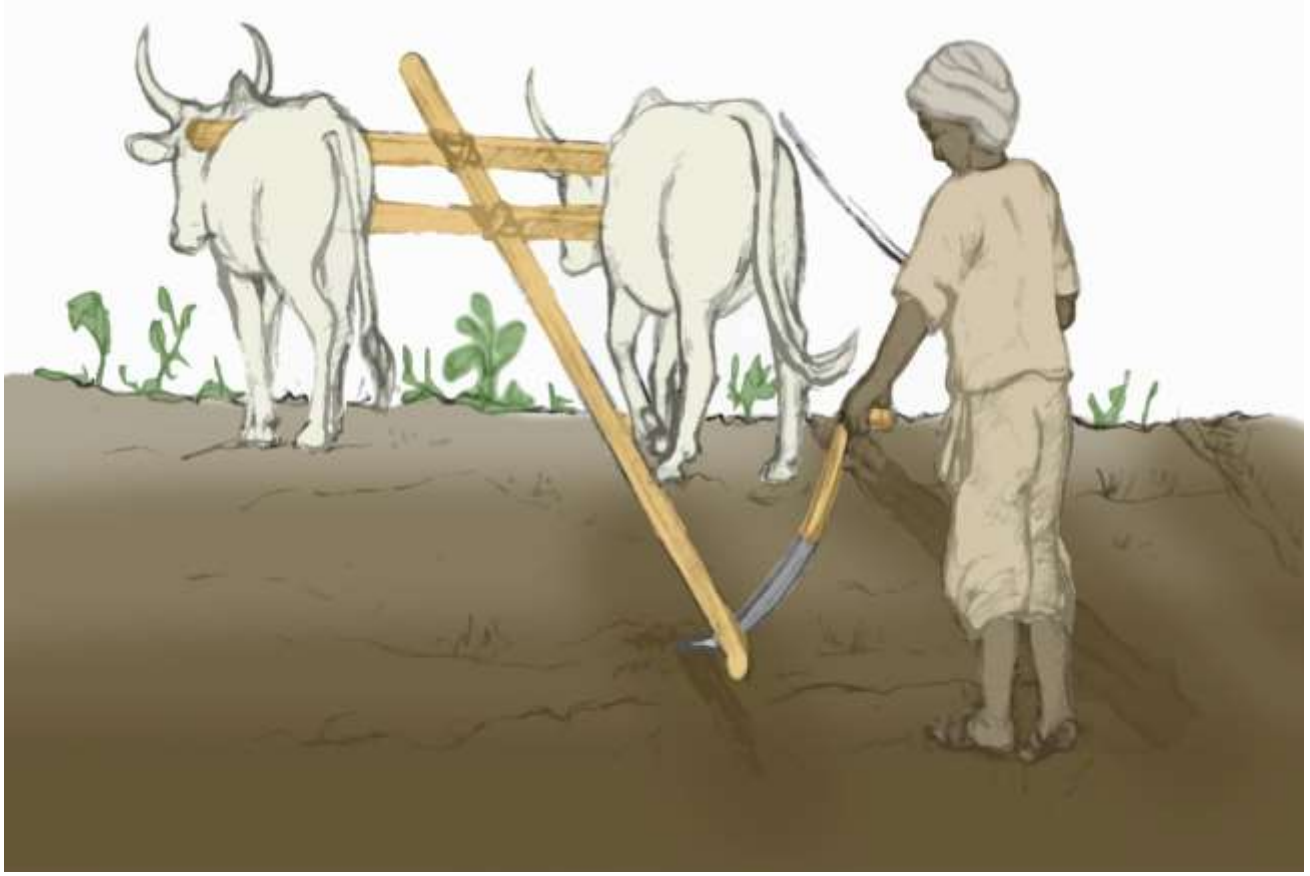
6 to 8 Millennia B.P.

Sinclair and Sinclair (2010)

BABYLONIAN ARD WITH ATTACHMENT FOR DRILLING GRAIN 3300 YEARS AGO



The human or animal-pulled implements to cover large areas, also used in the Indo-Gangetic Plains as cited in the epic “Ramayana.”

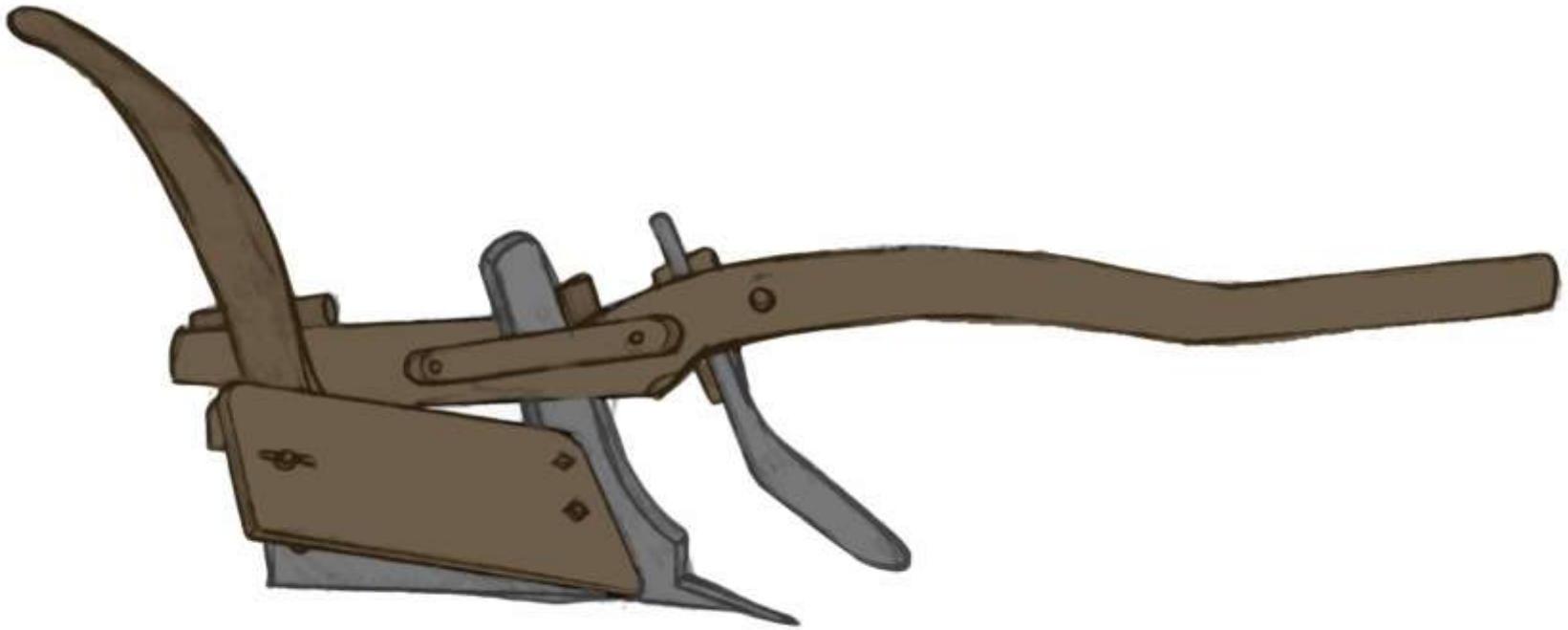


4 to 6 Millennia B.P.

