Science, Evolution, Plant Diversity and Food Sustainability.

BIODIVERSITY MATTERS

Agrobiodiversity

A scientific odyssey:

From high school biology to a working scientist and beyond.

Why teaching high school Science is of utmost importance
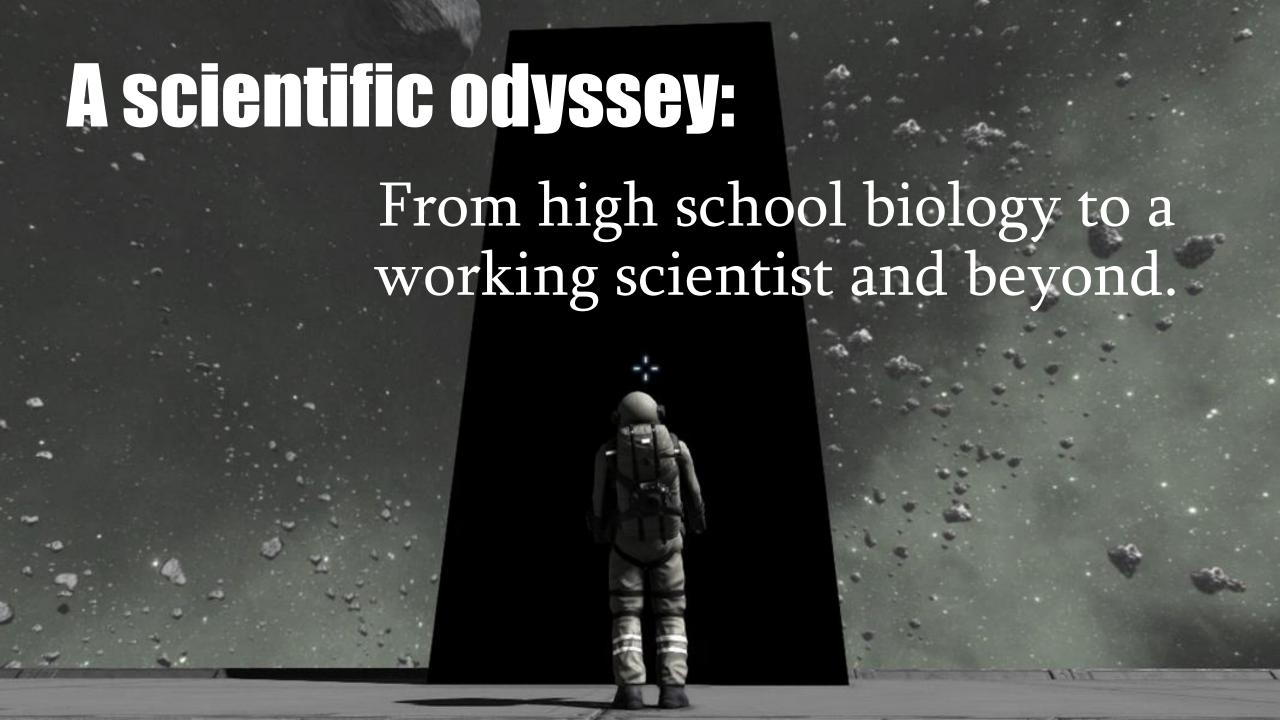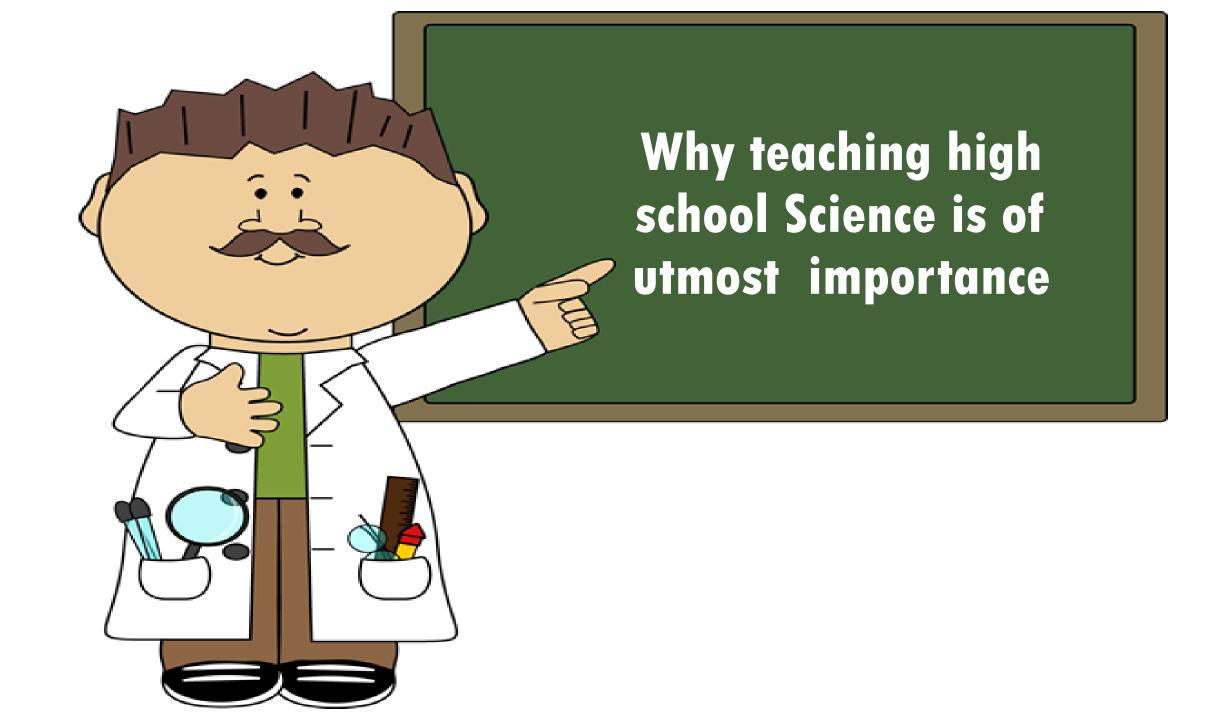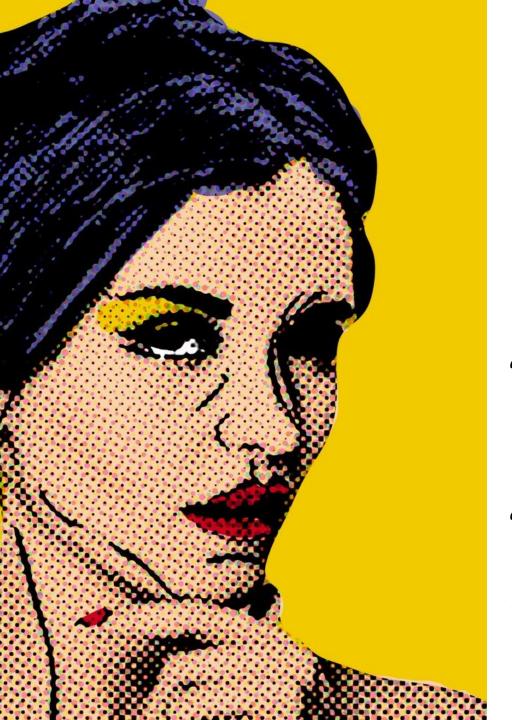
Seriously?

In the US

40% believe the earth is only 10,000 years old

40% reject evolution

50% deny anthropogenic climate change

Psychological link found between climate change denial and belief in free market economics
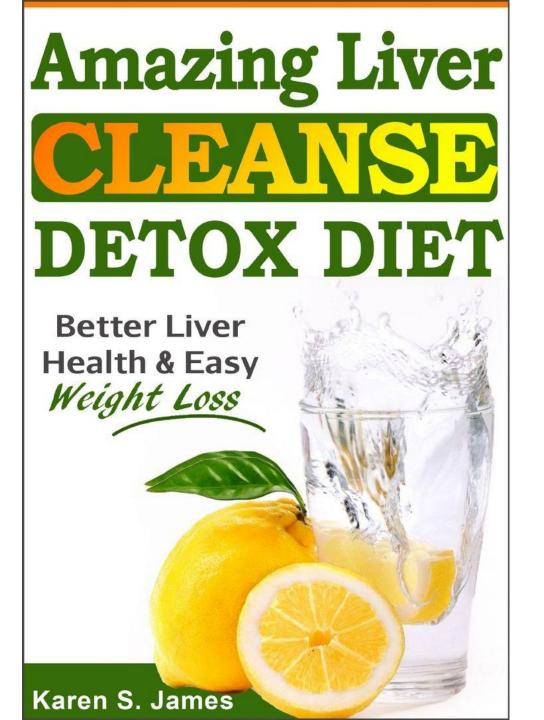
The Paleo Diet

Over 100,000 copies sold!

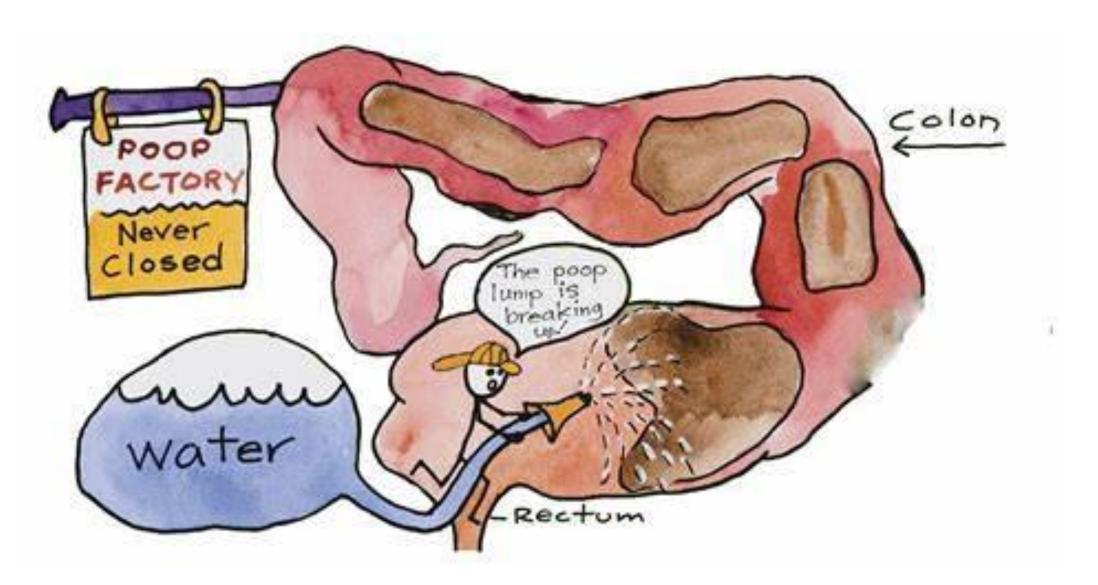## Lose Weight and Get Healthy by Eating the Foods You Were Designed to Eat
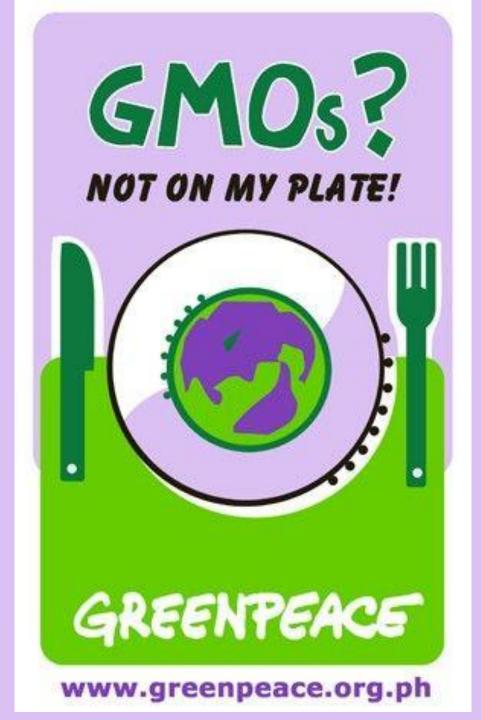
Loren Cordain, Ph.D.

