

Calidad del agua y la agricultura urbana

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- El agua y su manejo
- Caso de la ciudad de México
- Conclusiones

Traditional systems



Local and roof garden



Vertical wall and column





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Plants as drugs and medicines



Plants as Decorations



Plants as building materials



Water use and management

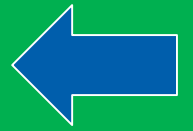
Simple solutions

- Local and seasonal plants
- Manual watering
- But technical solutions imply to explore new options

Water and physical components

Emitters





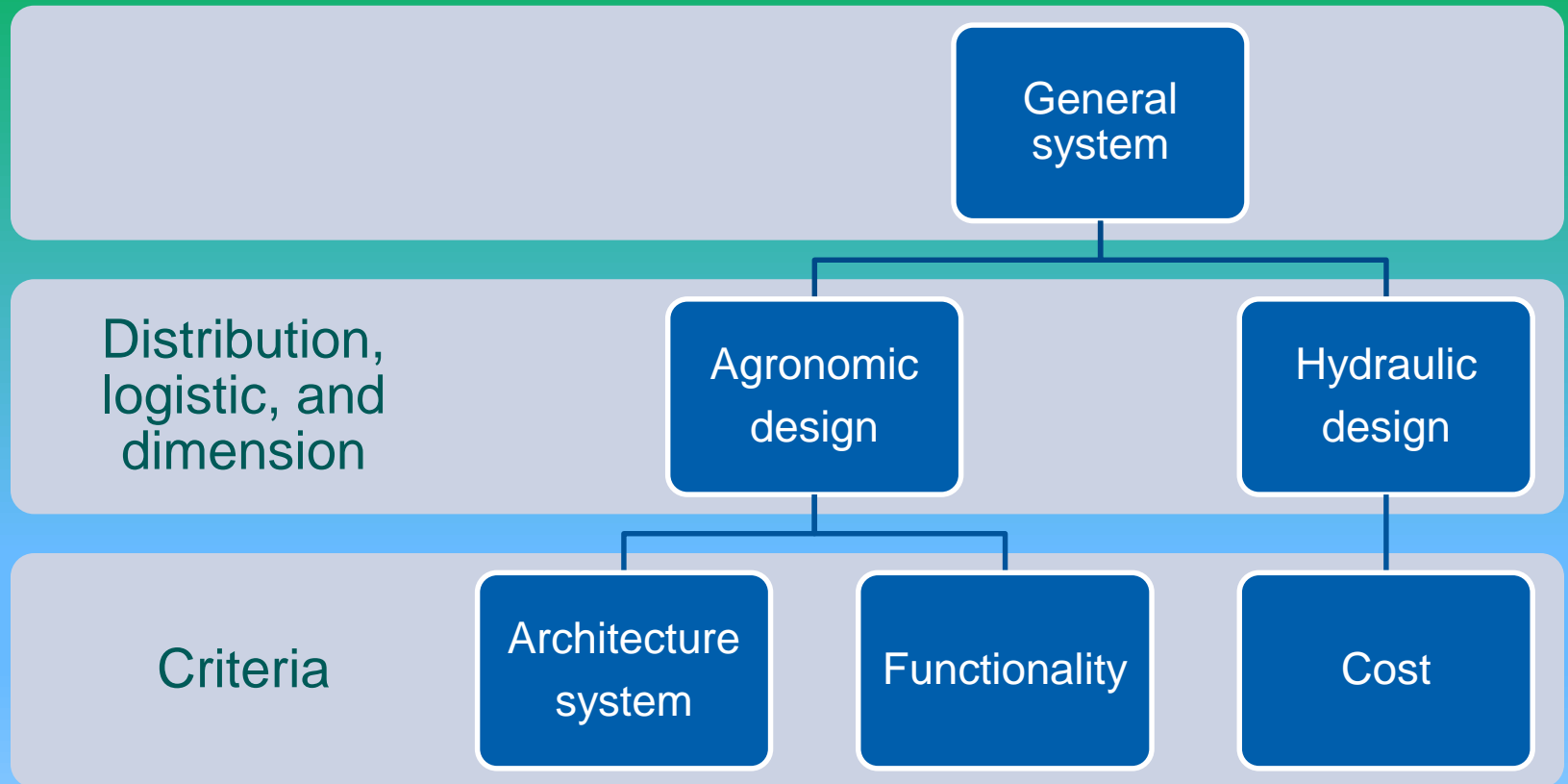
Emitters

Dripers

Micro-sprinklers

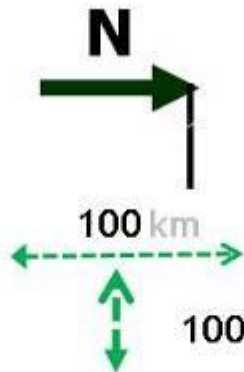


Water and irrigation engineering



Mexico City

(21 million inhabitants)