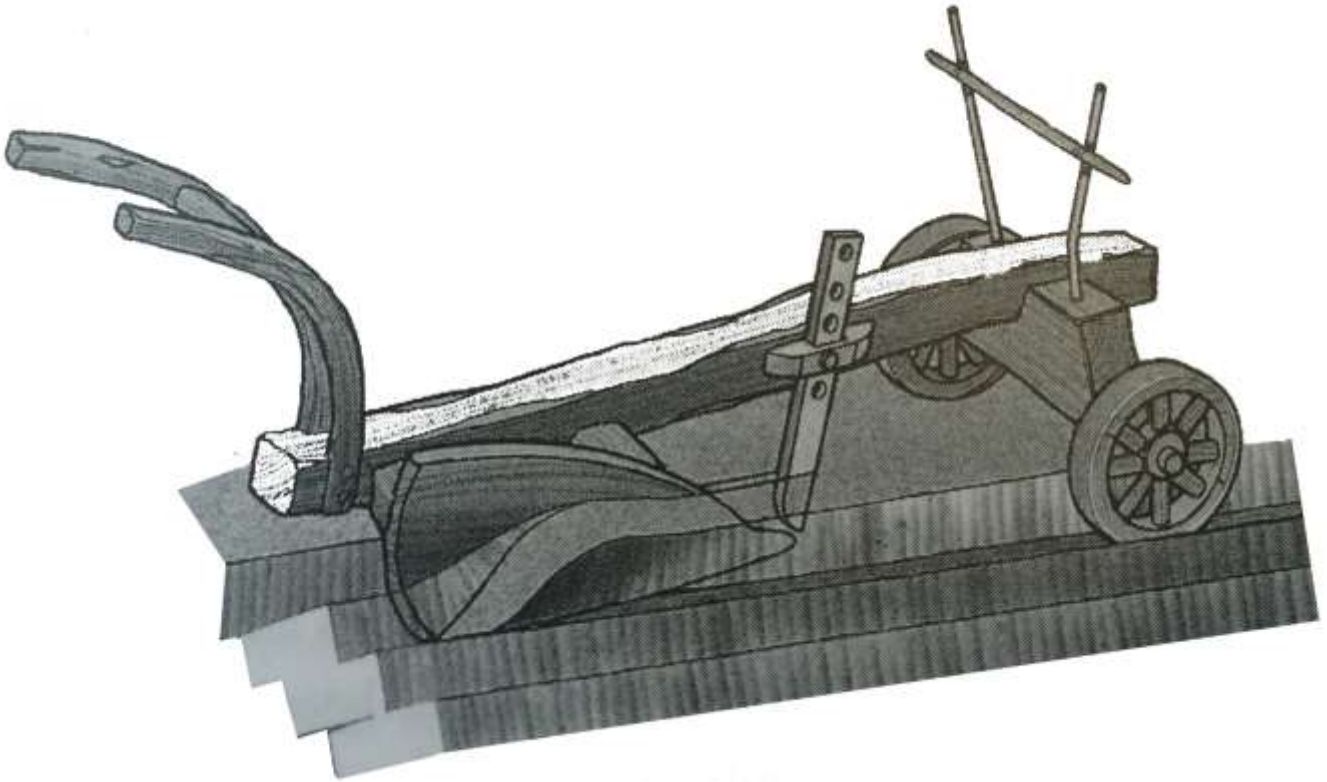
MOHENJODARO/HARAPPA IN INDUS VALLEY 3200 BC-1900 BC

British Museum

Iron plow share



5th to 10th Century A.D.

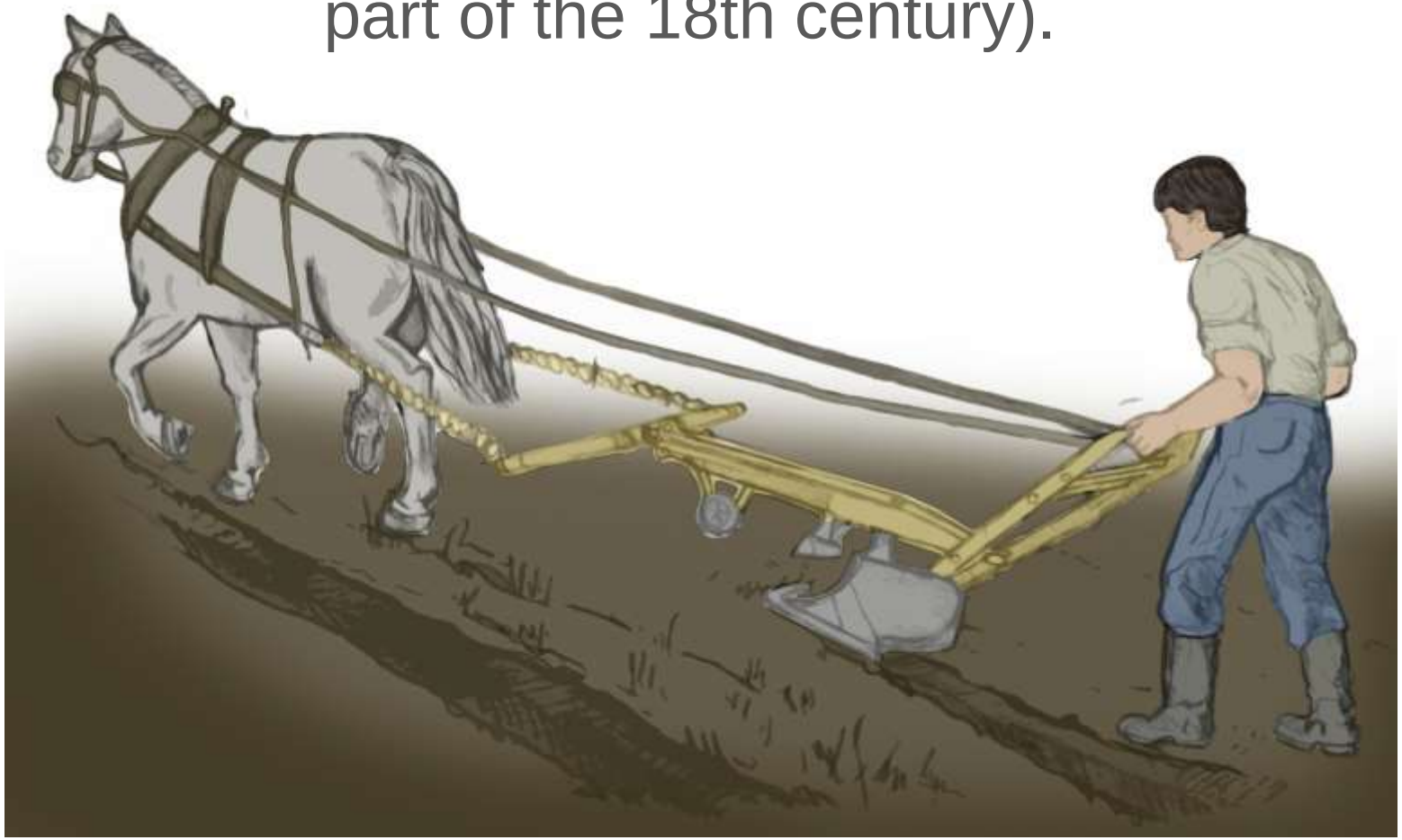


Sinclair and Sinclair (2010)

Roman Plow

The “Ard” evolved into the well-known “Roman plow.” Vergil gave the earliest description: “while still growing in the woods, an elm is bent with great strength and subdued so as to form the plow-beam, and is made to assume the shape of the curved plow. To this plow beam a pole stretching out 8 feet, two moldboards, and share beam with two ridges are fitted at the base.”

Horse-drawn implements (the Roman plow evolved into a rough inverting plow in the latter part of the 18th century).



15th to 19th Century A.D.

Jethro Tull (1674-1741)

He believed, imaginatively but erroneously, that an objective of plowing was to pulverize the soil grains into small particles so that they can be ingested by plant roots.

Thomas Jefferson

A moldboard plow used in the U.S. was designed by Thomas Jefferson in 1784, and patented by Charles Newfold in 1796.

This plow was marketed in the 1830s as a cast iron plow by a blacksmith named “John Deere.”