Author of *The Paleo Diet Cookbook*

Amazing Liver

CLEANSE

DETOX DIET

Better Liver Health & Easy *Weight Loss*

Karen S. James

Colonic hydrotherapy
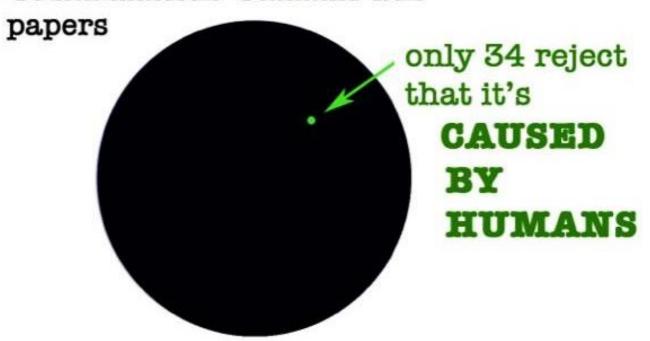
Interstellar lizards in people suits dominate the global ruling elite.

Of 33,700 authors
of peer-reviewed
CLIMATE CHANGE
papers

only 34 reject
that it's
**CAUSED
BY
HUMANS**

220.000 peer reviewed papers on climate change

- 1/2 reporting on research undertaken
- Team effort of 3 full time equivalents
- Average study time of 2 years

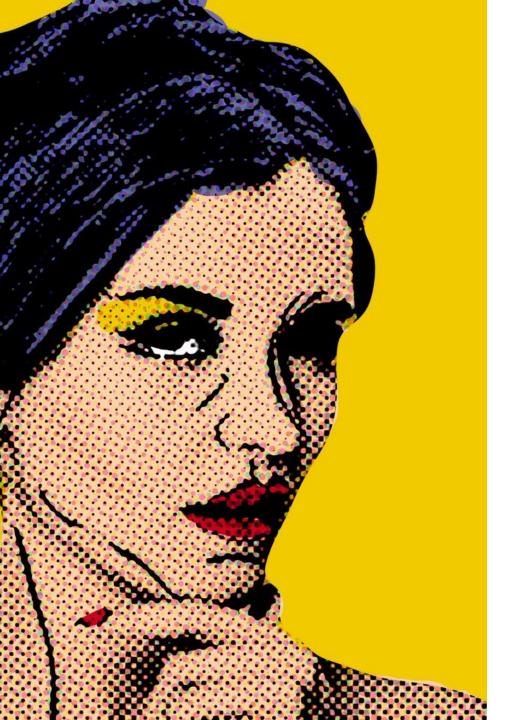# 660,000 person years of research

Human health

Heart disease –Kills one Australian every 12 minutes

Cancer – 47,753 died if cancer in 2017
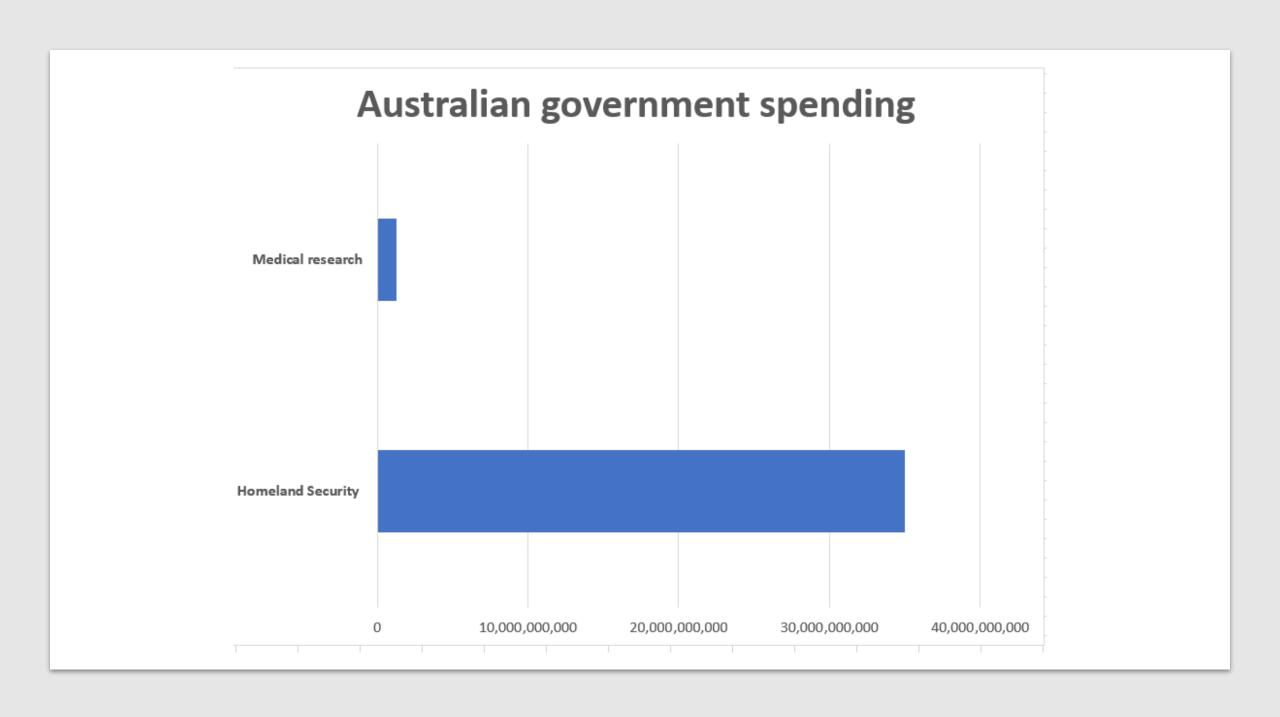
Diabetes - One person every five minutes diagnosed
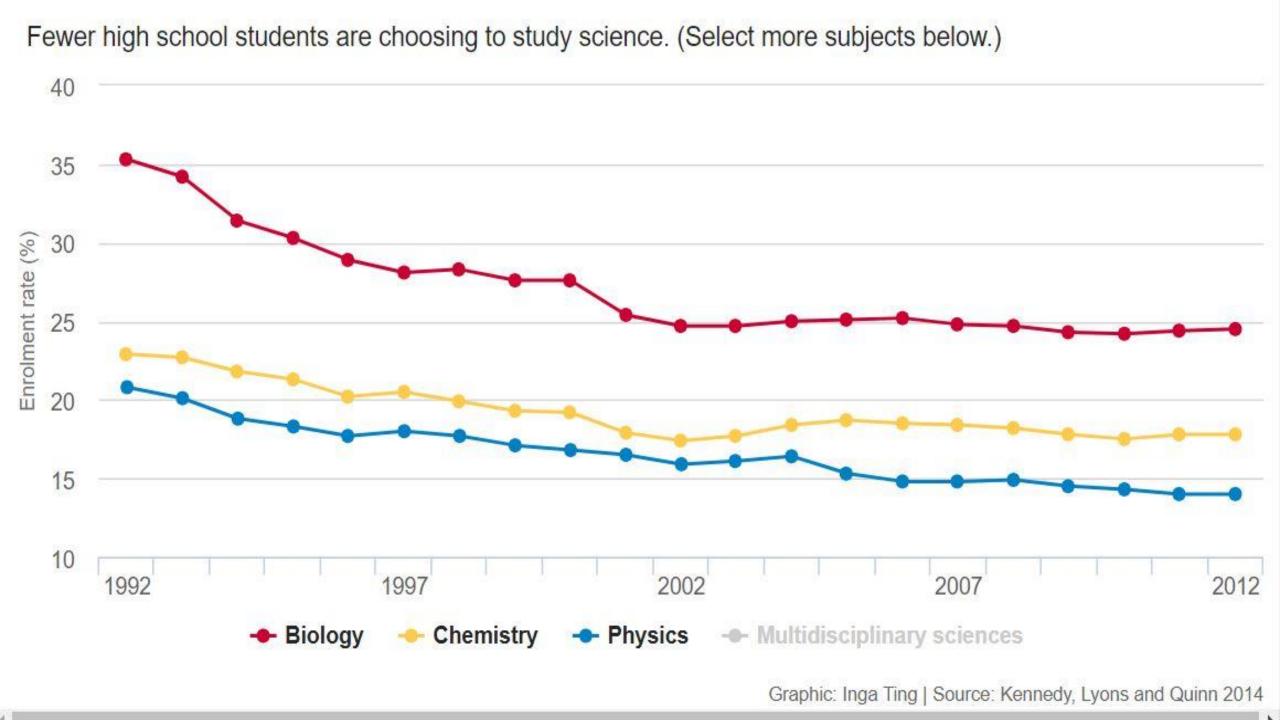
W.T.F

Scientific research shows an unequivocal link between these diseases and eating animal products.

Australian government spending
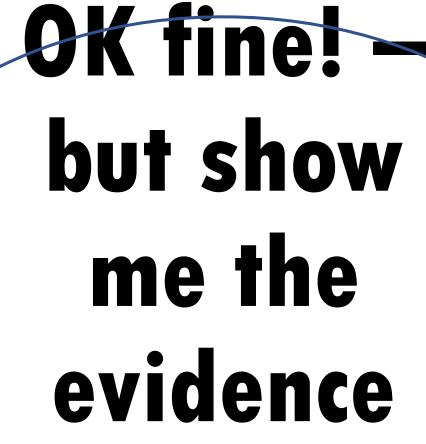
80% of Americans don't trust **science**

Fewer high school students are choosing to study science. (Select more subjects below.)

Enrolment rate (%)

Biology Chemistry Physics Multidisciplinary sciences

Graphic: Inga Ting | Source: Kennedy, Lyons and Quinn 2014

A scientific odyssey:

From high school biology to working scientist

Port Hedland

Port Hedland

AGRICULTURAL SCIENCE

BSc Agriculture (Hon)

PhD Pasture ecology

THE UNIVERSITY OF
WESTERN
AUSTRALIA

SEEK WISDOM

Global food sustainability

BSc – Agricultural science

Inorganic chemistry, organic chemistry, calculus, statistics, biometrics physics, animal biology, plant biology, plant physiology, computer science, agronomy, entomology, microbiology, genetics, plant pathology, geology, soil science, economics, agricultural economics, plant nutrition, science communication, pasture science, agricultural ecology, natural resource management, agricultural engineering.

International Center for Agricultural Research in the Dry Areas (ICARDA)

ICARDA's mission is to improve the welfare of poor people and alleviate poverty through research and training in dry areas of the developing world to increase the production and nutritional quality of food, while preserving and enhancing the natural resource base.