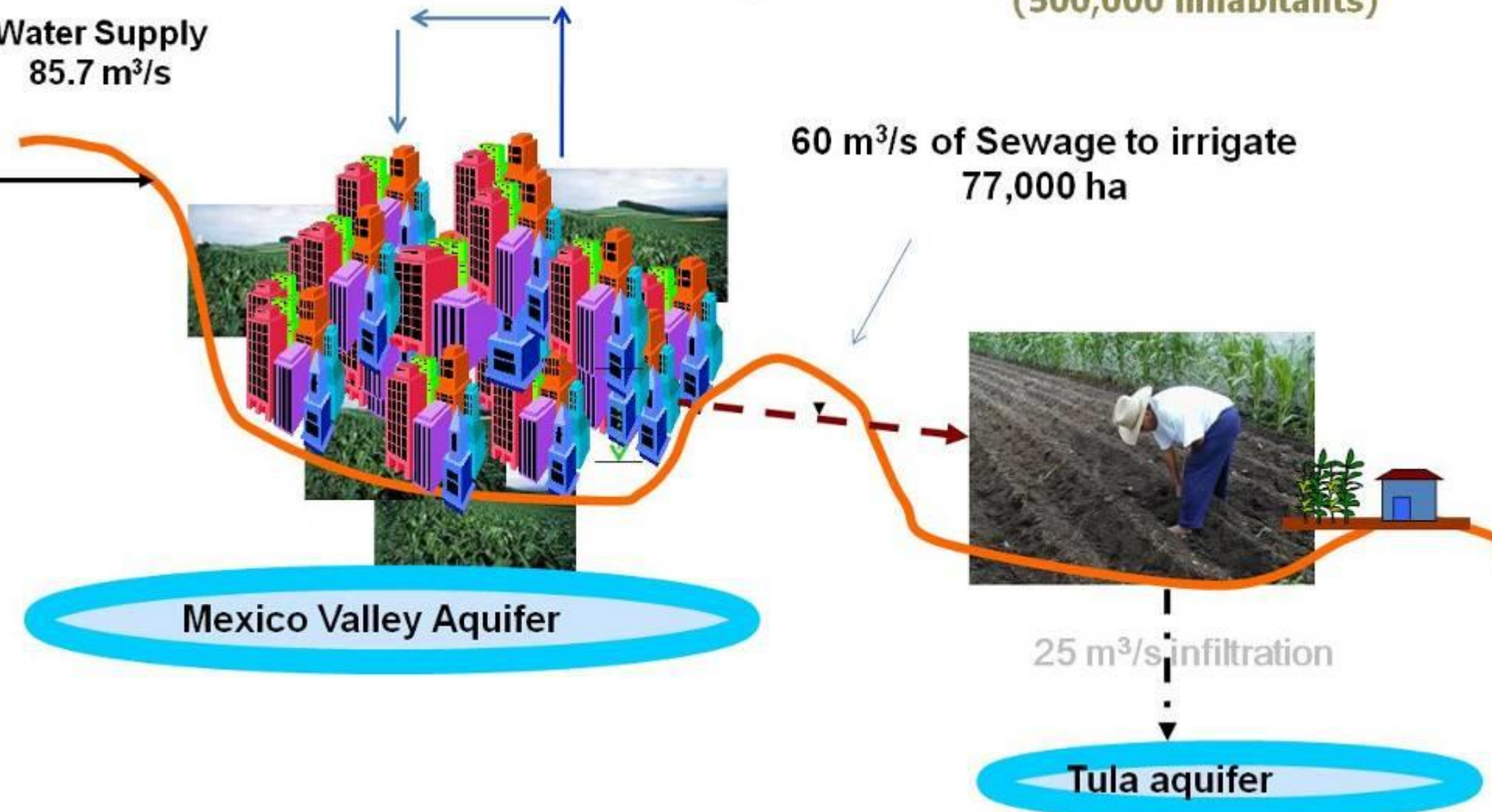


El Mezquital Valley

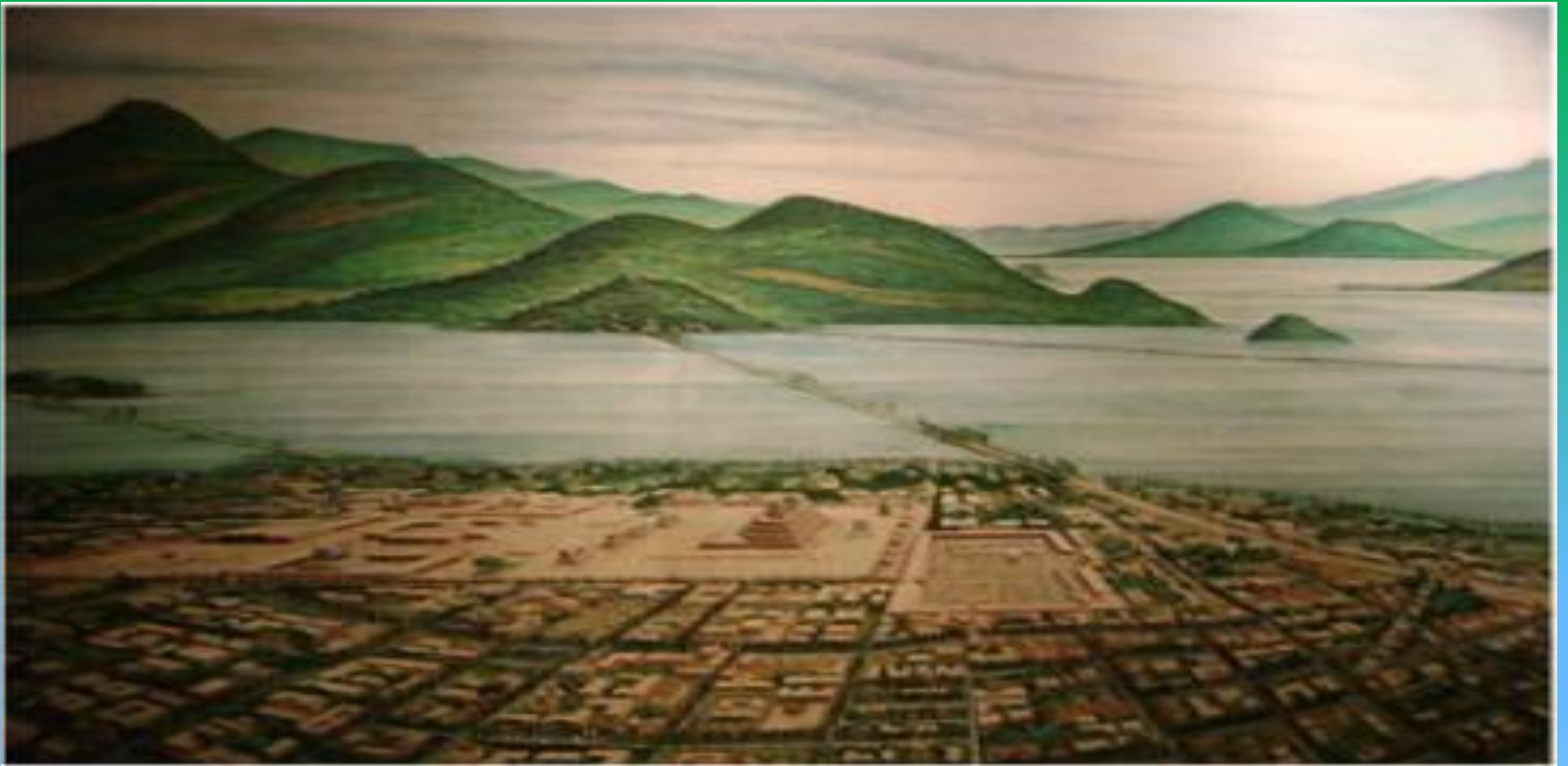
(500,000 inhabitants)

Water Supply
85.7 m³/s

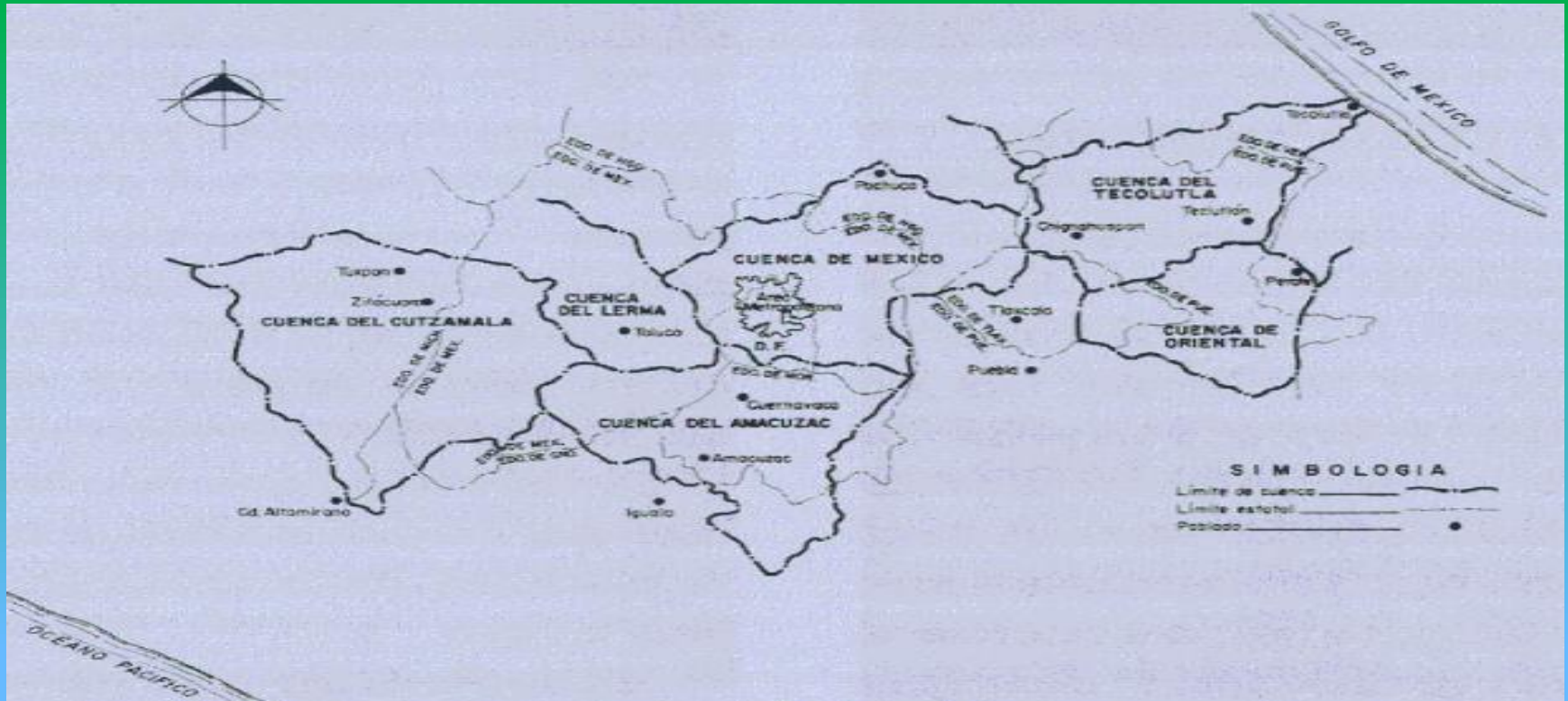
60 m³/s of Sewage to irrigate
77,000 ha



Pasado



Presente



Localización de la cuenca del valle de México y su relación con el entorno, de las cuencas de fuente de agua y desagüe.