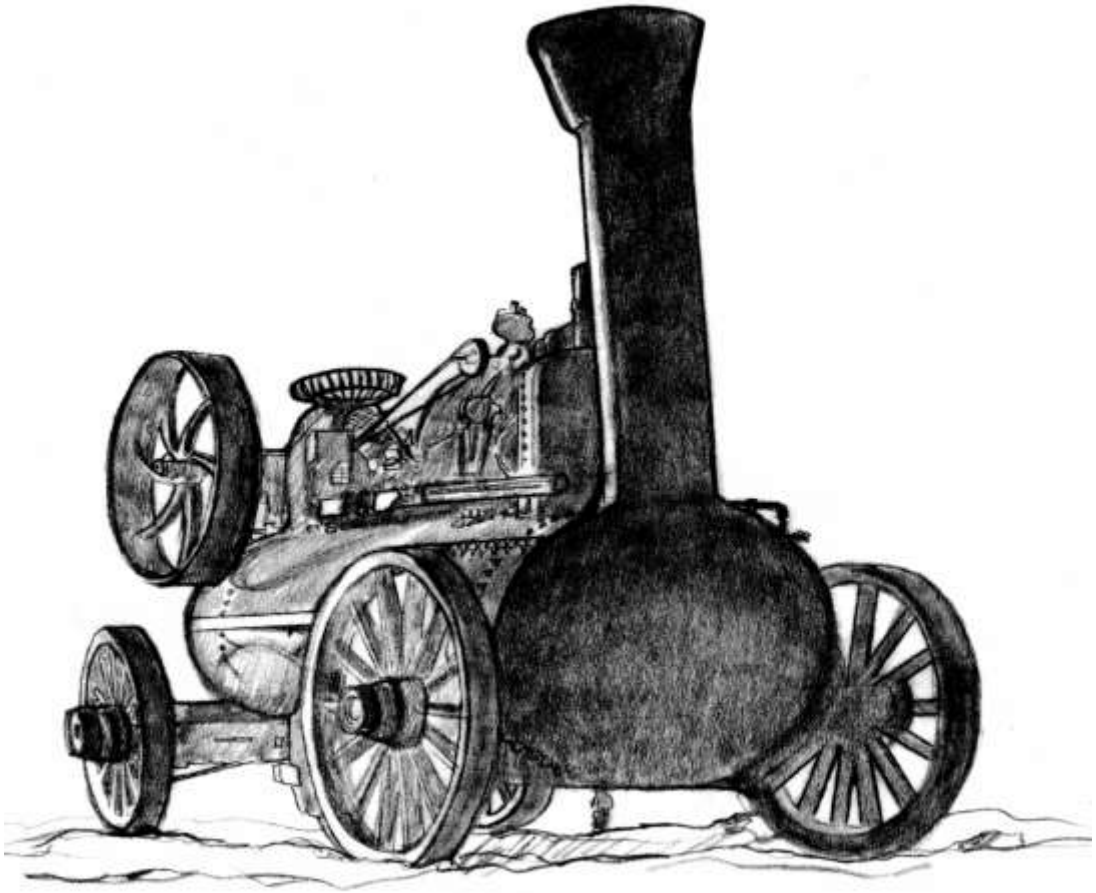
USDA Logo


UNITED STATES DEPARTMENT OF AGRICULTURE
1862
1889
AGRICULTURE IS THE FOUNDATION OF MANUFACTURE
AND COMMERCE

The Prairie Breaker

These new tools helped farmers in the U.S. plow their way to the west. The basic equipment for the prairie breaker was the plow.

The Steam Horse



1910 A.D.

Expansion of Global Cropland Area

The cropland area expanded dramatically.

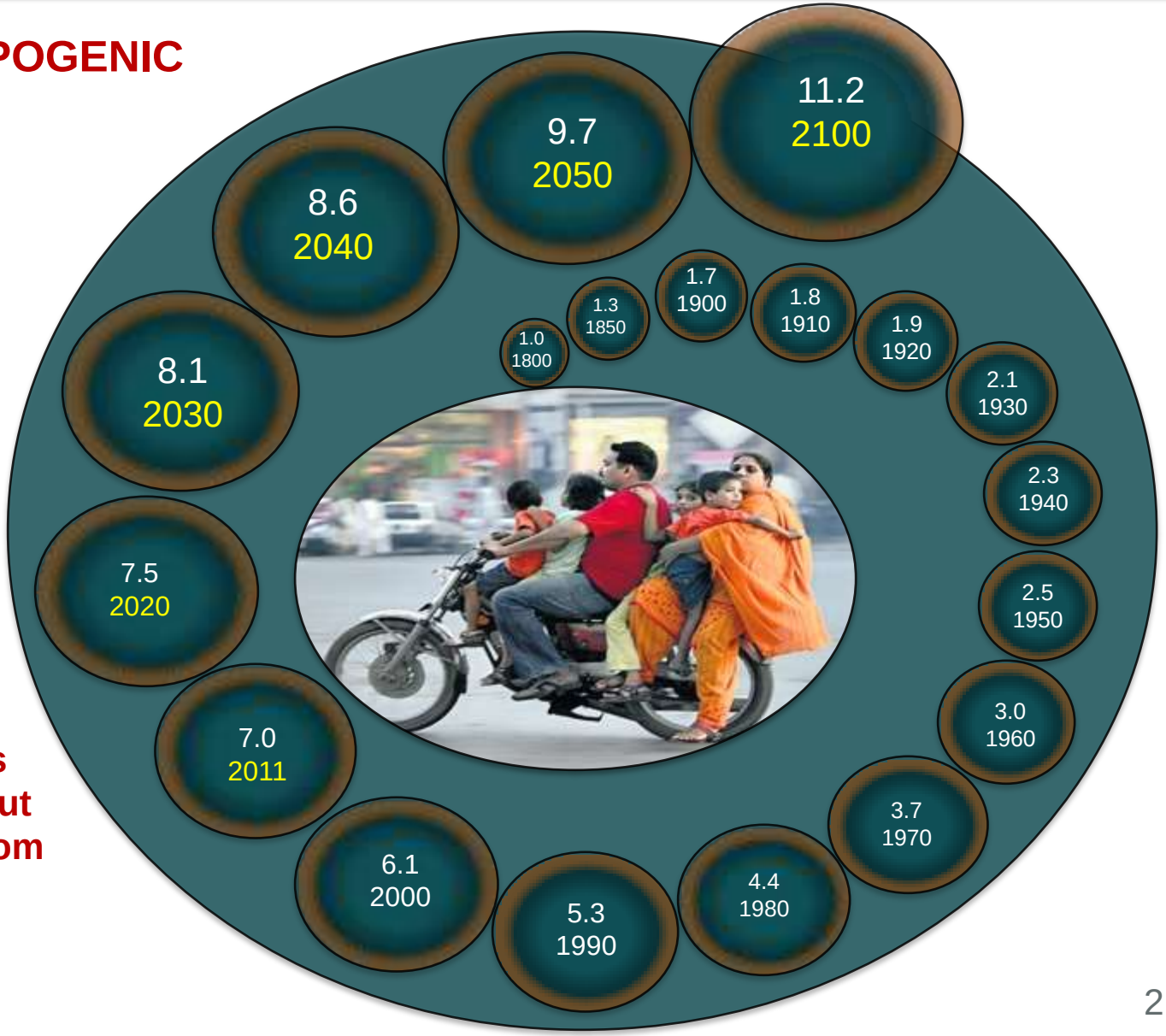
Year	Cropland Area (Mha)
1700	265
1800	573
1920	913
1950	1170
1980	1500
2000	1380

Source: FAO Stat

THE ANTHROPOGENIC DRIVER

I = P x A x T

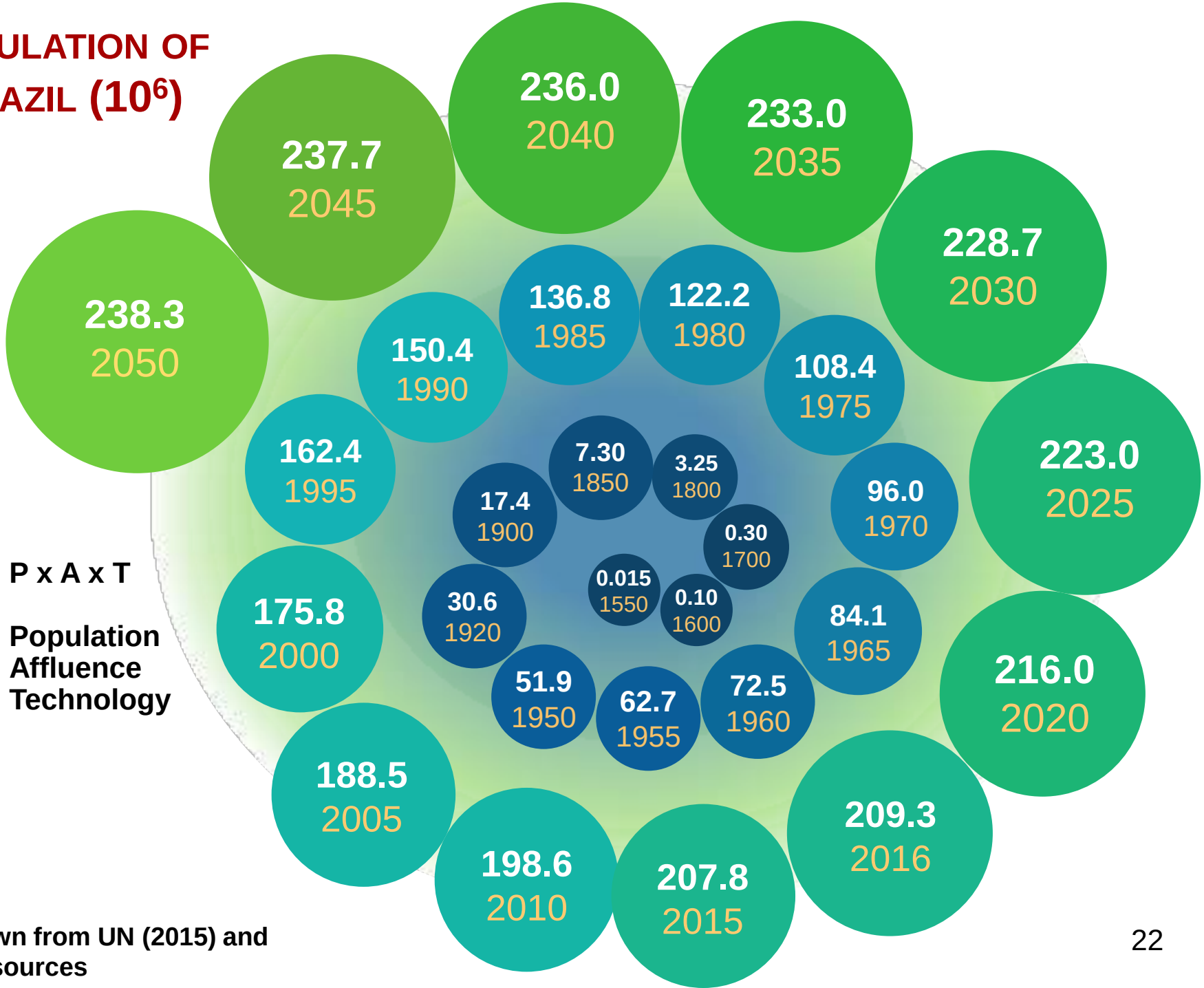
P = Population
A = Affluence
T = Technology



