



Climate Change & Plant Biosecurity

Emergence, Attribution & Policy

US Dept of State Geographer
© 2015 Google
Image Landsat
Data SIO, NOAA, U.S. Navy, NGA, GEBCO

Google earth

Climate Change & Plant Biosecurity

Climate Change Indicators

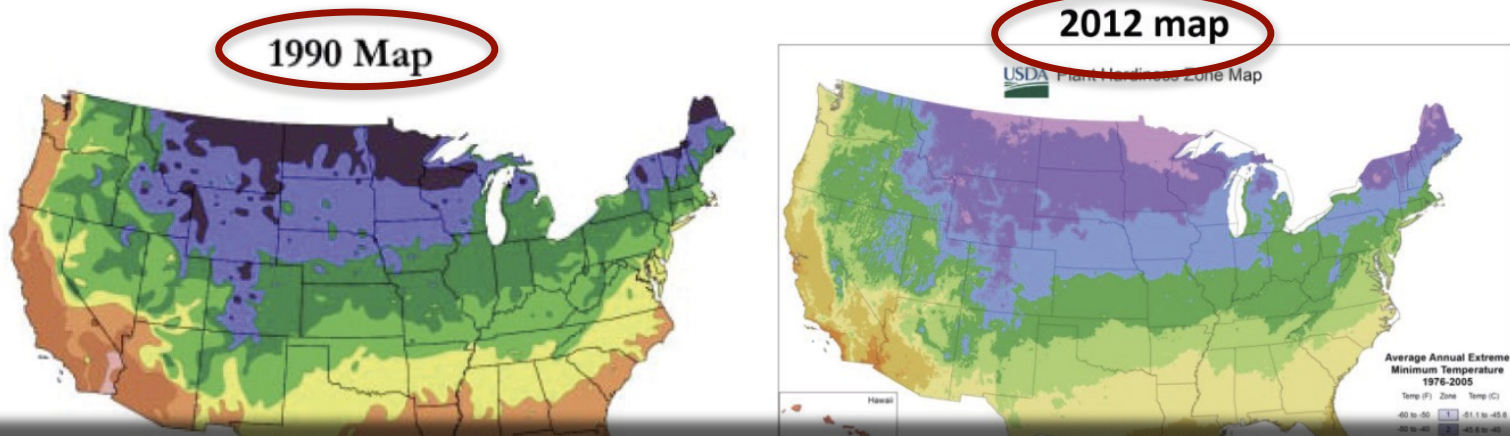
- Historically, there should be **20-30 species** flowering in the U.K. on January 1st
- In 2015, there were **368 species** flowering on January 1st
- Plants are flowering **10-12 days sooner** at several locations around the world.

