Remote Sensing and Desert Locusts

Schistocerca gregaria--the problem starts

Eggs deposited in sandy soil,
>200 eggs/female; last >15 years

Satellite-Assisted Desert Locust Control

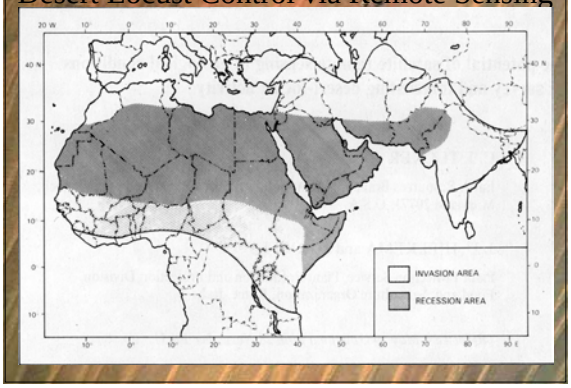
- Plagued *Homo sapiens* thru recorded history
- Affects 30,000,000 km^2 area
- Affects 55 countries & 850,000,000 people
- Episodic in time and space
- Desert locust recession area focus of control
- **Precipitation-->hatches eggs -->green vegetation**
- **ergo**
- Monitor **precipitation**
- Monitor **green vegetation**

Desert Locust Historical References

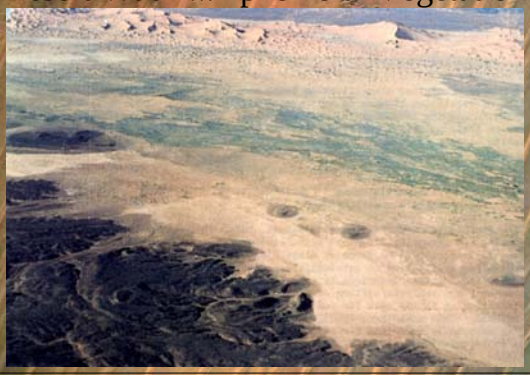
- **Egyptian 6th dynasty (~2400 BC) bas relief**
- **Assyrians bas relief of locusts for food (2000BC)**
- **Babylonian Ta'anith 3.5**
- **Ugaritic Legends, Epics, and Myths**
- **Biblical accounts in Exodus 10:3-20 (8^{th} plague)**
- **Deuteronomy 28:38; Joel 2:1, 11; I Kings 8:37 etc**
- **Pliny's Natural HistoryXXXVII:40 (they get so big in India the locals use their hind legs as saws…)**

Assyrian Desert Locust Kabobs

Desert Locust Control via Remote Sensing



Desert Wadi w/Ephemeral Vegetation



7 locust instars: 5 hopper, 2 flier

Gregarious Hoppers, 5th instar

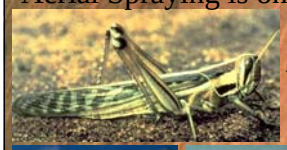
Swarming locusts hit Afghanistan

Insult to injury

Locusts munching Vegetation (80-160g/m^2/day)

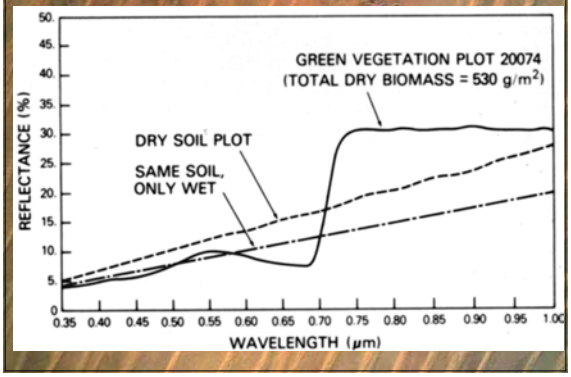
Locust defoliation: 1-2g leaves/locust/day

Aerial Spraying is only control alternative

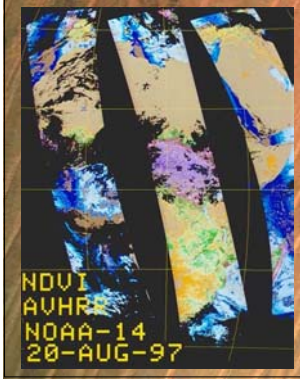


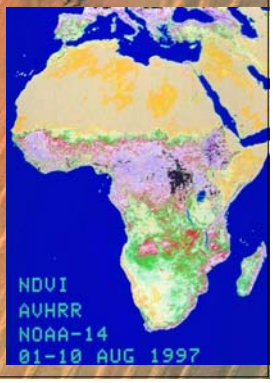
vs.