Over the last 10,000 years, the number of humans has increased about a thousand-fold from 2- 20 million to 7.3 billion.

Source: Lal (2014)

POPULATION OF BRAZIL (10^6)



I = P x A x T

P = Population
A = Affluence
T = Technology

Redrawn from UN (2015) and other sources

A Dust Storm in West Texas in 1934

Most soils have lost 25 to 75% of their original soil carbon pool!

DEGRADED LAND

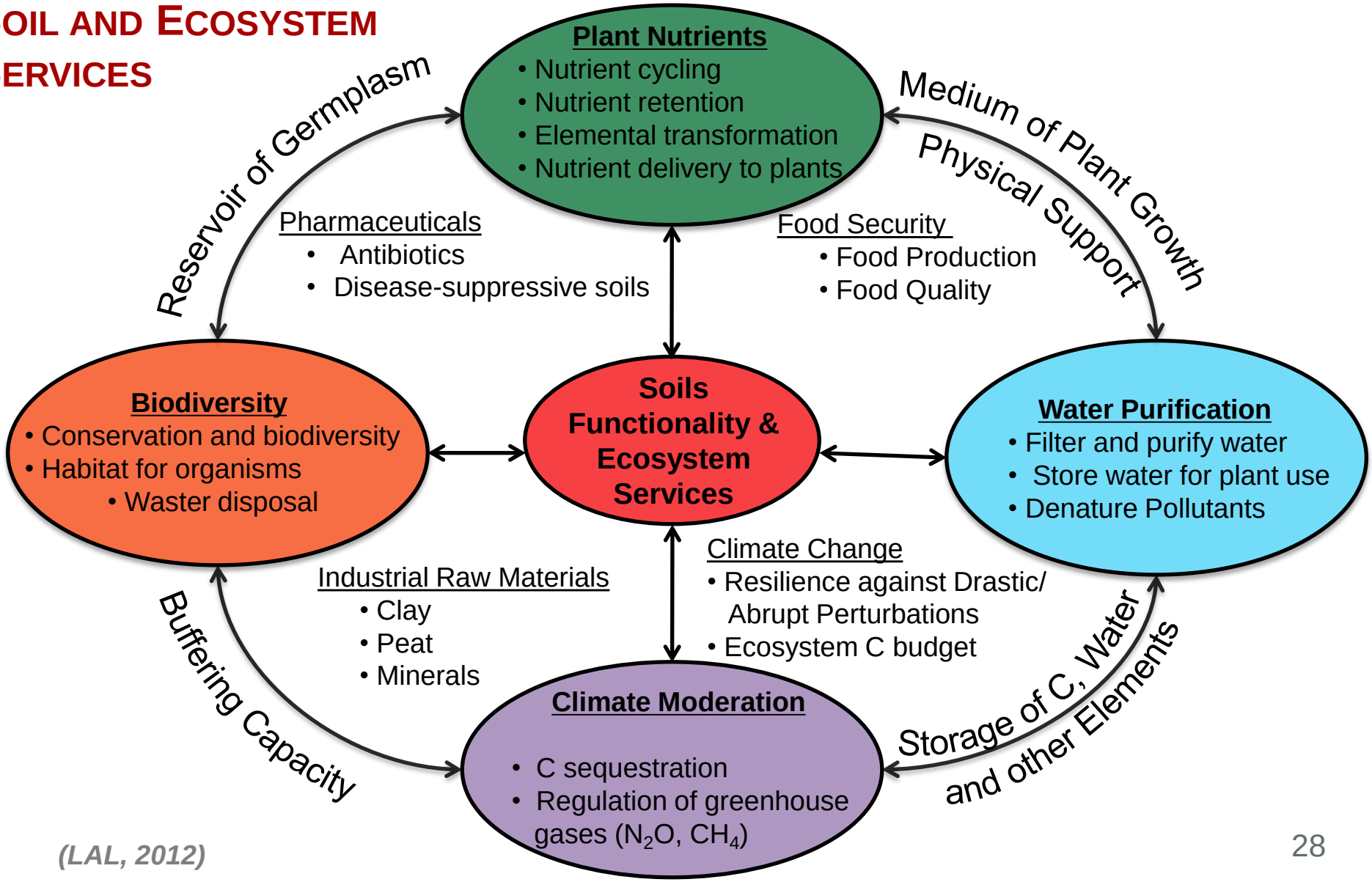
(BAI et al., 2008)

Category	Quantity
Degrading Area	3.5 Bha
Territory	23.54 (%)

GLOBAL SOIL DEGRADATION (10^9ha)

- **Water Erosion : 1.09 (Oldeman, 1994)**
- **Wind Erosion : 0.55 (Oldeman, 1994)**
- **Salinization : 0.85 (FAO, 2005)**

SOIL AND ECOSYSTEM SERVICES



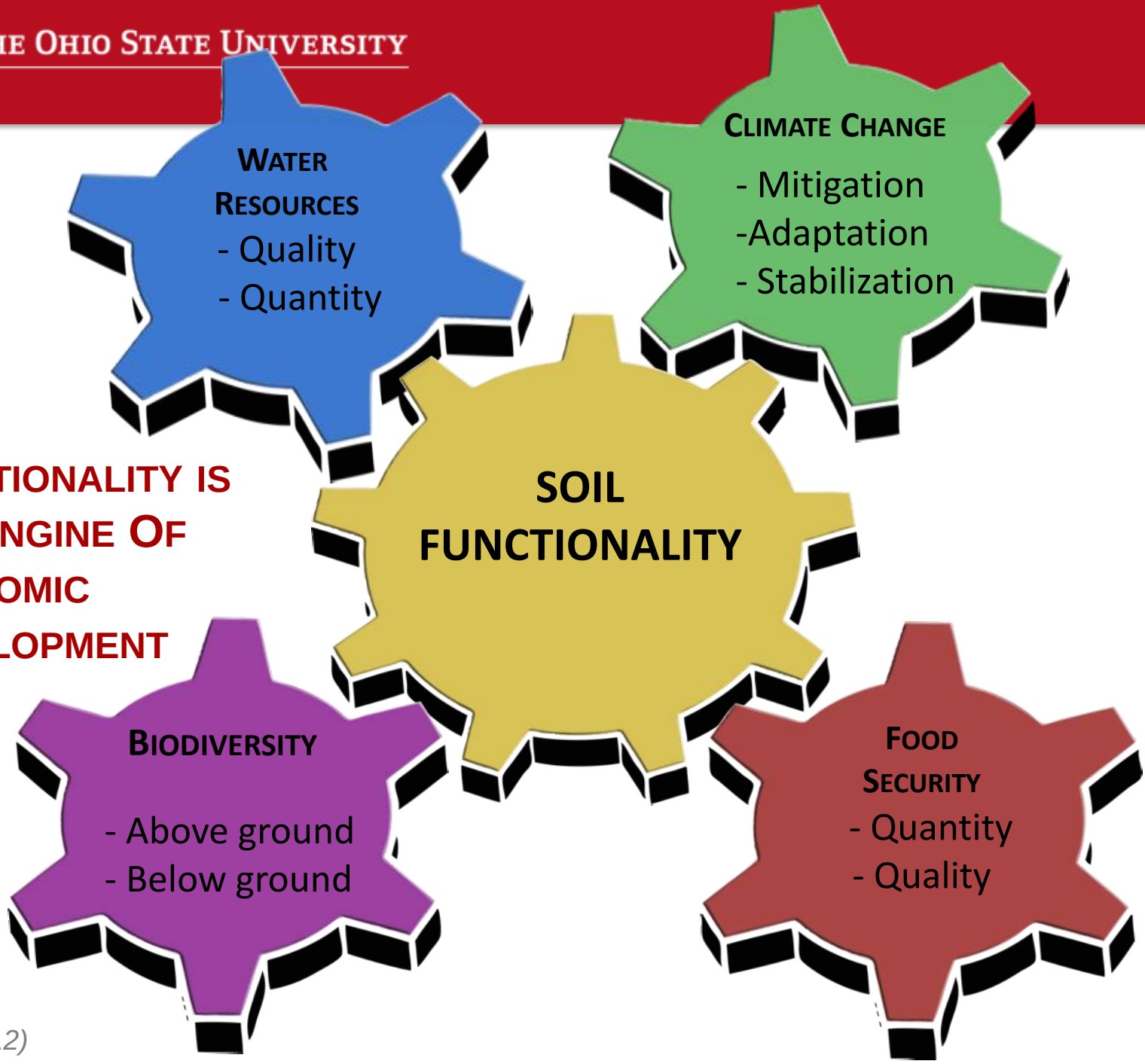
(LAL, 2012)