Ecogeographic variation in the reproductive ecology of *Vicia sativa* ssp. *amphicarpa*

VICIA SATIVA SPP. AMPHICARPA
IFV # 2614

SOURCE: UNDERGROUND   SOURCE: AERIAL

AERIAL PODS

UNDERGROUND PODS
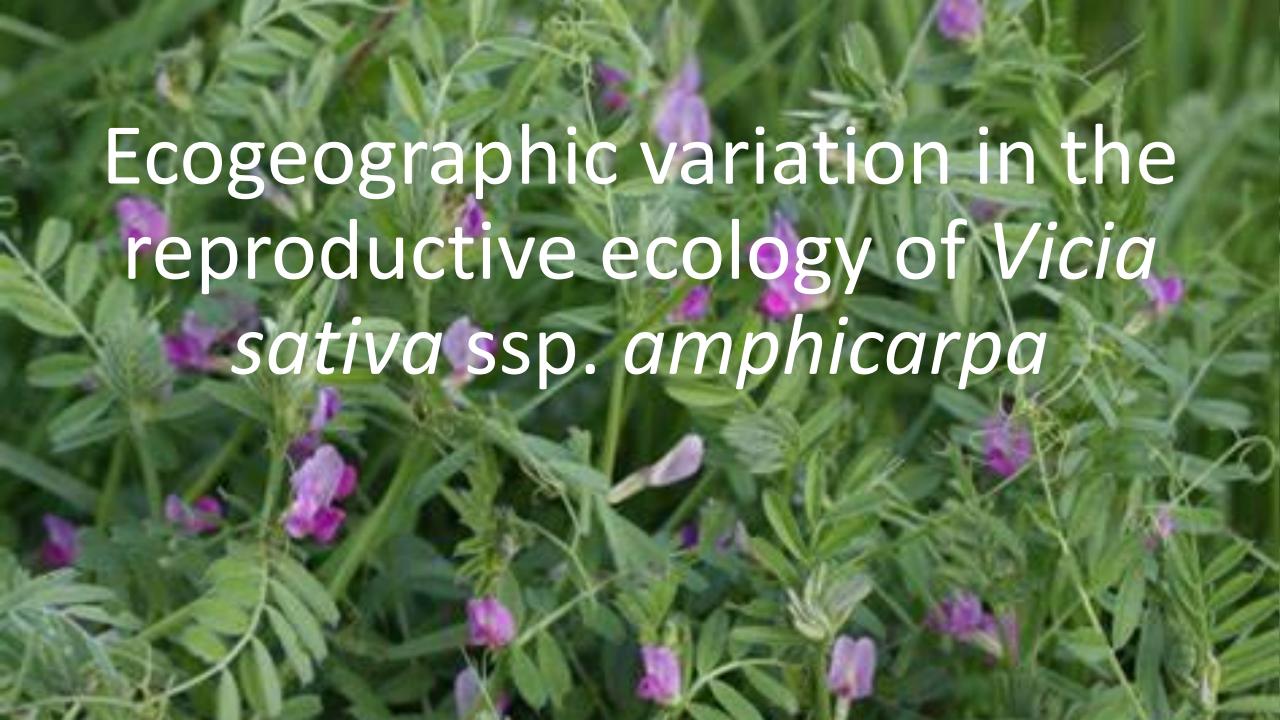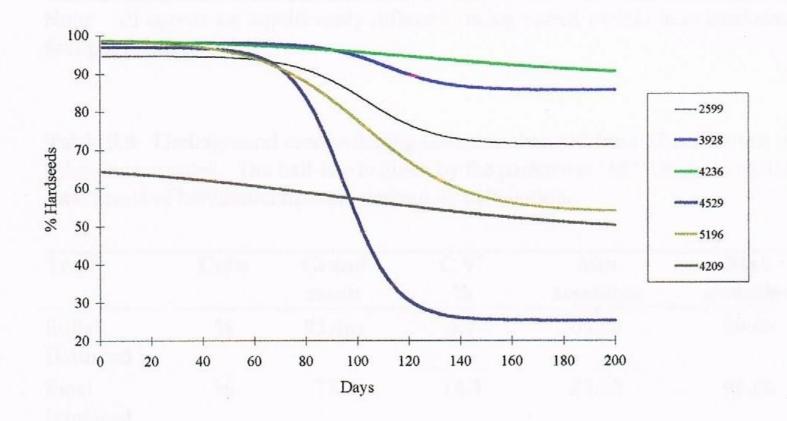
Figure 5.1: Underground seed softening profiles for 6 accessions (ICARDA accession numbers shown in legend box), which are examples of the variation both in half-lives and the final level of hardseededness of the collection as a whole. The curves represent models of the form (y=A+C/(1+exp[-B(t-M)])) fitted to the seed softening data set generated for each accession. Table 5.4 shows the parameters for each curve with their respective standard errors.

Genetic Resource Section (ICARDA-GRS)

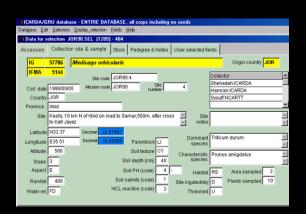**Mission:** collect   conserve   characterize   evaluate   document   distribute

Genetic diversity of wheat, barely, food legumes, pasture and forage species from diverse origins for use in research and plant breeding

Durum wheat evolution

Bread wheat evolution

ARCTIC OCEAN

BARLEY   LENTIL   BREAD WHEAT
DOG   OATS   BROAD BEAN
EINKORN WHEAT   RYE   CATTLE
EMMER WHEAT   SHEEP   OLIVE
GOAT   PIG