Futuro



Figura 3. Izquierda: Rio la Piedad (Viaducto) actualmente con el agua entubada y el arroyo vehicular. Derecha: vista futura con el cauce al aire libre propuesto como una solución
Fuente: izquierda, google; derecha, <http://www.univision.com/noticias/citylab-medio-ambiente/los-rios-invisibles-de-la-ciudad-de-mexico>

Sewerage system, History

- ✓ 3 artificial exits built to drain waste and pluvial water
- ✓ In total, Mexico City produces 67.7 m³/s of wastewater
- ✓ 11% is treated and **reused** since **1956**
- ✓ The rest, (60 m³/s, mean conditions but varying from 52 to > 300 m³/s) **IS non TREATED AND ALSO REUSED** since **1896** for irrigation of the Tula Valley
- ✓ **100% OF WASTEWATER REUSE**



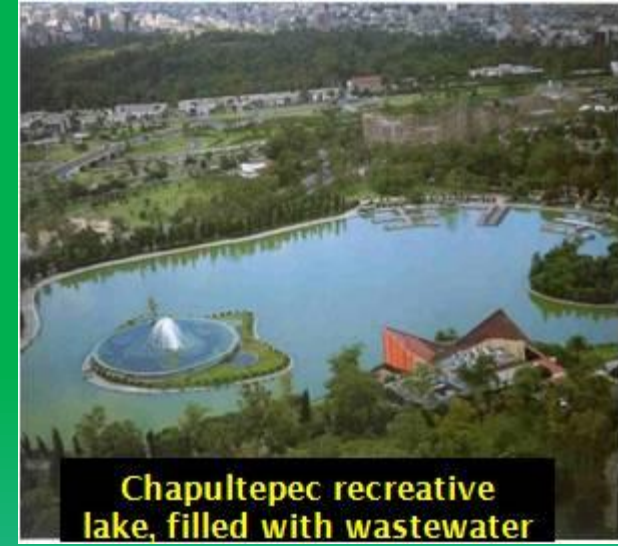
"Tajo de Nochistongo" during the Spanish period





Reuse is for

- 54% refill recreational lakes,
- 31% green areas irrigation (6,500ha),
- 5% **car washing and** fountains
- Environmental restoration,
- 8% **industrial uses (Cooling)**



The biggest WW irrigated district in the world

- ✓ From s 14,000 ha in 1926 it reached of 90,000 ha in four irrigation districts
- ✓ Among the most productive ones

Crop	Yield, tons/ha		Increase %
	Wastewater	'First use' water	
Corn	5.0	2.0	150
Barley	4.0	2.0	100
Tomato	35.0	18.0	94
Forage oats	22.0	12.0	83
Alfalfa	120.0	70.0	71
Chili	12.0	7.0	70
Wheat	3.0	1.8	67



Health effects

Parasites	Ages	Morbidity rates		
		Raw wastewater	Natural water	Ratio
<i>Ascaris lumbricoides</i> (Helminth)	0 to 4	15.3	2.7	5.7
	5 to 14	16.1	1.0	16.0
	> 15	5.3	0.5	11.0
<i>Giardia lamblia</i> (Protozoa)	0 to 4	13.6	13.5	1.0
	5 to 14	9.6	9.2	1.0
	> 15	2.3	2.5	1.0
<i>Entamoeba histolytica</i> (Protozoa)	0 to 4	7.0	7.3	1.0
	5 to 14	16.4	12.0	1.3
	< 15	16.0	13.8	1.2

Cifuentes *et al.*, 1992

Data used by WHO (1989 and 2006) to establish the criteria to reuse wastewater for agricultural irrigation

To be controlled with a WWTP (under construction)

Conclusiones

- El agua de las ciudades tendrá mayores usos
- La tecnología y complejidad de los sistemas agua-planta se incrementaran
- La agricultura urbana seguirá creciendo en diferentes alternativas
- La calidad del agua será cada vez de mayor importancia y será mejor medida

GRACIAS

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Why do plants look like plants and not like something else?



The Tula Valley, Description

- ✓ Semiarid area
 - Pluvial precipitation: 525 mm (5 months per year)
 - evaporation rate: 1,750 mm
- ✓ Original vegetation: *Xerophila* scrubs, such as mezquite, sweet acacia, yucca and a wide variety of cacti
- ✓ 1930-40s the Government was thinking on moving people, there was NO water for development