Historical Basis of No-Till Farming

1. Land is so disfigured…once it has been u
2. Principal objective of plowing is weed co
3. Vanishing lands……
4. Plowman's Folly……
5. The substitution of chemical……
6. "Mankind marches across the earth leavi
   .....

7. Manejo Ecologico do Solo ..... Prof. Dr. Ana Maria Primavesi (1979)

SOIL FUNCTIONALITY IS THE ENGINE OF ECONOMIC DEVELOPMENT



Lal (2012)

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NO-TILL FARMING AS AN EMERGING GLOBAL TECHNOLOGY

Boots with no residue.

Boots with residue.

Corn with no residue.

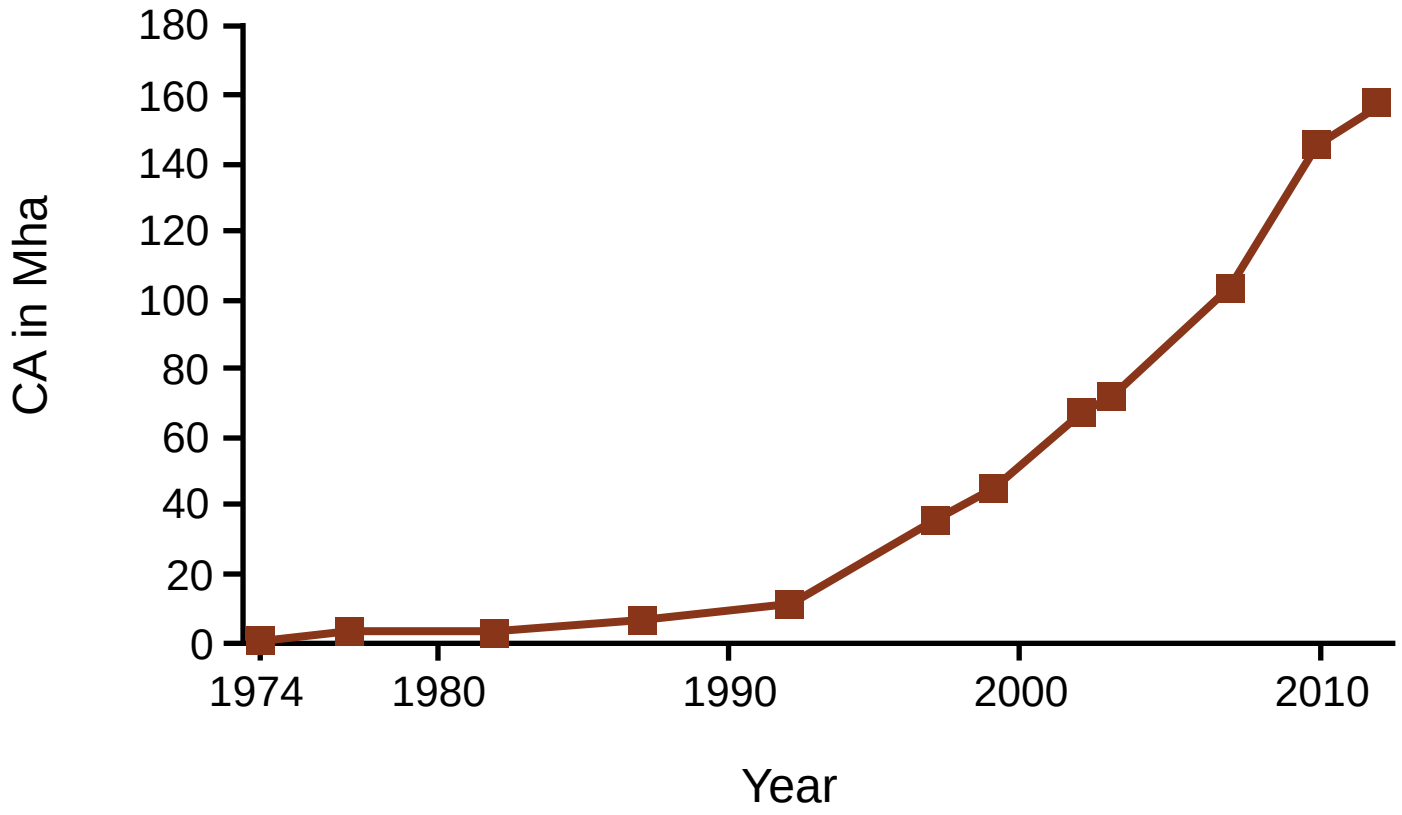
Corn with 100% residue

1940s and 1950s - The Herbicides as Alternative to Plowing

- Invention of 2, 4-D after World War II
- 1950s and 1960s: Atrazine, Simazine, Cyanazine
- 1960s: Paraquat by ICI
- 1990s: Roundup ready crops

Thus, plowing became dispensable

GLOBAL UPTAKE OF CA IN M ha OF ARABLE CROPLAND



Kassam et al. (2015)

CROPLAND UNDER CA

Continent	Cropland under CA (MA ha)	Global CA area (%)	Cropland (%)
South America	66.4	42.3	60.0
North America	54.0	34.4	24.0
Australia & NZ	17.9	11.4	35.9
Asia	10.3	6.6	3.0
Russia & Ukraine	5.2	3.3	3.3
Europe	2.0	1.3	2.8
Africa	1.2	0.8	0.9
Global Total	157.0	100.00	10.9

Kassam et al. (2015)

CA ADOPTION IN THE COUNTRIES OF NORTH AMERICA IN THE 2008/09 AND 2013 UPDATES

Country	Mha (2008/09)	Mha (2013)
USA	26.5	35.6
Canada	13.5	18.3
Mexico	0.02	0.04
Total	40.0	54.0
% Increase		40

Kassam et al. (2015)

CA ADOPTION IN THE COUNTRIES OF SOUTH AMERICA IN THE 2008/09 AND 2013 UPDATES

Country	CA area Mha 2008/09 update	CA area Mha 2013 update
Brazil	25.5	31.8
Argentina	19.7	29.2
Paraguay	2.4	3.0
Uruguay	6.6	1.1
Bolivia	0.7	0.7
Venezuela	0.3	0.3
Chile	0.2	0.2
Colombia	0.1	0.1
Total	19.564	66.4
% change		33

Kassam et al. (2015)