HORSE

Southwest Asia

East Asia

RICE
SOYBEAN
CHINESE CHESTNUT
WALNUT

PACIFIC OCEAN

ATLANTIC OCEAN

PACIFIC OCEAN

SQUASH
PEPPER
ALPACA
CASSAVA
COTTON
LIMA BEAN
LLAMA
MAIZE
POTATO
SWEET POTATO

Latin America

Sub-Saharan Africa

CATTLE
CHICKEN

INDIAN OCEAN

Southeast Asia

YAM
SORGHUM
COWPEA
AFRICAN RICE
COFFEE
FINGER MILLET

MANGO
TARO
COCONUT
PIGEONPEA
SLENDER MILLET

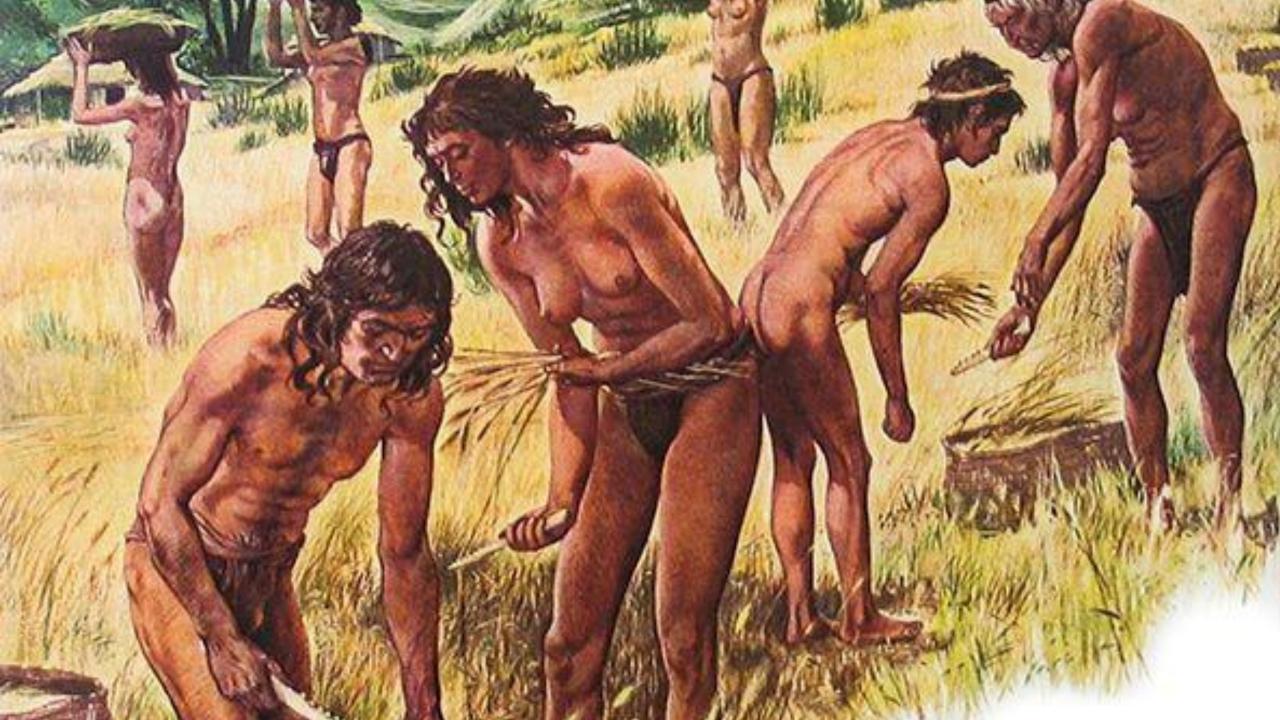0   1,000   2,000 Miles

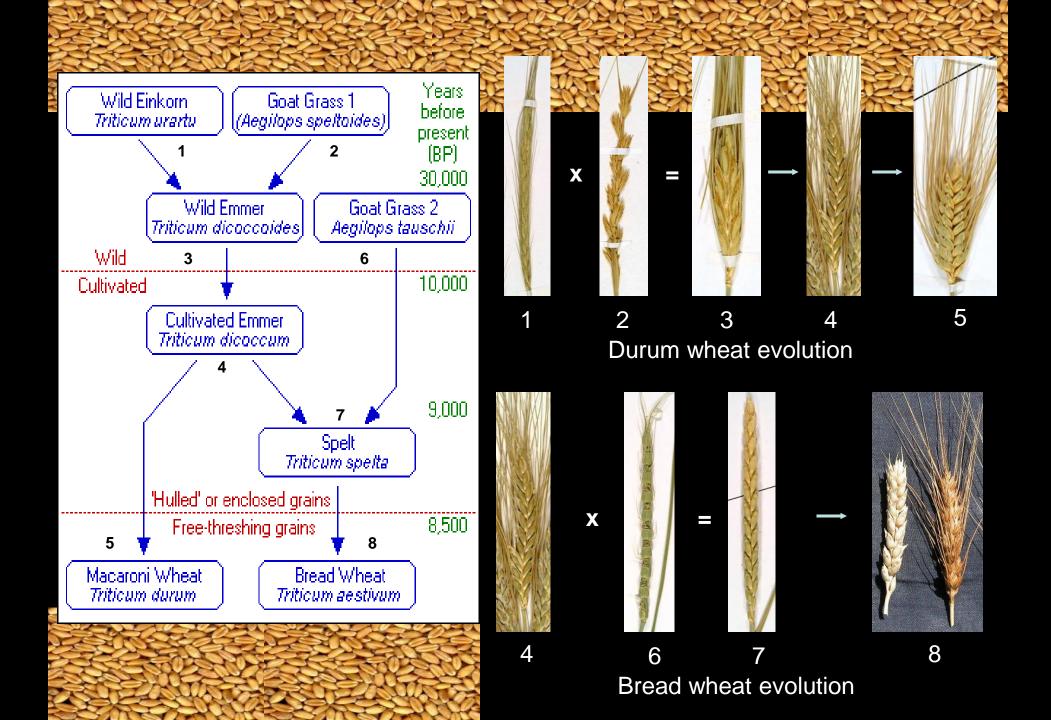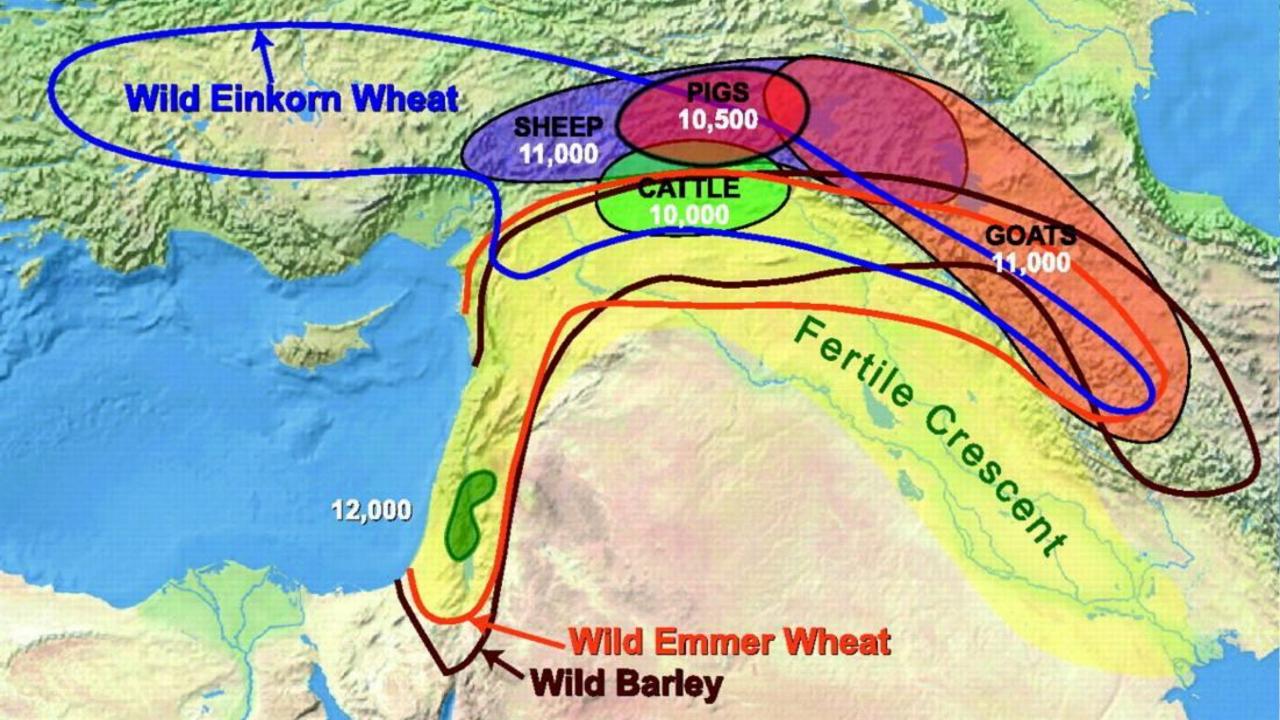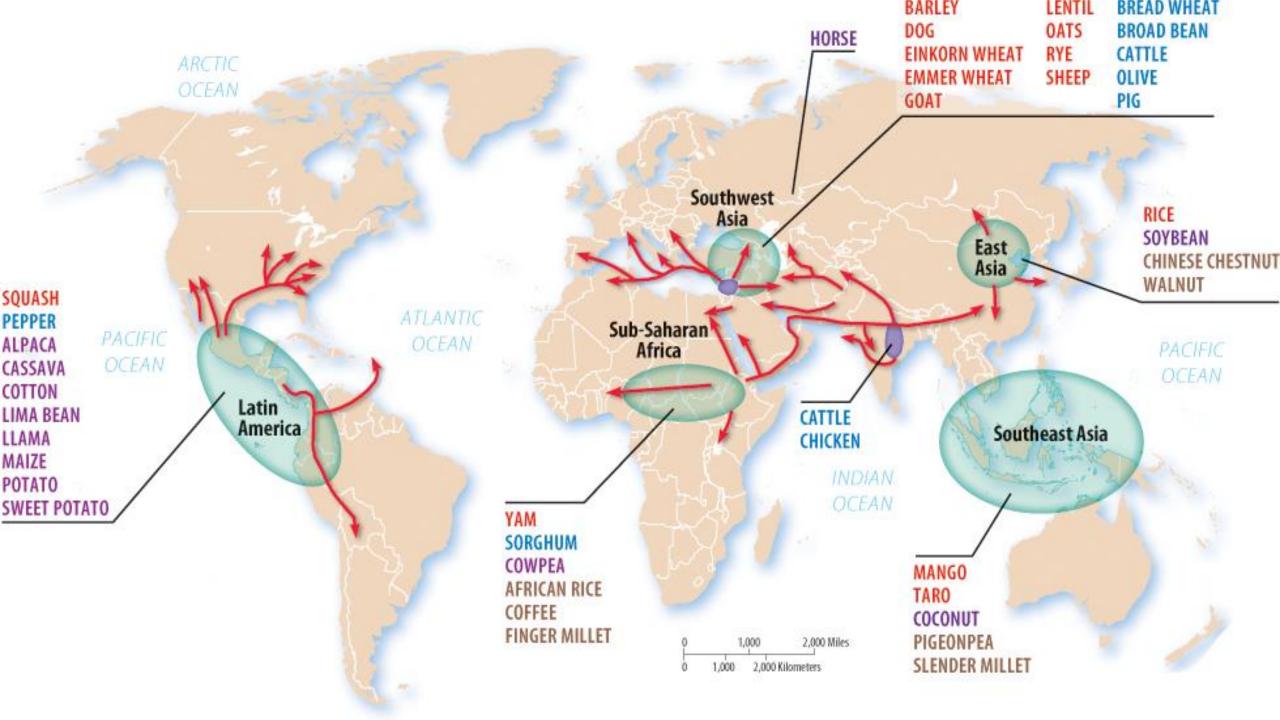0   1,000   2,000 Kilometers

Enormous intra-specific diversity

80% of the genetic diversity of major crop plants were lost in the last century.

Examples of Genetic erosion in crop varieties

Crop	Country	Number of varieties in use last century	Number of varieties in use now
Rice	Philippines	1000s	2 (98% of land)
Rice	China	8000 (1949)	50 (1970s)
Rice	Sri Lanka	2000 (1959)	5 (most land)
Wheat	China	10,000 (1949)	1000 (1970s)
Cabbage	USA		95% lost
Field corn	USA		91% lost
Pea	USA		86% lost
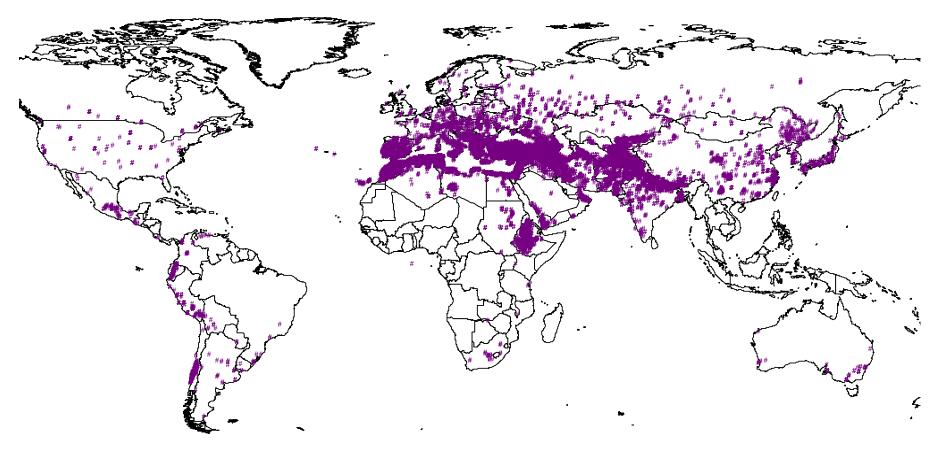
Doco Trailer

Global Food Security

Lisbon consumes about 1,000 tonnes of food per day

Urban populations eat 8.4 million tons of food per day

By 2050 global demand for food will increase by 60 – 90%

Resources flow

N,P,K **200 million tonnes**

16.6 billion barrels
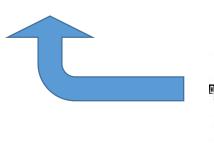
6800 trillion litres

A perfect storm is approaching

Inter-connected negative factors

Climate change

Population growth

Energy crisis/biofuels

Land degradation

Low genetic diversity

Looming water crisis
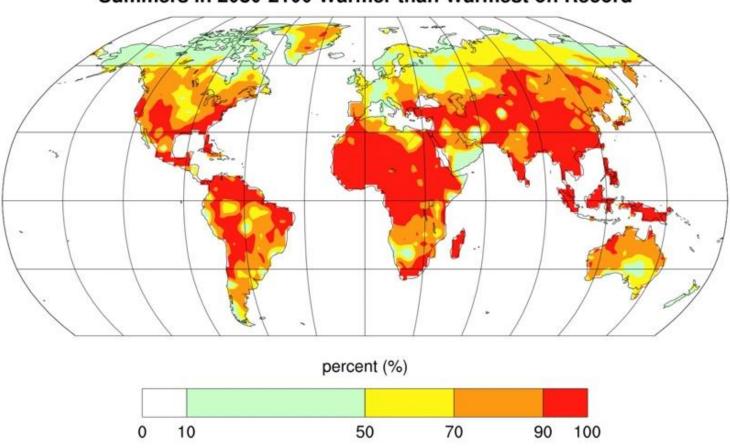
New pests and diseases

Under-investment in agricultural research

Climate change
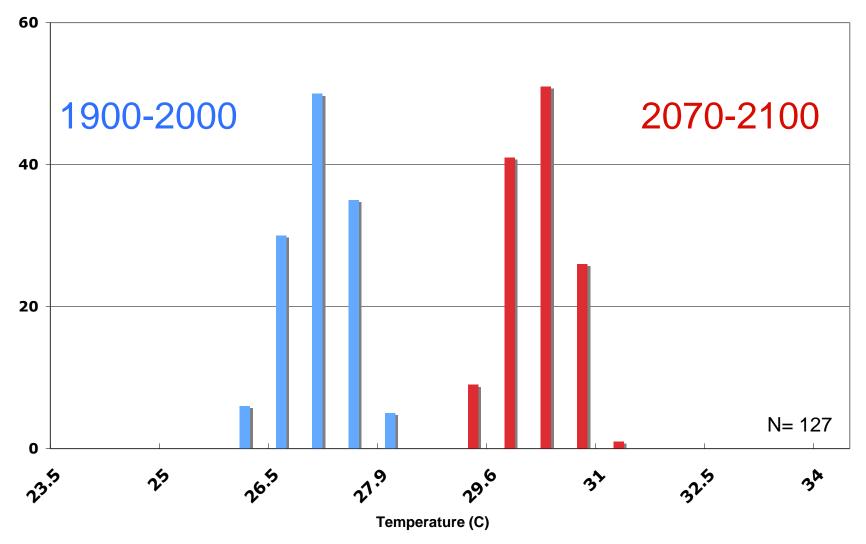
Likelihood (in percent) that the summer average temperature in 2090 will exceed the highest summer temperature ever observed (1900-2006).

Summers in 2080-2100 Warmer than Warmest on Record

percent (%)

| 0 | 10 | 50 | 70 | 90 | 100 |
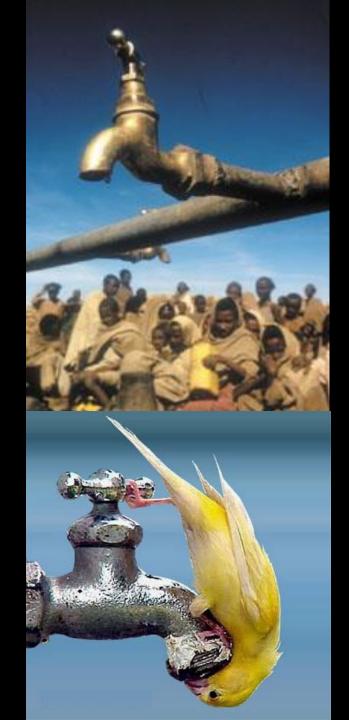
Source: Battisti D. S. and Rosamond L. Naylor R. L. 2008. Historical Warnings of Future Food Insecurity with Unprecedented Seasonal Heat. in publication.