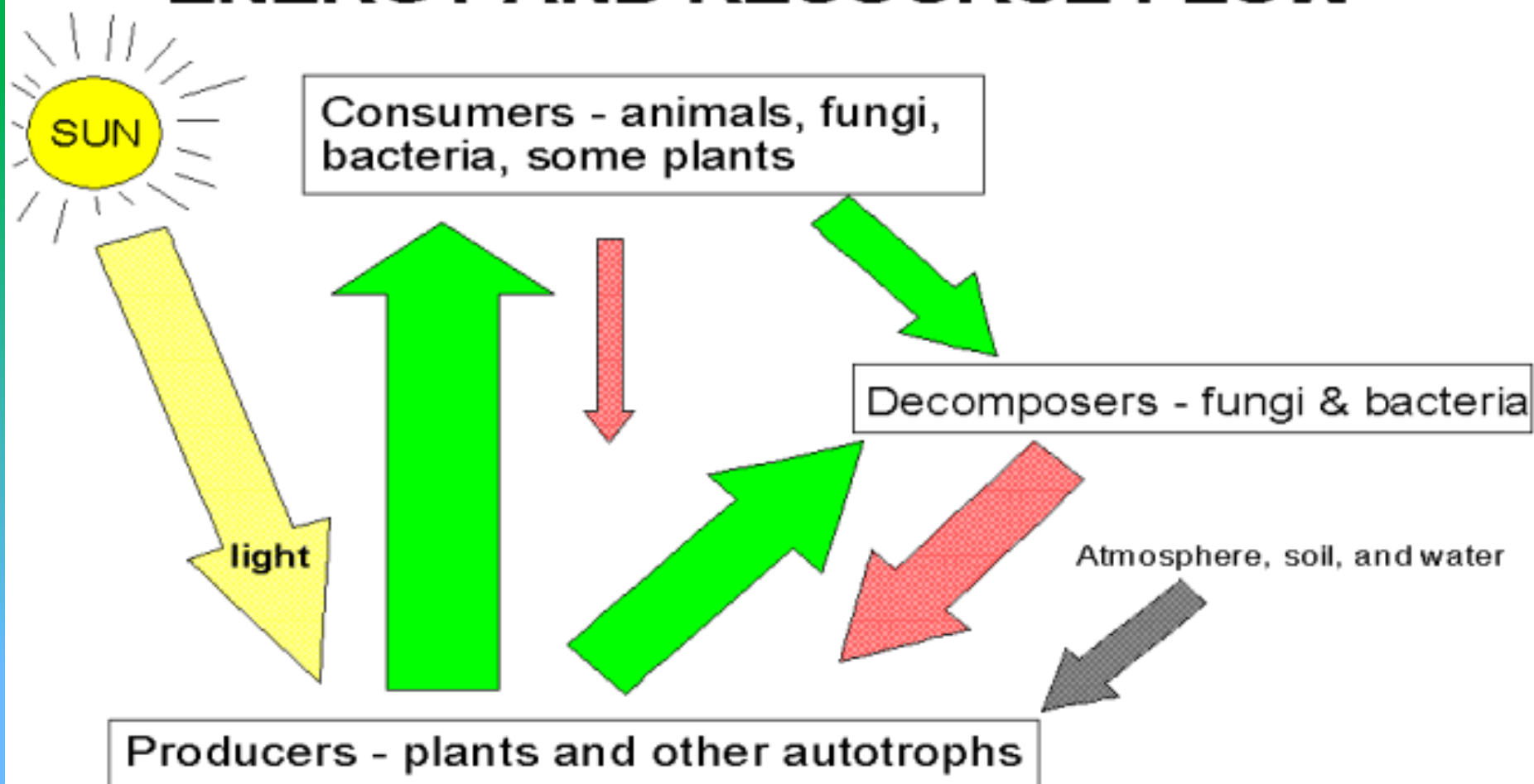
Attributes of Plants

- Autotrophs - obtain energy/building materials by process known as photosynthesis.
- Sedentary (Plants don't move about).
- Modular construction - repeating units due to localized areas of growth (meristems); plants grow at their tips and outward in girth.
- Different modules perform specific functions *Roots - anchorage and absorption of water and dissolved nutrients.*
 - *Leaves - absorption of light energy and atmospheric gases (carbon dioxide).*
 - *Reproductive structures: male, female, or both sexes (e.g., flowers, cones).*
 - *Structures that hold spores or seeds as they mature (e.g., sporangia, cones, fruits).*
 - *Stem - support leaves and reproductive structures, and the link between these modules and the root system.*
- Upper/lower surfaces of plants are highly branched. Maximize surface area for absorption of gas, light, nutrients and water.
- Cellular level (i.e., eukaryotes/multicellular, chloroplasts, cell walls, and large vacuoles).

Why study plants?

- ✓ Plants are necessary for the continued existence of most life in the biosphere.
 - ✓ Food
 - ✓ Resupply oxygen to atmosphere (11 year supply on earth).
 - ✓ Maintain the climate (deforestation is of concern).
 - ✓ Plants as a source of greenhouse gas? (Methane)
 - ✓ <http://news.bbc.co.uk/2/hi/science/nature/4604332.stm>
- ✓ For humans: source of medicine, spices, fibers, paper, clothing, lumber, oxygen, fuel (coal and wood), toothpicks, toilet paper, paper money, soft drinks, drugs, and so on.
- ✓ **TAKE-HOME MESSAGE:** Plants not only insure the continued survivability of people on this planet, but also the quality of our daily lives.