Green Plants and Soil Reflectances

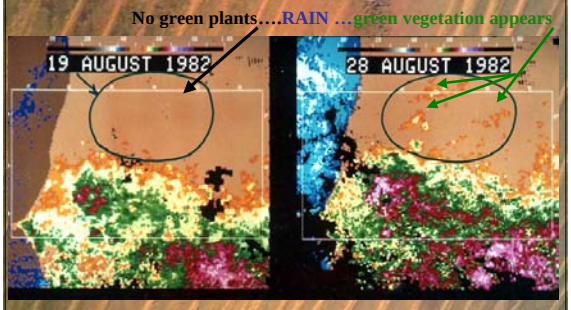


N-14 False Color Veg. Index





Ephemeral **Green Vegetation** "Flushes"



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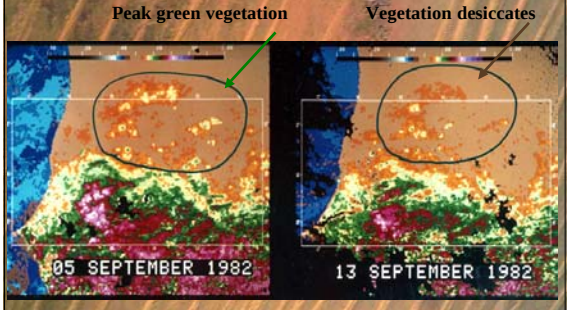
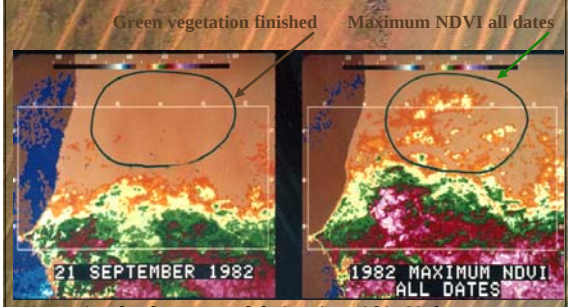


Ephemeral Green Vegetation "Flushes"



Vegetation development and desiccation within 32 days.
Detection requires frequent observation and coarse spatial detail.

FAO's Desert Locust News

DESERT LOCUST BULLETIN

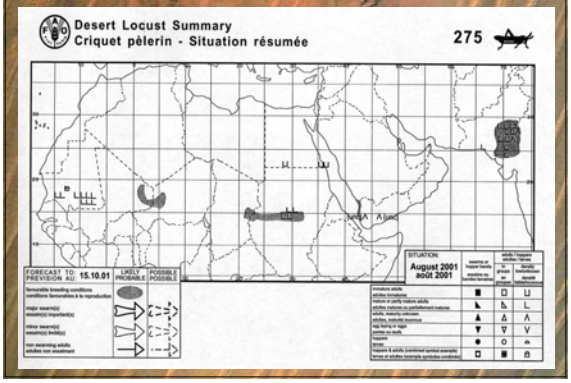
FAO Emergency Centre for Locust Operations

No. 275
(6 Sep 2001)

General Situation during August 2001
Forecast until mid-October 2001

The Desert Locust situation remained calm during August. Although conditions are exceptionally favourable in the summer breeding areas, only insignificant numbers of locusts have been reported to date in Egypt, Mauritania, and Sudan and along the Indo-Pakistan border. Small-scale breeding is expected to continue somewhat western **Eritrea**. Although breeding conditions are exceptionally favourable in both countries, only isolated locusts have been found so far in Sudan. Small-scale breeding will occur during the forecast period but locust numbers should continue to remain low and non-threatening. Good rains also fell on the Red Sea coast and interior of **Yemen**, on the southern