India

Source: Data from Naylor R., Falcon W. and Fowler C. 2007. The Conservation of Global Crop Genetic Resources In the Face of Climate Change: Summary Statement from a Bellagio Meeting. (Taken from D. Battisti.)

Land Degradation

Lose 10 million hectares of farming land each year
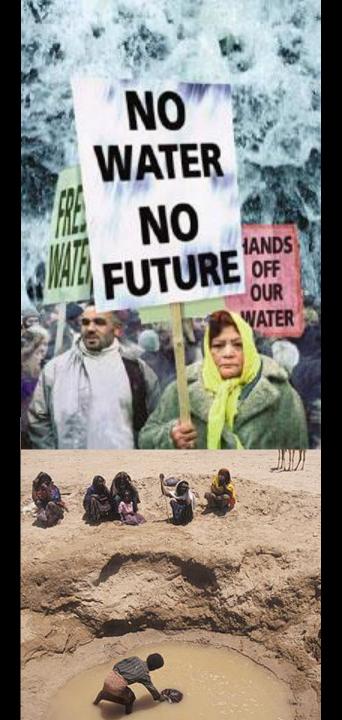
Water
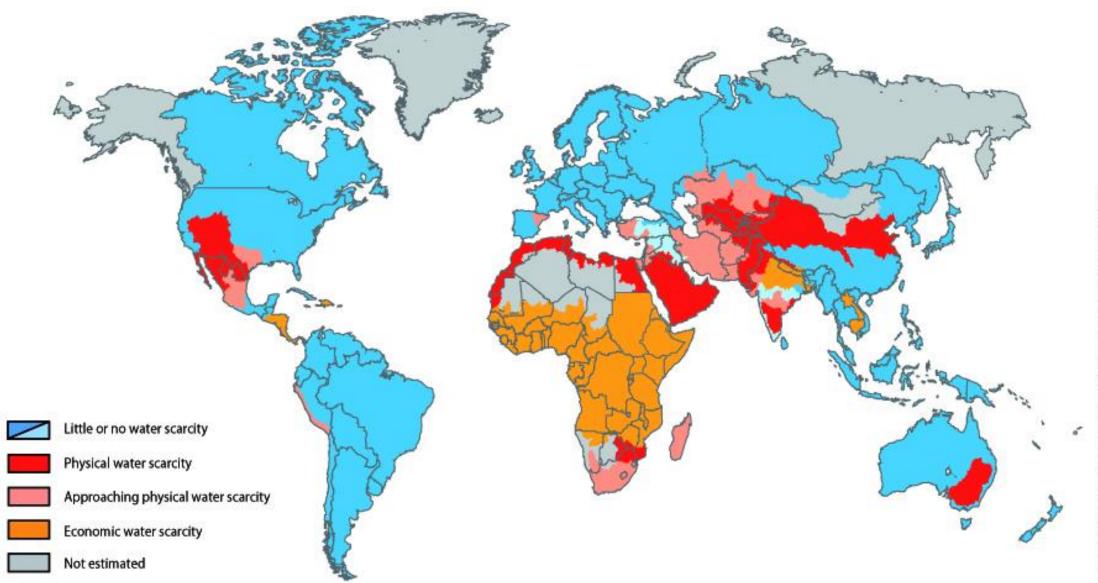
Use 3 times more water than a generation ago
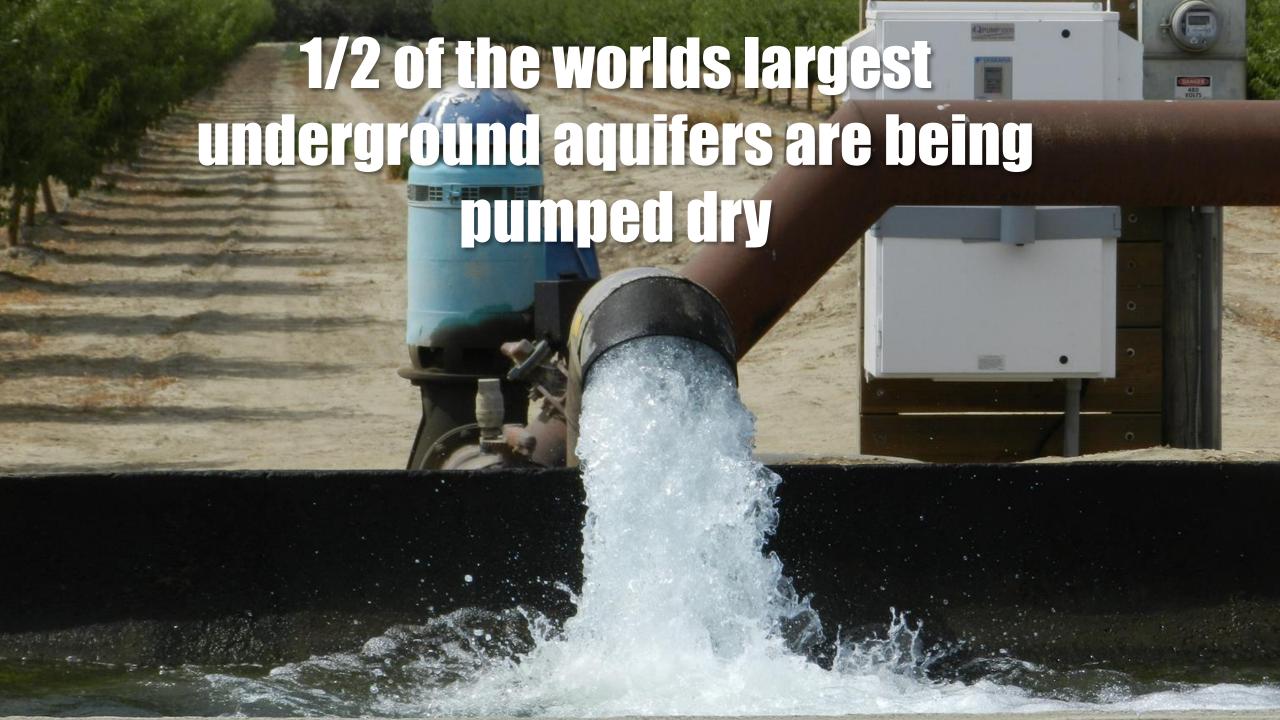
By 2025 1.8 billion people will live with water shortage

2/3 world in water stress
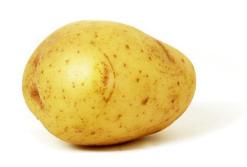
Areas of physical and economic water scarcity

Legend:
- Little or no water scarcity
- Physical water scarcity
- Approaching physical water scarcity
- Economic water scarcity
- Not estimated

1/2 of the worlds largest underground aquifers are being pumped dry

"There is a water crisis today. But the crisis is not about having too little water to satisfy our needs. It is a crisis of managing water so badly that billions of people - and the environment - suffer badly." World Water Vision Report

1 KG potato = 100 liters

1 kg beef = 13,000 liters

Migration of insect pests to new areas

Rapidly evolving disease virulence

Over 20,000 edible plant species

Only 2% provide 90% of our food.

Must grow more food on less land with less water, fewer inputs under harsher conditions

We must redefine the capabilities of our agro-ecosystems and crop plants

A paradigm shift

Innovative science is desperately required
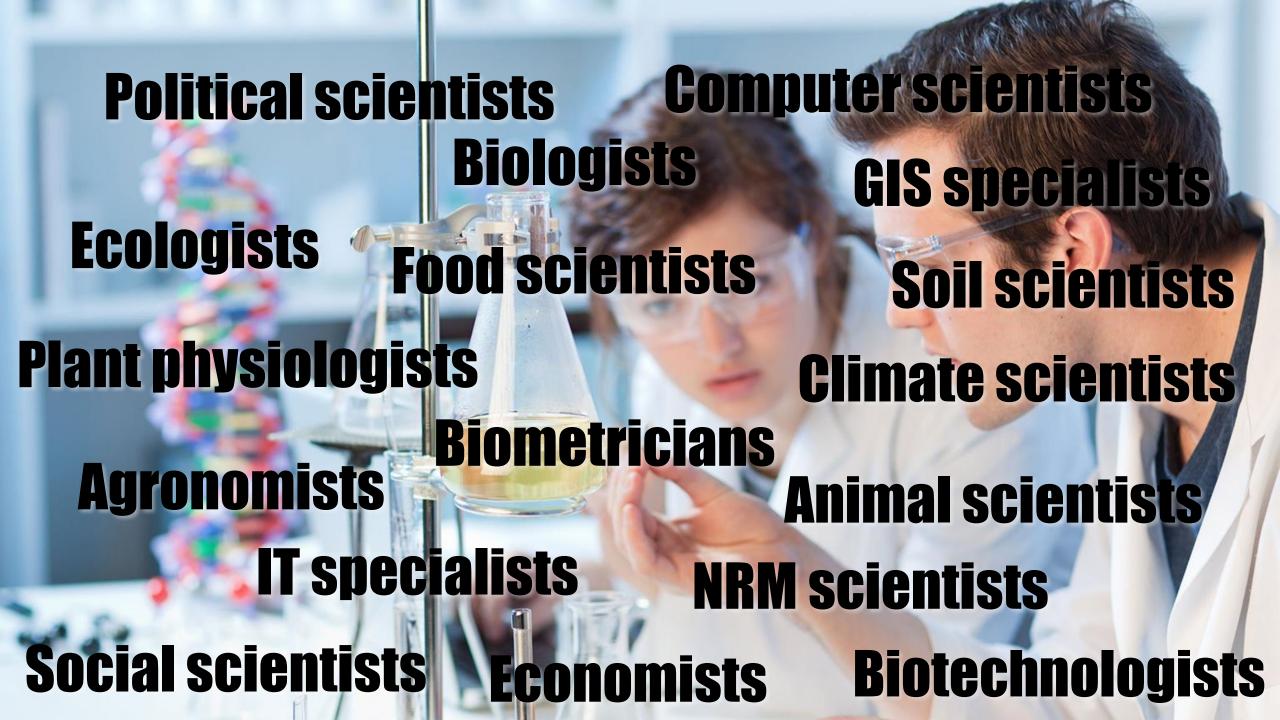
Australian government funding for research has dropped to the lowest it had ever been at just 0.4% of GDP.