ENERGY AND RESOURCE FLOW



Plants & Humans: History

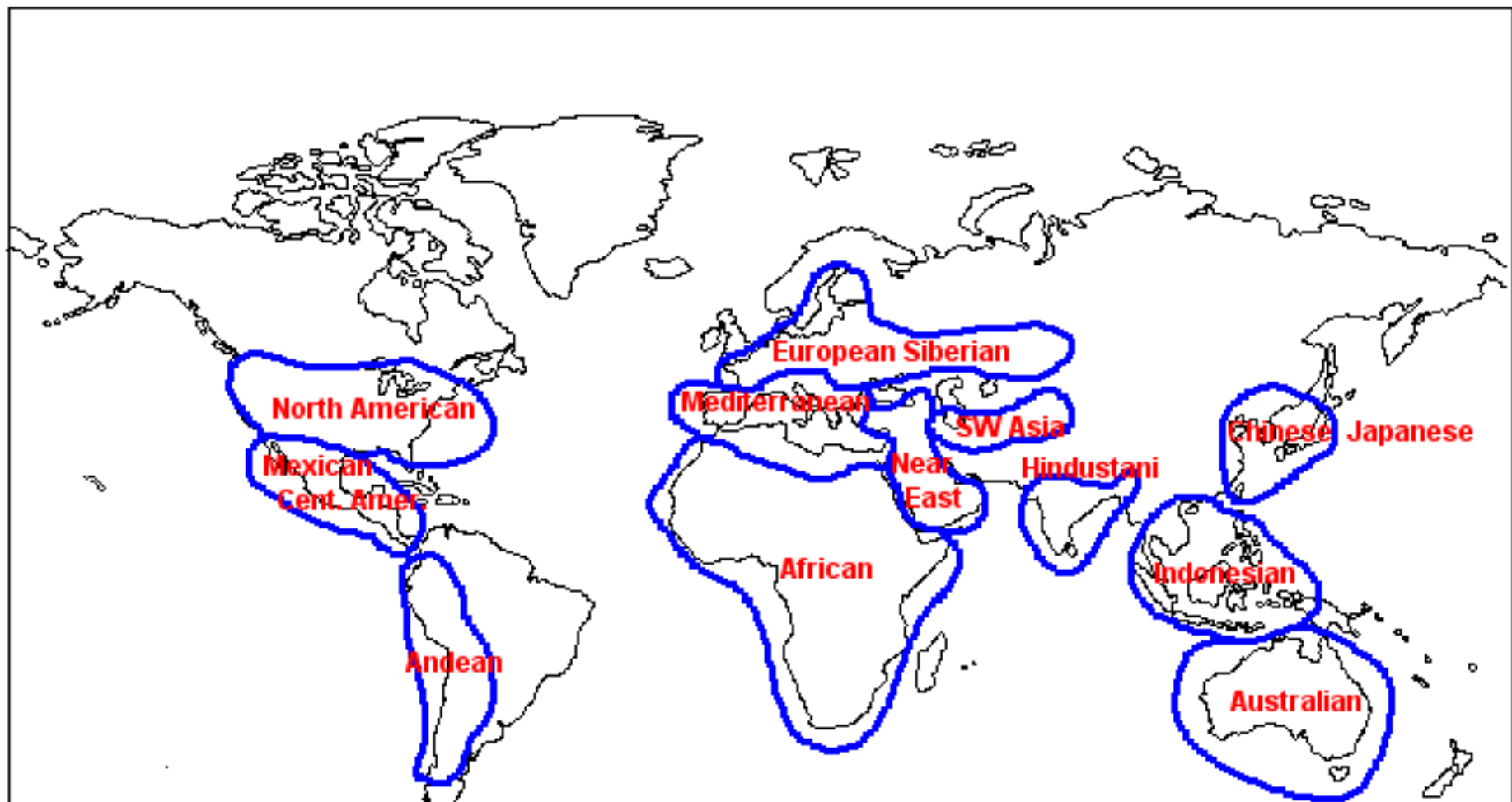
- Early human cultures were hunter/gatherers. One of the first professions was botany (plant taxonomy), because it was important knowledge to be able to distinguish poisonous from edible plants.
- About 8,000 -12,000 years ago something happened that changed the heart of human society. What was it? Answer: Agriculture!
- Agriculture - fossilized plant remains (e.g., seeds, charred plant remains, pollen) in archaeological digs of human encampments place the discovery of agriculture about 8,000 to 12,000 years ago.
- Most ancient civilizations (e.g., Chinese, Egyptians, Assyrian, Inca, Mayan, etc.) practiced agriculture regardless of their geographical location in the world. Indigenous plants (and animals) were domesticated by each respective society

Origins of Agriculture

- **Dump heap or Trash heap hypothesis**
 - early people may have discovered that the plants collected in the wild grew in refuse piles.
- **Two hypotheses about origin of agriculture:**
 - Independent discovery in different parts of world.
 - Diffusionist hypothesis - discovery originated in one part of the world and spread from one

Plants and Humans





-Nikolay Ivanovich Vavilov

o *Centers of origin for cultivated plants.*

- # Old World Crops
- Chinese-Japanese Center
 - 6000 BP (BEFORE PRESENT)
 - buckwheat *Fagopyrum esculentum*
 - Millet *Panicum* spp.
 - Soybean *Glycine max*
 - Legumes
 - Citrus
 - Indonesian
 - 12000 BP
 - Banana *Musa* spp.
 - breadfruit *Artocarpus communis*
 - clove *Caryophyllus aromaticus*
 - pepper *Piper nigrum*
 - coconut *Cocos nucifera*
 - yam *Dioscorea* spp.
 - rice *Oryza* spp.
 - sugar cane *Saccharum officinarum*