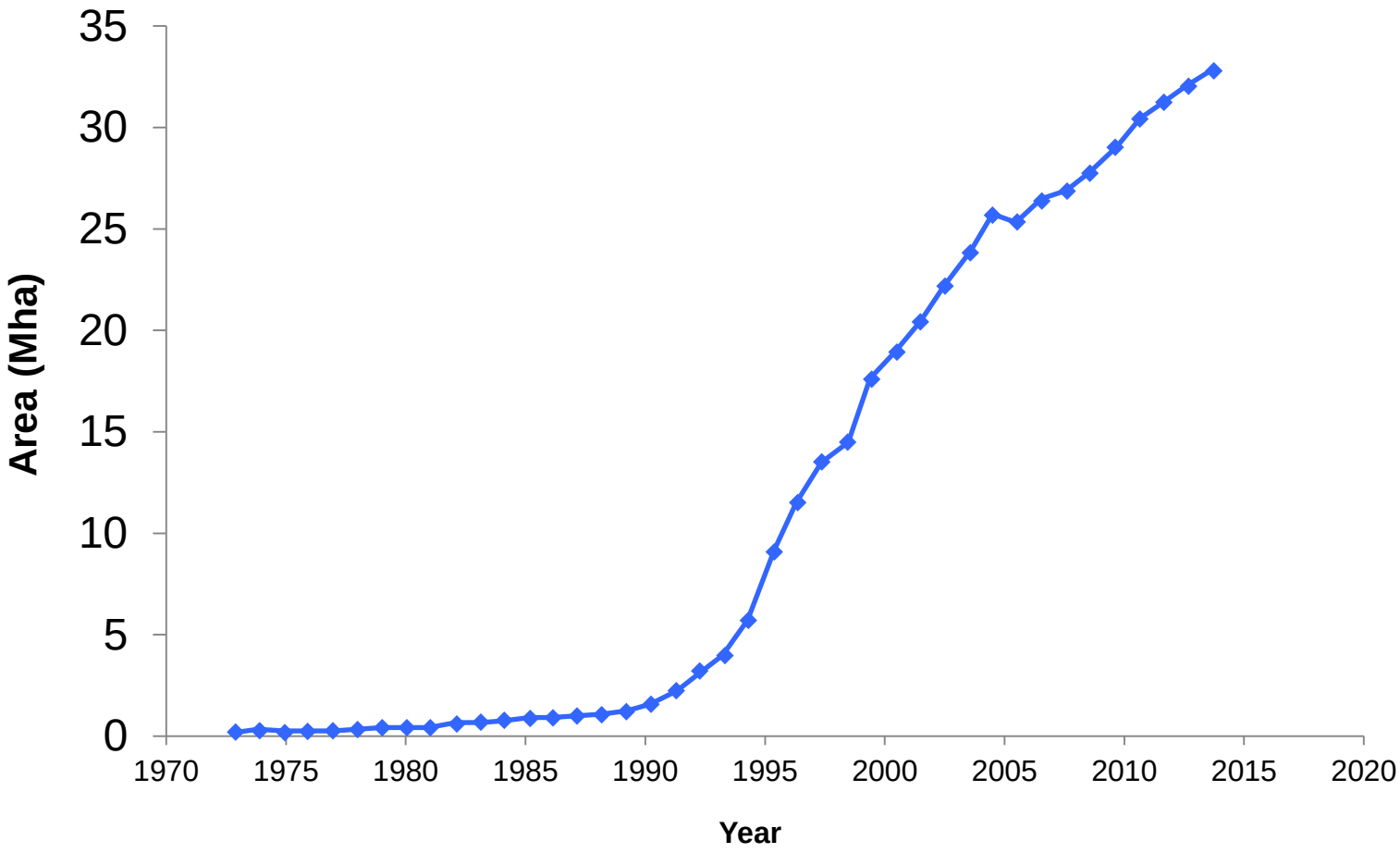
Brazilian No-till Pioneer Herbert Bartz

Adopted no-till in 1972

Evolution of No-till Farming in Brazil

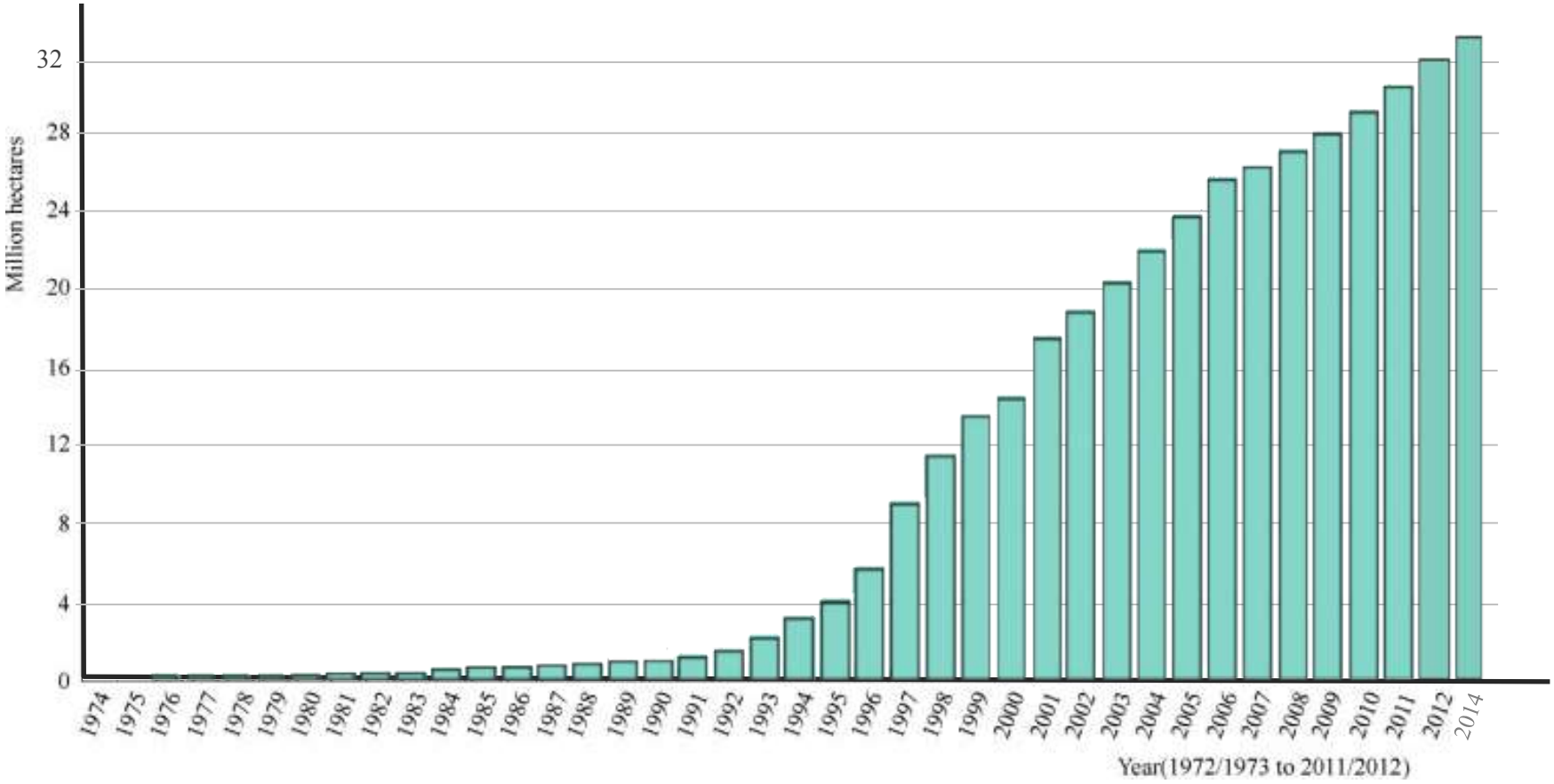
Year	Institution
1971	IPEAME/EMBRAPA
1972	Herbert Bartz, the first no-till farmer in Brazil
1975-1976	The first no-till planter built in Brazil
1981	The first NT conference, Ponta Grossa, Parena

AREA UNDER CONSERVATION AGRICULTURE IN BRAZIL



Source: Wilson (2012); Derpsch and Fredrich (2007); Thompson (2000); de Freitas adn Landers (2014); Derpsch (2015)

Evolution of ZT/CA management systems in Brazil



Source: Freitas and Landers (2014)

AGROECOSYSTEM

Management of energy transformation and biochemical cycles of specific plant and animal communities within a landscape to generate ecosystem services such as food, feed, fiber and fuel.