Why teaching high school Science is vitally important
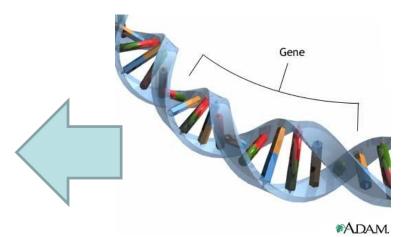
Plant Breeding

- **Multiple disease resistance**
- **Multiple insect resistance**
- **High water use efficiency**
- **High nutrient use efficiency**
- **Drought tolerance**
- **Abiotic stress tolerance**
- **Heat tolerance**
- **Higher yield**

313,500 wheat accessions

Core collections

Main Collection 10,000s accs

$$t = \frac{\bar{w} - \omega}{\sigma_w / \sqrt{N}} = \frac{\bar{w} - \omega}{\sqrt{\frac{\sum_{i=1}^{n}(w_i - \bar{w})^2}{N(N-1)}}}$$

Method

Core Collection 5%–10%
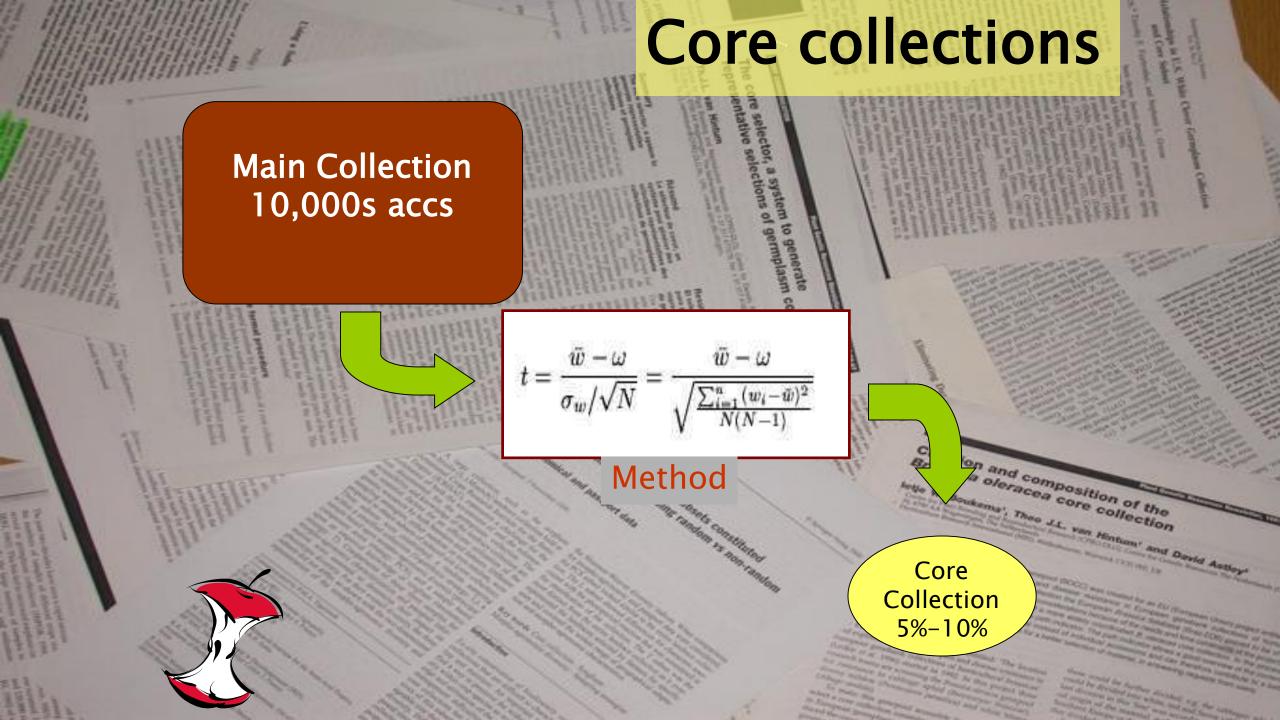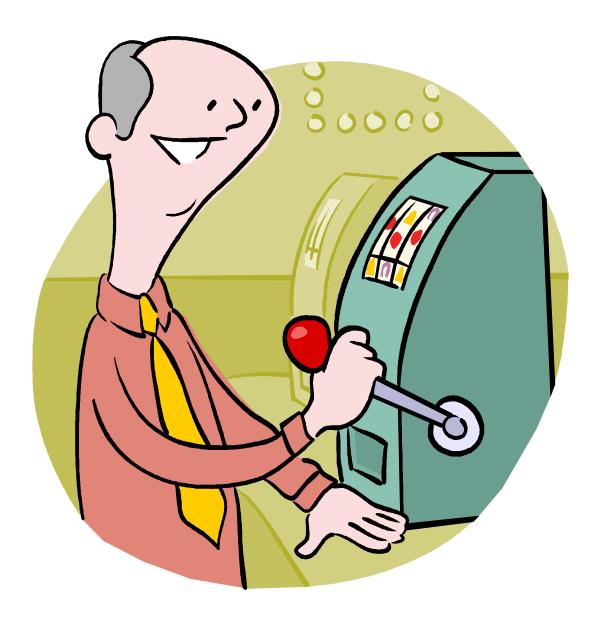
Core collections

- Good to explore the general diversity in a collection

- Good to undertake comparative molecular studies

- Fun and interesting to do

- Generate publications – 1000s

- **But!!** how useful are they to actually select subsets of material containing specific traits ?

- Rarely if ever requested by user

A matter of LUCK

Depending on the set size and the frequency of the sought after gene

getting what you want was most often

a question of luck
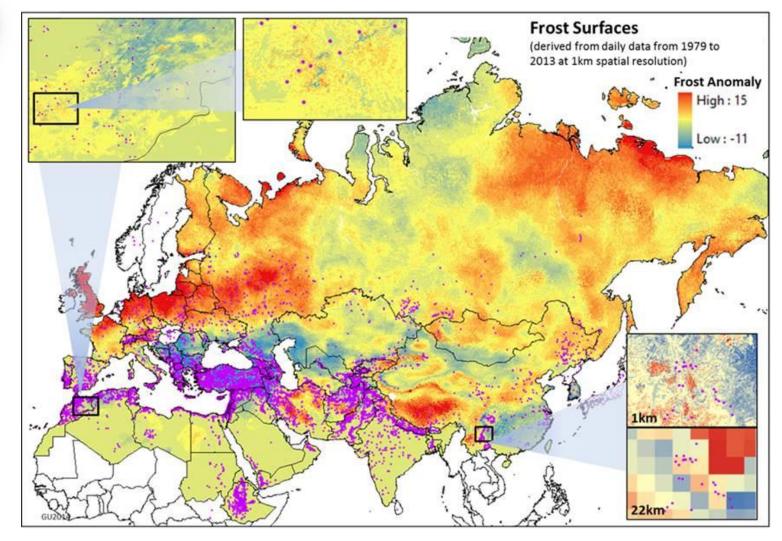
Focused identification of Germplasm Strategy

The aim of FIGS is to catch useful traits in small sub-subsets of genebank accessions

FIGS premise

Emergence of adaptive traits are influenced by environmental factors
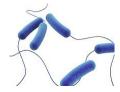
Investigating the case of human nose shape and climate adaptation
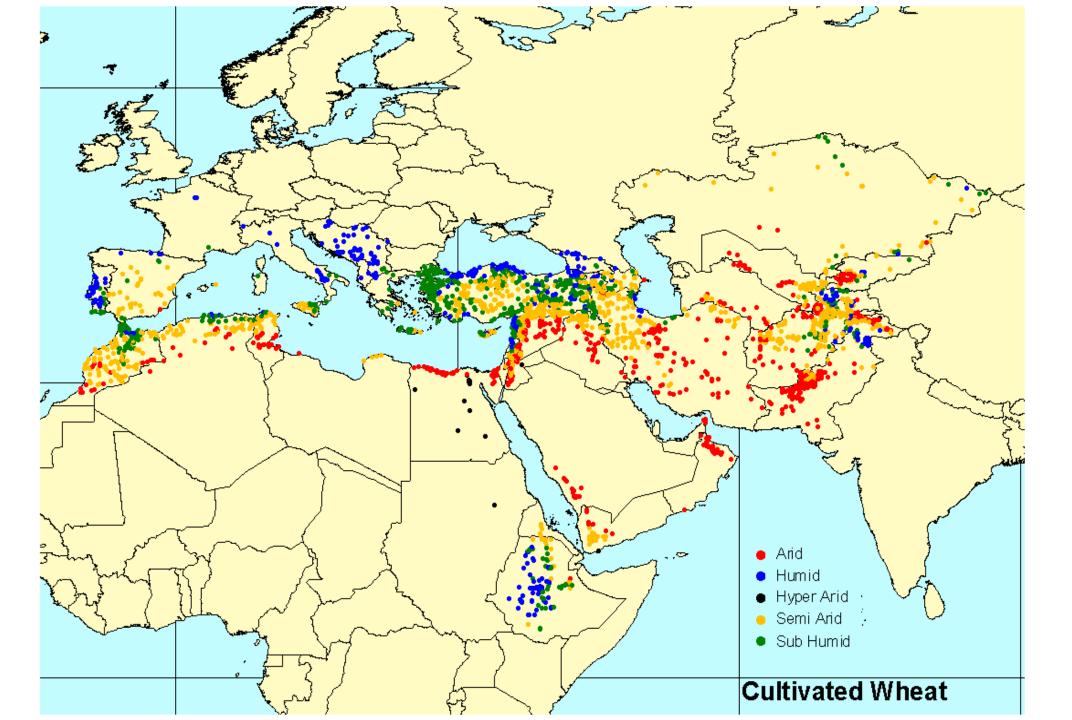
Arslan A. Zaidi ✉, Brooke C. Mattern, Peter Claes, Brian McEcoy, Cris Hughes, Mark D. Shriver ✉

FIGS: In a nutshell

Look to environments that are likely to have imposed a selection pressure for the required trait .

Cultivated Wheat

Legend:
- Arid (red)
- Humid (blue)
- Hyper Arid (black)
- Semi Arid (orange)
- Sub Humid (green)
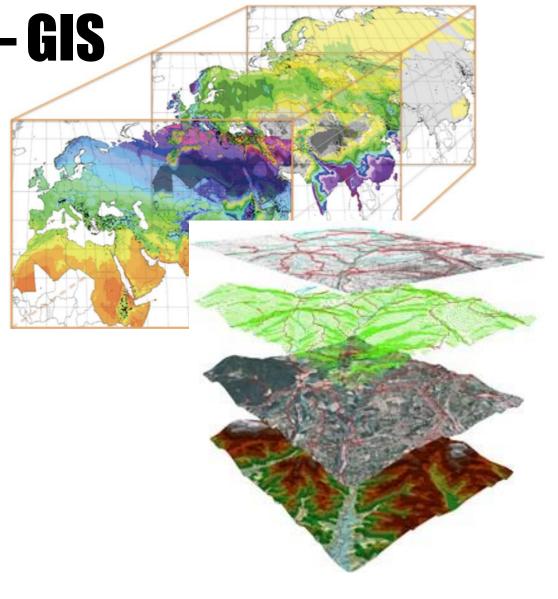
Long-term daily averages – GIS

Temp at 2 meter

max temp at 2 meter

min temp at 2 meter

Precipitation

Absolute humidity

Relative humidity

Photosynthesis active radiation

Wind at east-west direction

Wind at north-south direction

Vapor pressure deficit

Soil data

109,500 global surfaces generated

Over 200TB of data
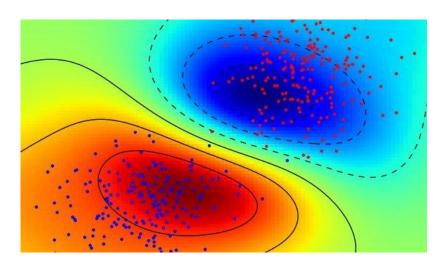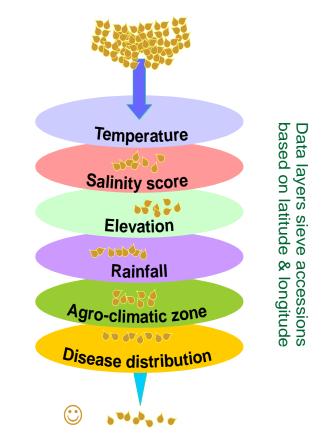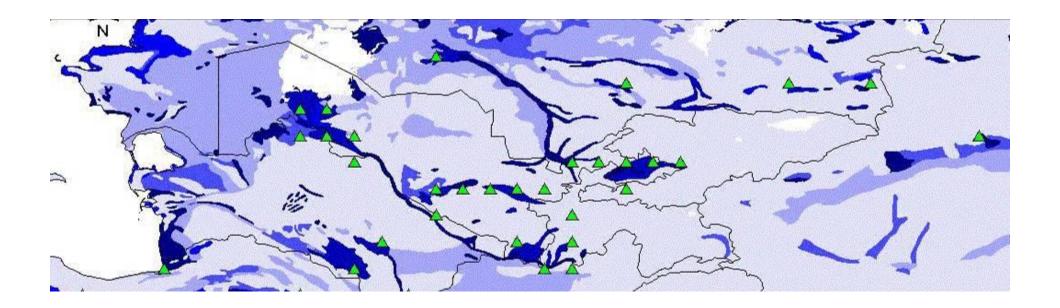
Screening for salinity tolerance in bread wheat landraces