Old World Crops

- **Hindustani**

- 4000 BP
- cotton *Gossypium arboreum*
- bamboo *Bambusa* spp.
- mango *Mangifera indica*
- taro *Colocasia antiquorum*
- cucumber *Cucumis sativa*
- banana *Musa* spp.
- rice *Oryza sativa*
- gram *Phaseolus mungo*
- pepper *Piper* spp.
- sesame *Sesamum indicum*
- hemp *Cannabis indica*
- kenaf *Hibiscus cannabinus*
- safflower *Carthamus tinctorius*

- **Southwest Asia**

- 7000 BP
- pistachio *Pistacia vera*
- apricot *Prunus armeniaca*
- almond *Amygdalus communis*
- onion *Allium cepa*
- garlic *Allium sativum*
- carrot *Daucus carota*
- vetch *Lathyrus sativus*
- flax *Linum usitatissimum*
- pea *Pisium sativum*
- spinach *Spinacea oleraceae*
- fava bean *Vicia faba*

Old World Crops

- **Near East**

- 11000 BP
- wheat *Triticum* spp.
- rye *Secale* spp.
- kale *Brassica oleracea*
- fig *Ficus carica*
- barley *Hordeum vulgare*
- lentil *Lens esculenta*
- alfalfa *Medicago sativa*
- pomegranate *Punica granatum*
- vetch *Vicia sativa*
- grape *Vitis vinifera*

- **Mediterranean**

- 7500 BP
- olive *Olea europea*
- oats *Avena* spp.
- beet *Beta vulgaris*
- hops *Humulus lupulus*
- clover *Trifolium* spp.

- **Australian**

- grape *Vitis vinifera*
- Tobacco *Nicotiana debbneyi*
- Tobacco *Nicotiana goodspeedii*
- gum *Eucalyptus* spp.

Old World Crops

- **African**

- 6000 BP
- coffee *Coffea* spp.
- melons *Cucumis* spp.
- cotton *Gossipium* spp.
- banana *Ensete ventricosum*
- rice *Oryza* spp.
- millet *Pennisetum* spp.
- date palm *Phoenix* spp.
- castor bean *Ricinus communis*
- sesame *Sesamum indicum*
- millet *Setaria* spp.
- sorghum *Sorghum bicolor*

- **European Siberian**

- kale *Brassica oleracea*
- chicorie *Chicorium* spp.
- digitalis *Digitaria sanguinalis*
- strawberry *Fragaria* spp.
- lettuce *Lactuca sativa*
- hops *Humulus lupulus*
- lucern *Medicago* spp.
- currant *Ribes* spp.
- raspberry *Rubus* spp.
- clover *Trifolium* spp.

New World Crops

- **Andean**

- 8000 BP
- oca *Oxalis tuberosa*
- potato *Solanum* spp.
- ulluca *Ullucus tuberosus*
- papaya *Carica* spp.
- amaranth *Amaranthus* spp.
- pineapple *Ananas comusus*
- peanut *Arachis hypogaea*
- chili *Capsicum* spp.
- quinoa *Chenopodium quinoa*
- cotton *Gossypium barbadense*
- rubber *Hevea brasiliensis*
- tomato *Lycopersicum* spp.
- manioc *Manihot esculenta*
- tobacco *Nicotiana tabacum*
- Mango *Bromus mango*

- **Mexico and Central America**

- 9000 BP
- mays *Zea mays*
- agave *Agave* spp.
- cashew *Anacardium occidentale*
- chilis *Capsicum* spp.
- gourds *Cucurbita* spp.
- cotton *Gossypium* spp.
- sweet potato *Ipomoea batates*
- beans *Phaseolus* spp.
- cocoa *Theobroma cacao*

- North American

- strawberry *Fragaria virginiana*
- sunflower *Helianthus* spp.
- plum *Prunus* spp.
- raspberry *Rubus* spp.
- blueberry *Vaccinium* spp.
- grapes *Vitis* spp.

New World Crops

- Development of New Crops from Prairie and Woodland Plants
- For example: breeding of perennial grains from native grasses, testing of new legumes (*Cassia marilandica*), commercialization of pawpaws





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Plants as drugs and medicines