CARBON COST OF PLOWING

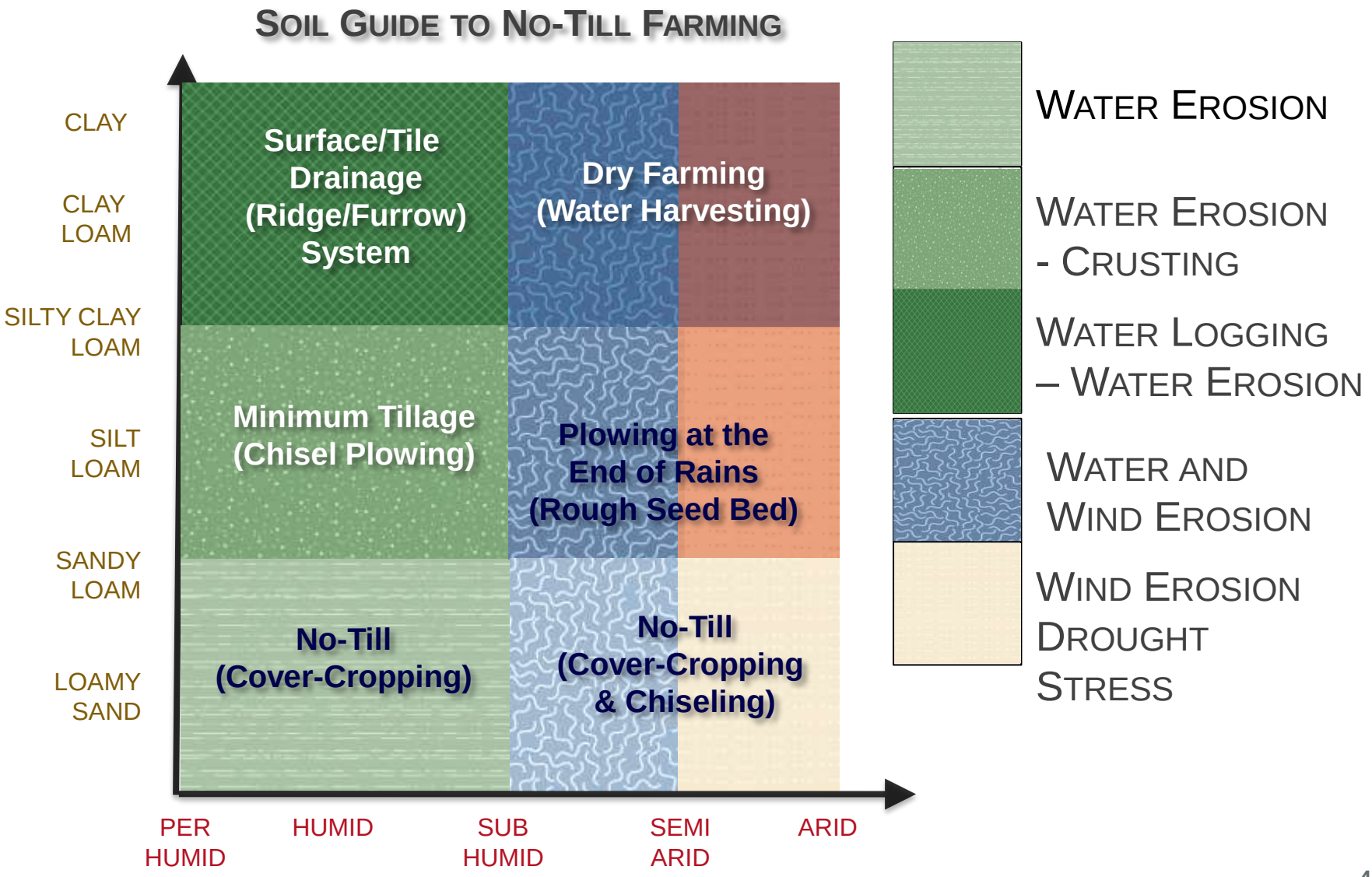
TILLAGE	kg C E/ha
Moldboard plowing	15.2
Chiseling	7.9
Heavy Disking	8.3
Standard Disking	5.8
Sub-soiling	11.3
Cultivation	4.0
Rotary hoeing	2.0

CARBON COST OF FERTILIZERS &PESTICIDES (LAL, 2004)

Input	Equivalent Carbon Emission (Kg C Kg^{-1})
(i) Nitrogen fertilizer	0.9 - 1.8
(ii) Phosphorous	0.1 - 0.3
(iii) Potassium	0.1 - 0.2
(iv) Herbicides	1.7 - 12.6
(v) Insecticides	1.2 - 8.1
(vi) Fungicides	1.2 - 8.0

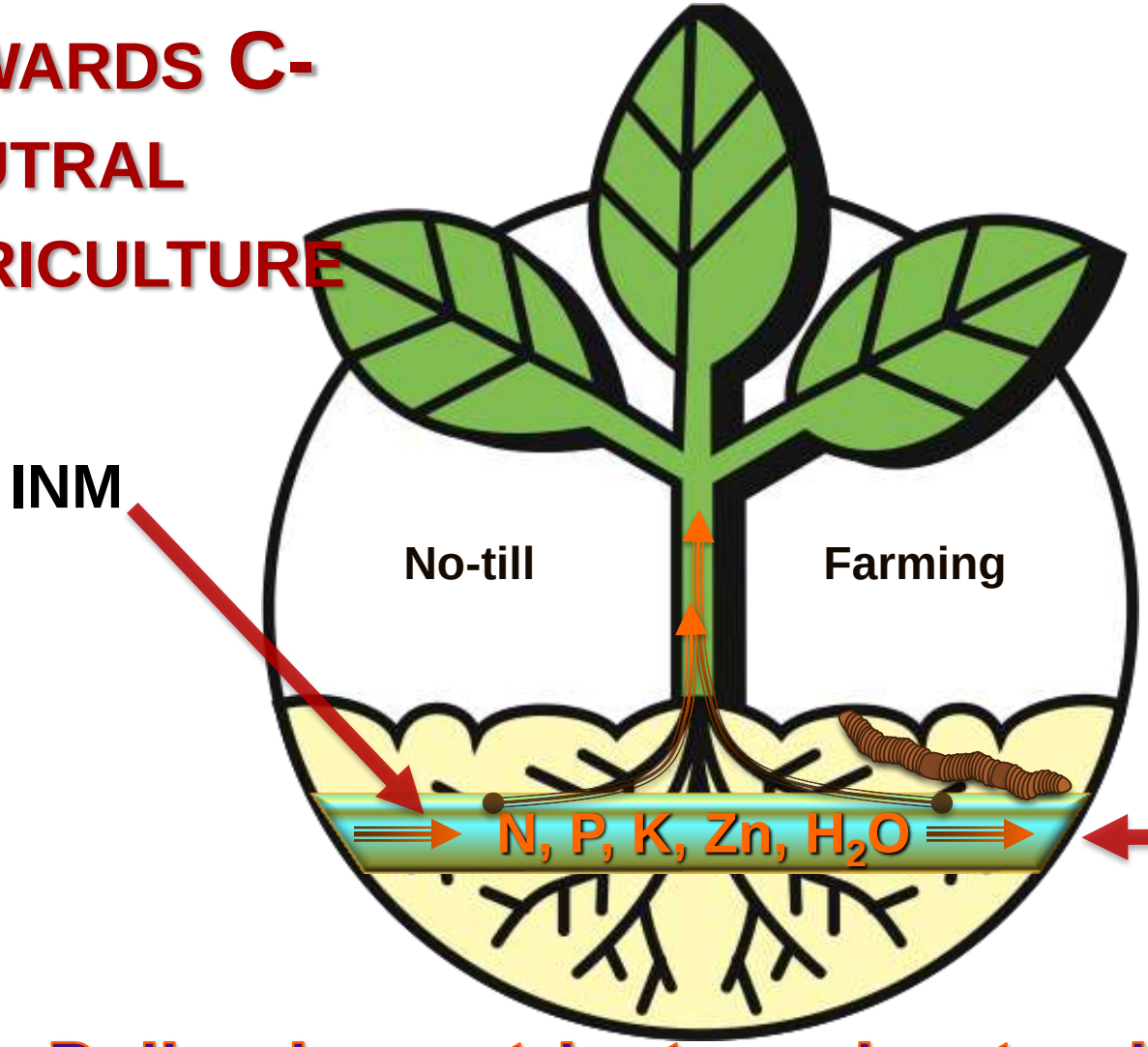
CARBON COST OF HERBICIDES (LAL, 2004)

HERBICIDE	kg C E/kg a:i
Atrazine	3.8
Dicamba	5.9
Glyphosate	9.1
Paraquat	9.2



Source: Lal (1985)