VIR,ICARDA,AWCC collection

FIGS subset chosen by mapping collection sites over salinity probabilities

Bread wheat landrace collection sites

Hydroponic system for salt-tolerance evaluation at VIR, Russia

**Method after R.Munns *et al.* 2003.
Na and K content measured in 3rd leaf after salinity treatment imposed for 10 days**
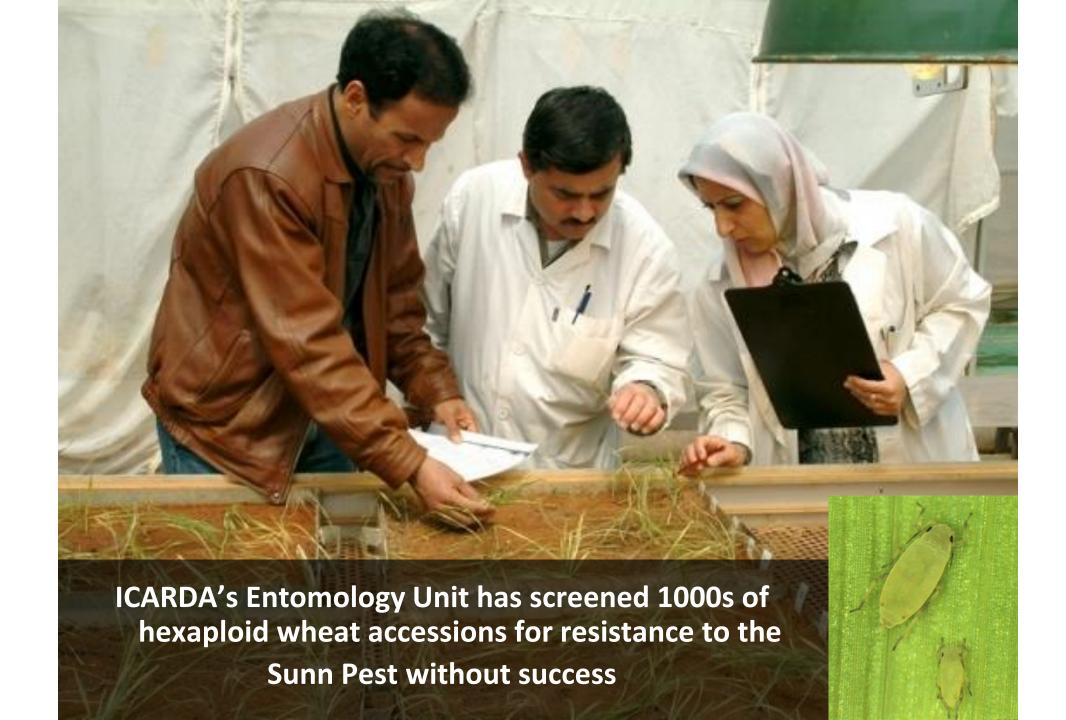
Preliminary results

Set	Leaf Na content range in accessions mg/g dry weight (min – max)	Average leaf Na content mg/g dry weight	Number of accessions with Na content below 3 mg/g dry weight		Total accessions evaluated
			accessions	%	
salt	1.16 – 22.46	5.42	67	21	320
core	1.57 – 51.26	10.63	10	3	319

Table and screening by Irina Koserava (VIR, Russia)

ICARDA's Entomology Unit has screened 1000s of hexaploid wheat accessions for resistance to the Sunn Pest without success

Sunn pest set selection

Starting with a set of over 16,000 accessions from VIR, ICARDA and AWCC

Selected material collected between 30-45 latitude, 35-80 longitude

Excluded CHN, PAK, IND as only recent reports of Sunn pest in these countries – retained 6,328 accessions

Excluded particularly dry environments - rainfall below 280mm/year, low Aridity Index

Excluded sites where the winters temps fall below -10 degrees – retained 534 accessions

Sunn pest set selection

534 accessions screened at ICARDA

Verified
under controlled conditions

8 landrace accessions from Afghanistan and
2 from Tajikistan identified as resistant at juvenile stage

Now in ICARDA breeding program
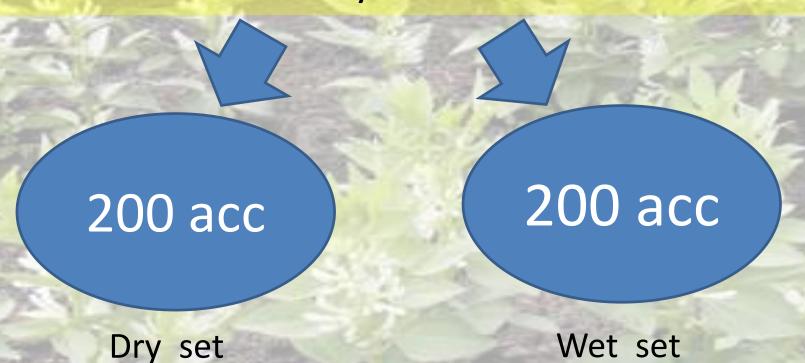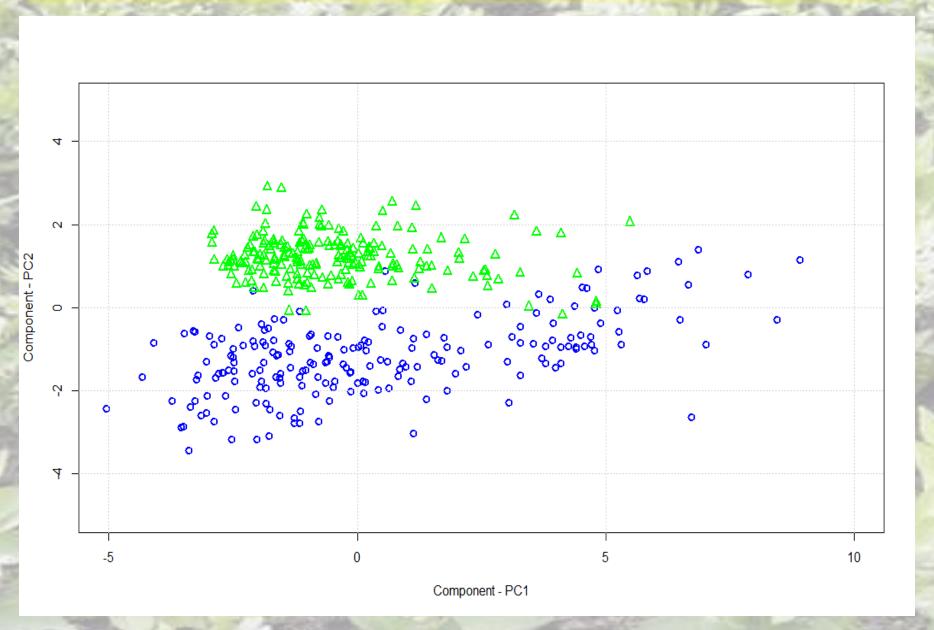
Using FIGS to search for indicators of drought tolerance in Faba bean

- ICARDA hold 9545 faba bean accessions
- Selected material based on measures of moisture availability at collection sites

200 acc

200 acc

Dry set

Wet set
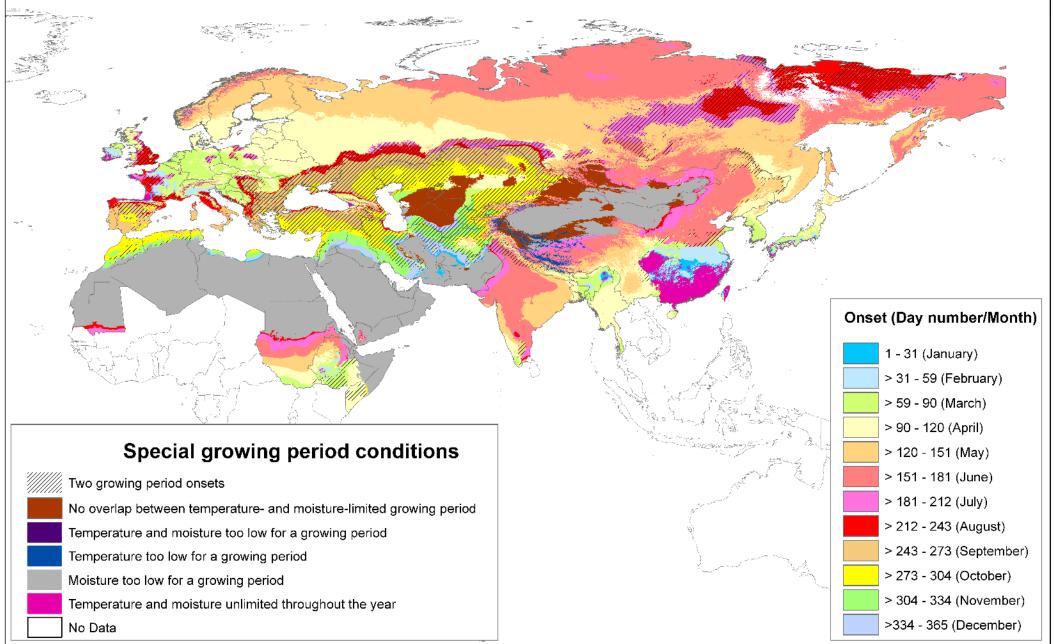
Results: clear differences between sets

After Hamid Khazaei[1]*et al 2012

Faba bean

Wet set

Nepal

Bangladesh

Sweden

China

Dry set

Afghanistan

Tajikistan

Syria

Morocco

© H Khazaei
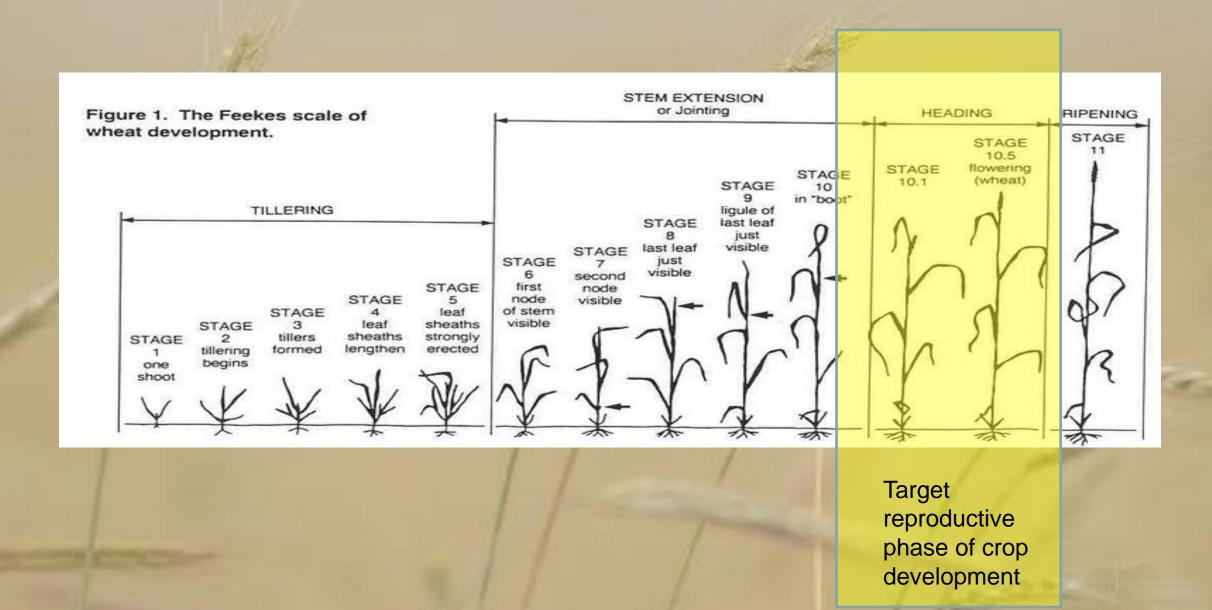
Onset of the temperature & -moisture-limited growing period (1)