Plants as Decorations

003: Spider Plant



005: Scented Geranium



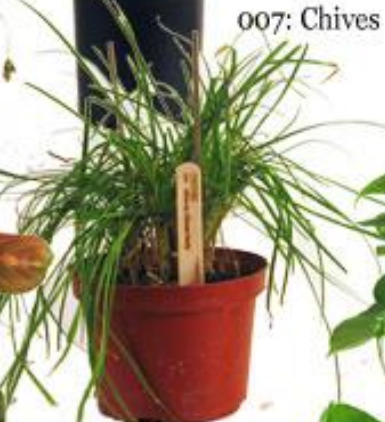
010: Papyrus



009: Cuban Oregano



007: Chives



001: Fiddle Leaf Fig



011: Scotch Moss



004: Prayer Plant



002: Living Stones



012: Pothos

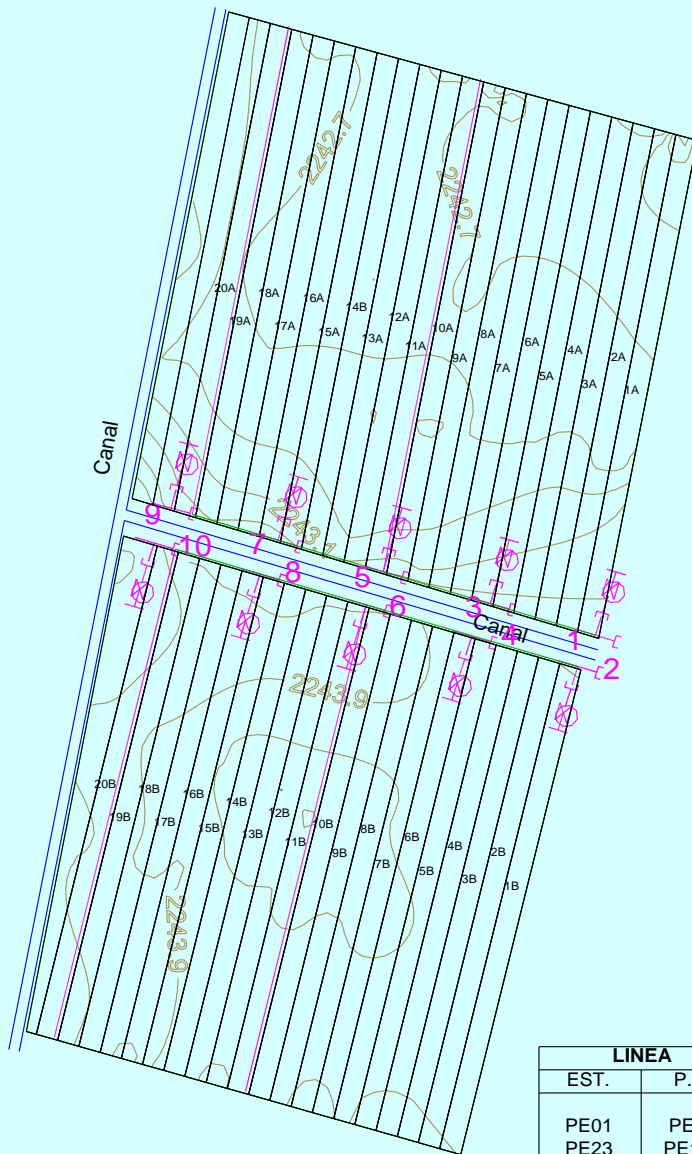


Plants as building materials



Plants for food/medicine

- In preliterate societies, knowledge of what was good or bad was passed on in oral traditions, usually through religious leaders - the 'medicine man' or shaman among certain North American Indians and their counterparts in other societies (e.g. priests, rabbis, teachers).
- In literate societies, this information was transmitted by means of the written word.
 - Shen Nung, born 2737 B. C., founder of Chinese agriculture, wrote books on drugs and medicines from plants.
 - About 300 B. C., the Greek Theophrastus collected information about plants into books including the "History of Plants" and "Causes of Plants". Carolus Linnaeus in the 18th century A. D. referred to Theophrastus as the "Father of Botany".
 - Dioscorides wrote the "Materia Medica" in the 2nd century A.D., which contained illustrations of plants, just as many modern field guides of wild plants (and other organisms) do today.



LINEA		DISTANCIA		
EST.	P.V.	(m)		GRA
PE01	PE23	230.22	N	29
PE23	PE135	625.24	S	54
PE135	PE123	233.64	S	32
PE123	PE01	614.11	N	54
TOTALES		1.703.20	M	

Dripper mathematical models

$$\Theta = \frac{\theta - \theta_r}{\theta_s - \theta_r}$$

$$\Theta = \frac{1}{\left[1 + (\alpha h)^n\right]^m}$$

$$K = K_s \exp(\alpha h)$$

$$K = K_s \left[\frac{1 - (\alpha h)^{n-2} \left[1 + (\alpha h)^n\right]^{-m}}{\left[1 + (\alpha h)^n\right]^{2m}} \right]$$

$$\nabla \cdot (K \nabla h) = \frac{\partial K}{\partial z}$$

Subject to

$$h = h_0$$

$$K \nabla h = q_0$$

or

$$\nabla^2 D = \alpha \frac{\partial D}{\partial z}$$

with its appropriate boundary conditions and explicit solution as follow

$$D = \frac{q_0}{4\pi(x^2 + y^2 + z^2)^{0.5}} \exp\left(\frac{\alpha}{2(z - (x^2 + y^2 + z^2)^{0.5})}\right)$$

Texture	θ_s	θ_r	α	n	K_s
	cm^{-1}				cm d^{-1}
Sand	0.43	0.045	0.145	2.68	712.8
Loamy sand	0.41	0.057	0.124	2.28	350.2
Sandy loam	0.41	0.065	0.075	1.89	106.1
Loam	0.43	0.078	0.036	1.56	24.96
Silt	0.46	0.034	0.016	1.37	6.00
Silt loam	0.45	0.067	0.020	1.41	10.80
Sandy clay loam	0.39	0.100	0.059	1.48	31.44
Clay loam	0.41	0.095	0.019	1.31	6.24
Silty clay loam	0.43	0.089	0.010	1.23	1.68
Sandy clay	0.38	0.100	0.027	1.23	2.88
Silty clay	0.36	0.070	0.005	1.09	0.48
Clay	0.38	0.068	0.008	1.09	4.80

Source: <http://hopmans.lawr.ucdavis.edu/papers+PPT+zip/Chapt3-3-4rev.pdf>