TOWARDS C-NEUTRAL AGRICULTURE

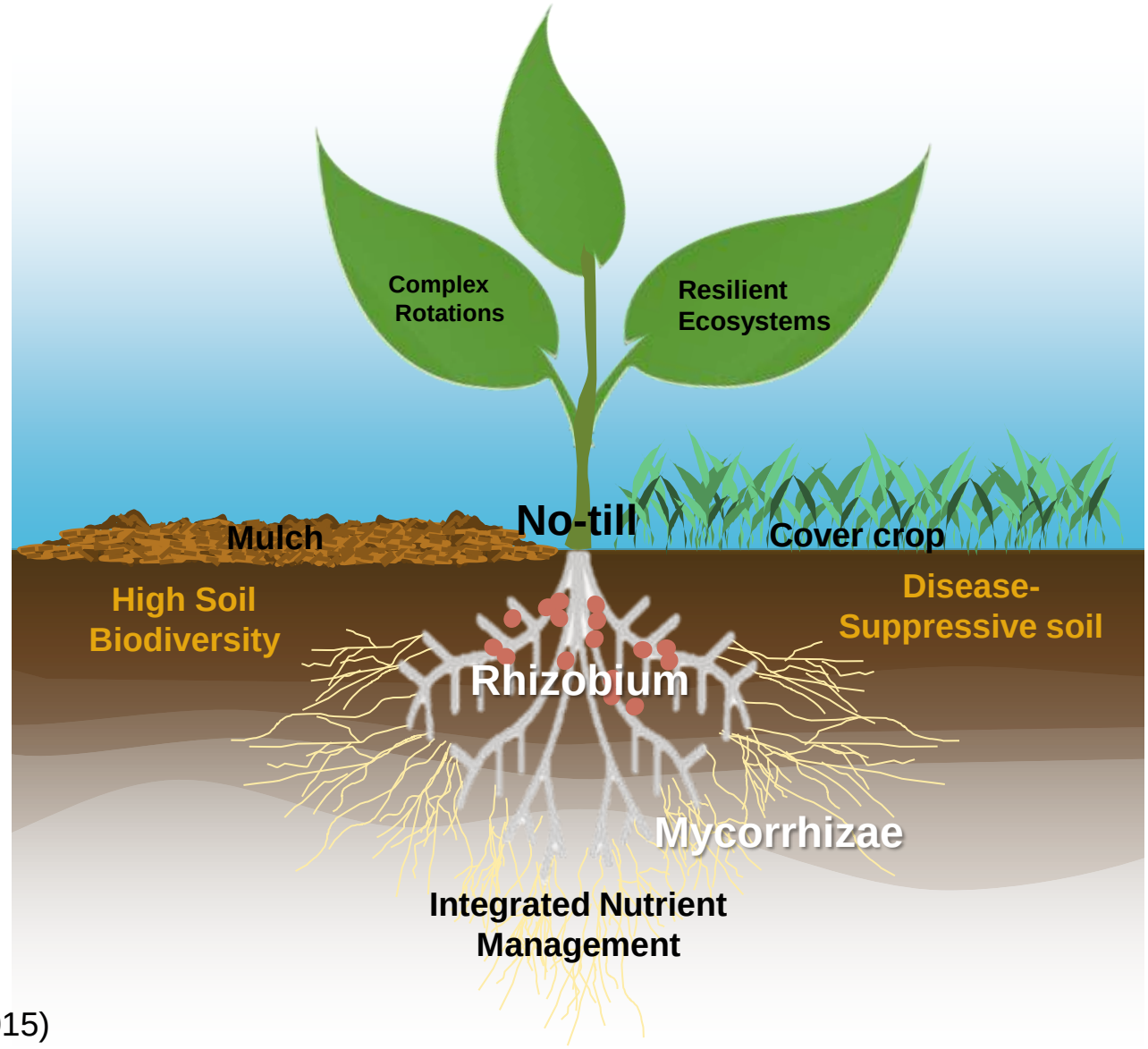


Chatting with plants through molecular-based signals

Delivering nutrients and water directly to plant's roots

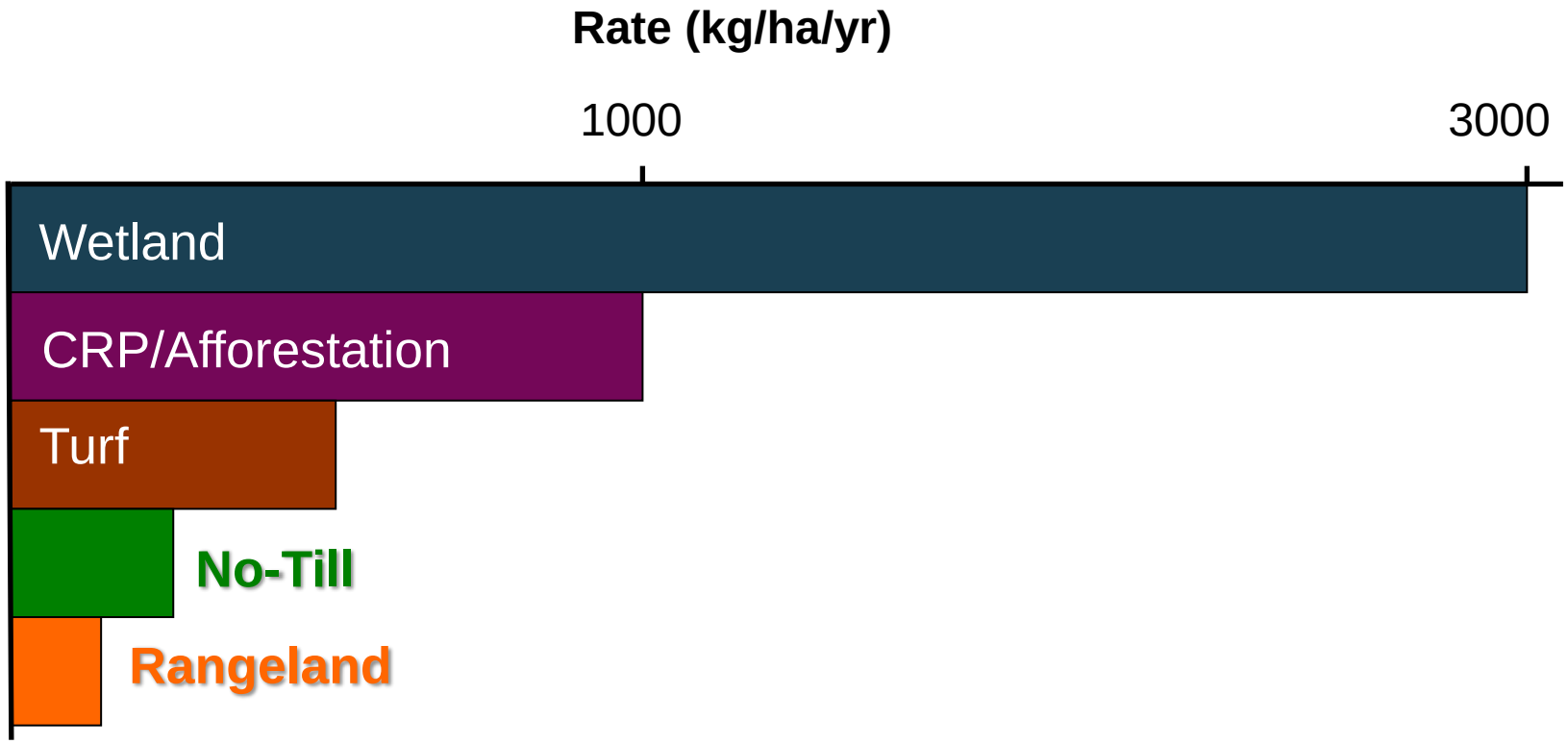
Source: Lal (1999)

Conservation Agriculture System



Source: Lal (2015)

RATE OF CARBON SEQUESTRATION



GLOBAL POTENTIAL OF SOC SEQUESTRATION (Pg C/YR)

Cropland:	0.4-1.2
Grazing land:	0.3-0.5
Salt-affected soils:	0.3-0.7
Desertified soils:	~~0.2-0.7~~
Total:	1.2-3.1

Lal (2010)

SOIL STEWARDSHIP

Soil stewardship and care must be embedded in every fruit and vegetable eaten, in each grain ground into the bread consumed, in every cup of water used, in every breath of air inhaled, and in every scenic landscape cherished.