Special growing period conditions

▨	Two growing period onsets
■	No overlap between temperature- and moisture-limited growing period
■	Temperature and moisture too low for a growing period
■	Temperature too low for a growing period
■	Moisture too low for a growing period
■	Temperature and moisture unlimited throughout the year
□	No Data

Onset (Day number/Month)

■	1 - 31 (January)
■	> 31 - 59 (February)
■	> 59 - 90 (March)
■	> 90 - 120 (April)
■	> 120 - 151 (May)
■	> 151 - 181 (June)
■	> 181 - 212 (July)
■	> 212 - 243 (August)
■	> 243 - 273 (September)
■	> 273 - 304 (October)
■	> 304 - 334 (November)
■	>334 - 365 (December)

FIGS
Faster solutions for crops of tomorrow

Applying FIGS within growing season

Figure 1. The Feekes scale of wheat development.

Target reproductive phase of crop development
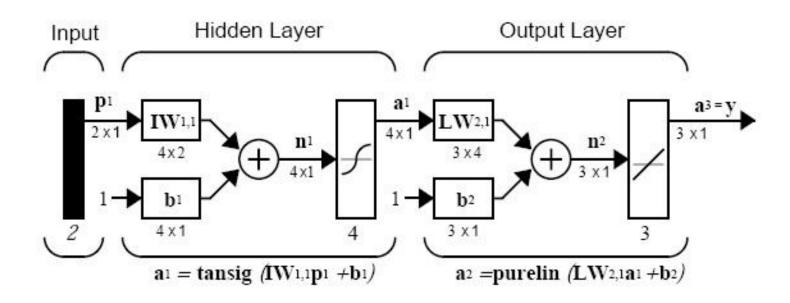
Multiple trait state data + Collection site daily data
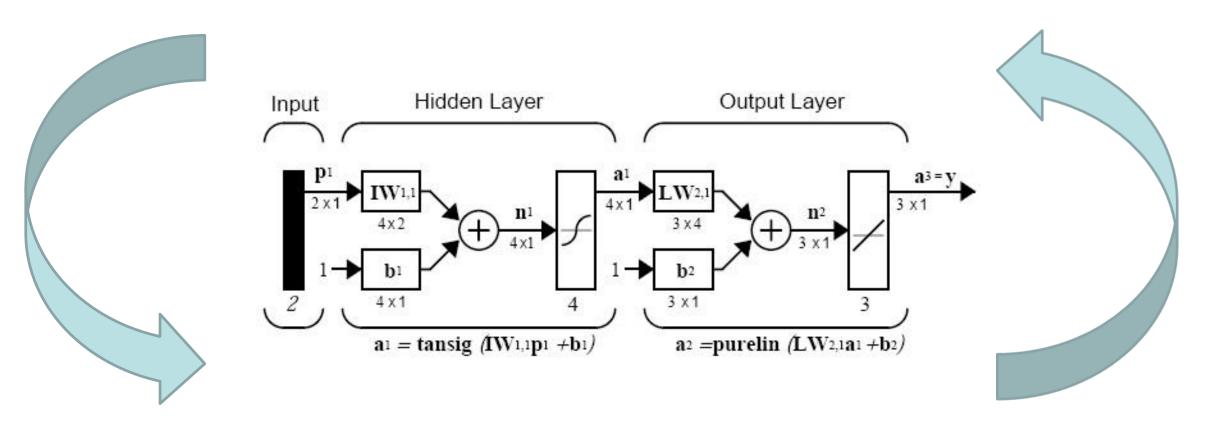
Non-linear model
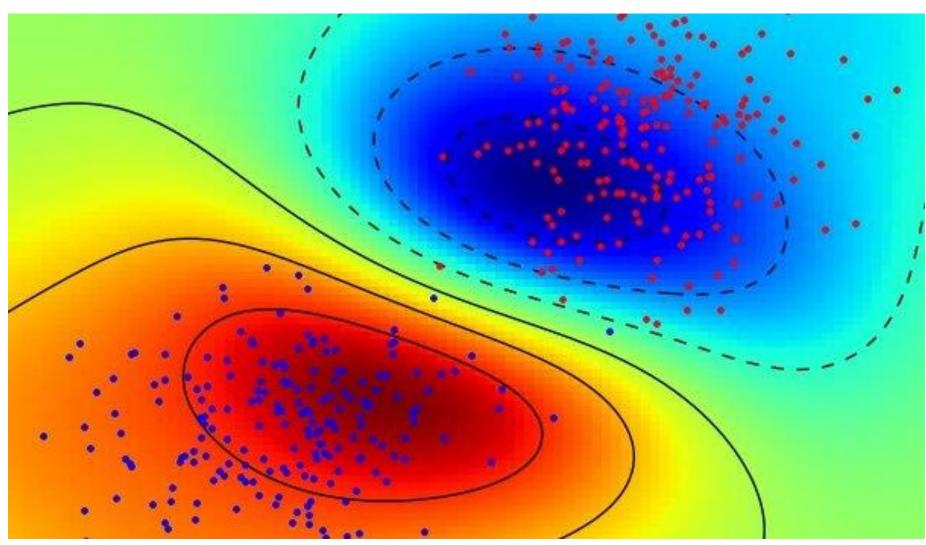
Support vector machine, Random forest, Neural networks

Model attempts to discriminate between trait states

Model parameters iteratively refined
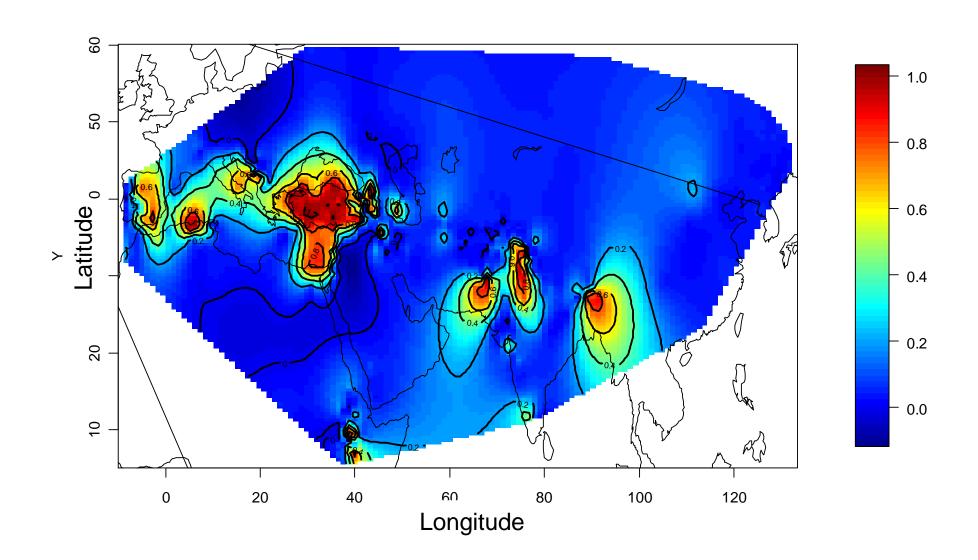
Trained model used to predictively classify sites

Predictive modelling

Areas where resistance is likely to occur (dark red)

Russian wheat aphid

Sunn Pest

Pod borer

Powdery mildew – wheat and barley

Barley yellow dwarf virus

Spot blotch

Net blotch

Drought tolerance

Frost tolerance

Beet western yellows virus

Chickpea chlorotic stunt virus

Alfalfa mosaic virus

Been yellow mosaic virus

A simple paradigm shift – leading to different results

Need a paradigm shift in what we eat.

Input Use Efficiency

1. less land and water is required

2. Greenhouse gas emissions are lower

3. High feed/substrate conversion efficiencies

4. Can transform low-value organic by-products into high-quality food or feed

5. Climate change resilient

6. A lot of medicinal values

7. Low energy input

SPIRULINA
Cyanobacteria

3.6 billion years old

RAW LIVING SPIRULINA

A Spoonful of Life

Order Now

A NUTRITIONAL SUPERSTAR

3900% more beta-carotene than carrots

2300% more iron than spinach

300% more calcium than fresh milk.

280% more anti-oxidants than blueberries.

200% more protein than meat

JUST 3 GMS OF SPIRULINA

has more antioxidants and anti-inflammatory properties than **5** servings of vegetables.

Most nutrient dense food on the planet

Here is what leading science and health organizations say about spirulina:

"1 lb of spirulina is the equivalent to 1000 lb of vegetables"

"Spirulina is the future of nutrition"

"The most complete balanced and nutritious food on earth"

A medical marvel

- Strong **anti-cancer** activity
- **Anti-allergy** activity.
- Helps in the regulation of **cholestero**l.
- Helps combat **liver damage**.
- Help regulate **blood pressure**.
- Alleviates **anaemia**.
- Boost **immune system**.

- Helps fight **infections**.
- **Detoxifies** the body of heavy metals and toxins.
- Protects the brain from **degenerative diseases**.
- Improves **mental acuity**.
- Improves muscle strength and **endurance**.
- Helps Manage **HIV/AIDS**.
- Used to treat **radiation** sickness.

Spirulina – high input use efficiency

Yield (kg)/unit of input

https://spirulinagrowco.com.au/for-teachers/

Apps | Bookmarks | spirulina | Imported | WP Dash | FIGS Folder | Dashboard ‹ Kenjo... | Games | Foundations | cool vids | Free images | Other bookmarks

Spirulina Grow Co

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Feedback

Spirulina for science and biology teachers

Products – Spirulina Grow Co.   spirulina farms - Bing images

https://spirulinagrowco.com.au/shop/

Apps   Bookmarks   spirulina   Imported   WP Dash   FIGS Folder   Dashboard ‹ Kenjo...   Games   Foundations   cool vids   Free images   Other bookmarks

Default sorting

VIEW: 12 / 24 / ALL

Live spirulina culture

1000 ml live Spirulina culture and Fast Grow starter nutrient pack

$158.00

Add To Cart

Live spirulina culture

1000 ml live Spirulina starter culture

$142.00

Add To Cart

Live spirulina culture

50 ml live Spirulina culture and Fast Grow starter nutrient pack

$52.00

Add To Cart

Live spirulina culture

50 ml live Spirulina starter culture

$43.00

Add To Cart

Feedback

MUITO OBRIGADO!

🙏