FAO's Monthly Locust Situation

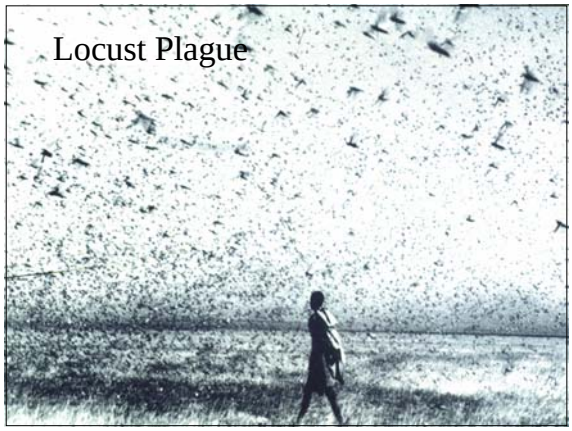


Possible satellite data 1982-1998

Main characteristics of satellite sensors suitable for detection/monitoring of green-leaf-vegetation biomass.

Characteristic	LANDSAT MSS	LANDSAT TM	NOAA/ AVHRR	SPOT
Spatial resolution	80 m (0·5 ha)	30 m (0·1 ha)	1100 m (120 ha)	20/10 m (0·04; 0·01 ha)
Spectral resolution	4 bands	7 bands	5 bands	3 bands
Useful bands for vegetation monitoring	2	4 (optimized for vegetation monitoring)	2	2
Radiometric resolution (quantizing levels)	64	256	1024	256
Temporal resolution (repeat frequency)	16 days	16 days	2–3 days every 9 days	9 days
Swath width	185 km	185 km	2700 km	92 km
Single-frame coverage	34 000 km^2	34 000 km^2	2 000 000 km^2	8500 km^2
Present single frame cost	$650 (standard) $1000 (spec. acq.)	$2800	$100	Not known
Scenes/orbits required to cover the desert-locust recession area	700 scenes	700 scenes	7 orbits	2800 scenes

Locust Plague



Earliest Desert Locust Depiction

Kagemni's tomb ~2400-2350 BC @ Saqqara
Egyptian Old Kingdom, Dynasties V-VI

Exodus 10:19

- And the Lord said onto Moses, stretch out thine hand over the land of Egypt for the locusts, that they might come up upon the land of Egypt, and eat every herb of the land, even all that the hail hath left.
- And the locusts went up over all the land of Egypt…very grievous were they…
- For they covered the face of the whole earth, so that the land was darkened…they did eat every green herb of the land…

Exodus 10:19 cont.

- The Pharaoh asks Moses and Aaron to forgive him for doubting them.
- Moses entreats God to spare Egypt.
- And the Lord turned a very strong wind, which lifted the locusts and drove them into the Red Sea; not a single locust was left in all the country of Egypt--**First Example of Desert Locust Control**
- But the Pharaoh reconsiders letting the Israelites leave--so God sends 3 days of darkness upon Egypt (**how God did this is still a mystery…)**
- Not surprisingly, now the Pharaoh lets Moses and the Jews leave Egypt.

Traveling Insects

- Group tours and long distance travel: Breakfast in Casablanca, lunch in Tripoli, and dinner in Cairo… (Arab locust joke)
- 1889 swarm crossed Red Sea & was estimated to be larger than 2,000 miles^2 in area -- (probably an exaggeration--no airplanes then)
- Swarms have been documented 1,200 km out to sea (ancients thought sea was locust source)
- Somalia 1958 swarm measured 1,200 km^2
- 40-80 Million locusts/km^2 of swarm
- Eat body weight every day (~2 g leaf mass)
- 60M locusts/km^2 = 60/m^2; 120g/m^2/day munched

Desert Locust Natural History

- Desert locusts exist throughout **recession area** in **solitary** phase--no problems
- Following good **rains**, several generations can develop and increase densities exponentially
- Rain hatches eggs and sustains ephemeral vegetation
- When densities are high, locusts enter **gregarious** phase--different behavior, different color, and different metabolism--**swarm(s)** result
- Swarms of several **million** to several **billion** insects
- Travel great distances, **eat body weight every day**…
- **Havoc** results, loss of crops, etc.

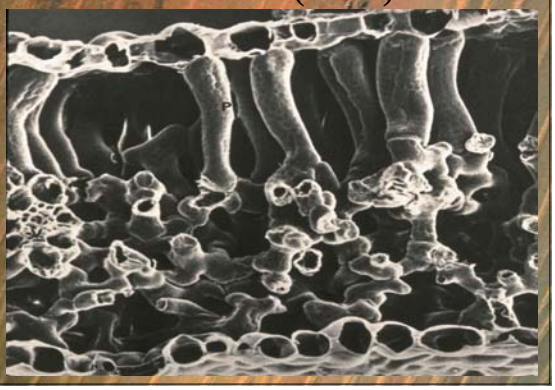
Desert Locust as Food

- Talmud discusses in detail locusts as food, some are clean, some are not
- Bedouin delicacy
- Pliny's Nat. History VI.35 & VII.2
- Semitic health food: 75% protein; 4% fat; 8% carbohydrates + vitamins

Assyrian attendants carrying locusts and pomegranates on skewers

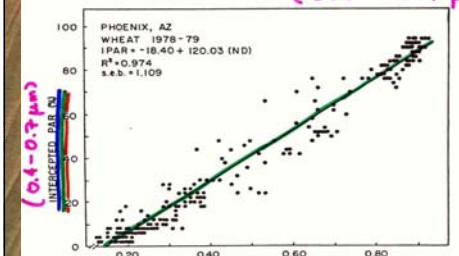
A Wadi on the Saharan margin

Dicot Leaf (x 420)



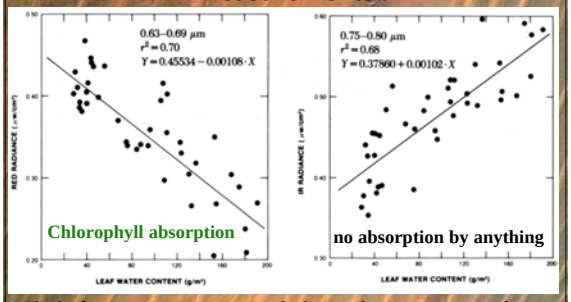
What NDVI is really measuring--APAR

PAR = photosynthetically Active Radiation (0.4 – 0.7 μm)



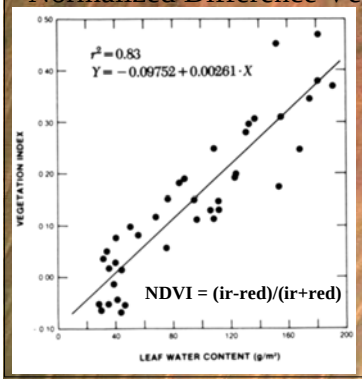
NDVI = (Ir - red) / (Ir + red)

Green Plants and red & near-infrared measurements



The leaf water content in grass is the best and easiest measure of green leaf biomass and is very highly correlated with the chlorophyll content

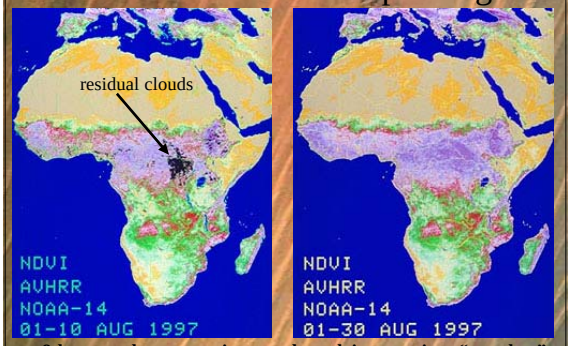
Normalized Difference Vegetation Index



NDVI = (ir-red)/(ir+red)

simple transform, normalized for intensity, directly related to green leaf biomass & ??

Maximum Value Compositing



8-km, equal-area, maximum value ndvi composites, "seamless"

Maximum Value Compositing
No Assumptions