Nature 2013

BBC.com

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Climate Change Indicators



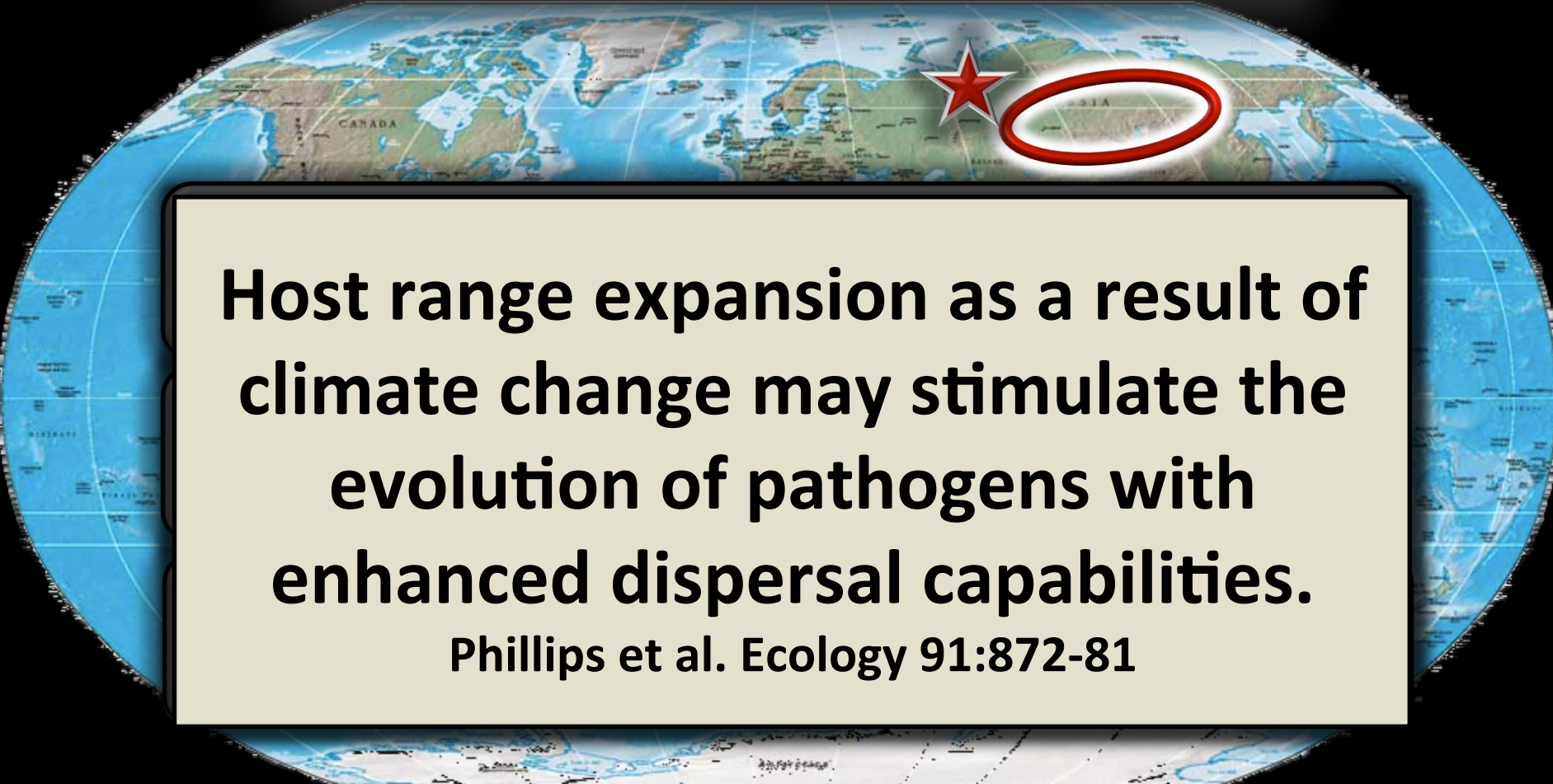
Models predict that Extreme Heat will occur **every 1-3 years** in the U.S.

Could be devastating for heat sensitive crops like **wheat and corn.**

<http://planthardiness.ars.usda.gov/PHZMWeb/AboutWhatsNew.aspx>

Climate Change and Emerging Pathogens

Permafrost in Russia is melting



Host range expansion as a result of climate change may stimulate the evolution of pathogens with enhanced dispersal capabilities.

Phillips et al. Ecology 91:872-81

Climate Change and Emerging Pathogens

A world map showing the continents and oceans. India is highlighted with a red star and a red circle. The map is centered on the Indian subcontinent.

**Climate change models predict India
will be seriously affected**

**Losses to plant diseases and pests are
predicted to triple by 2050**

**Very productive wheat area in northern India
will be drastically reduced**

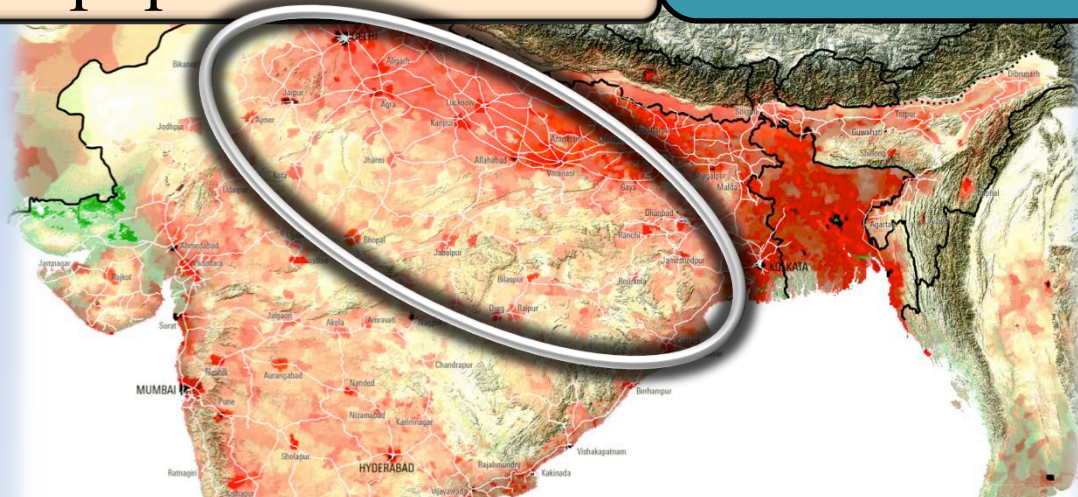
Asia

Region of Concern

2013: 2ND most populous nation

2025: Most populous nation?

2013: Just barely food secure. - wheat



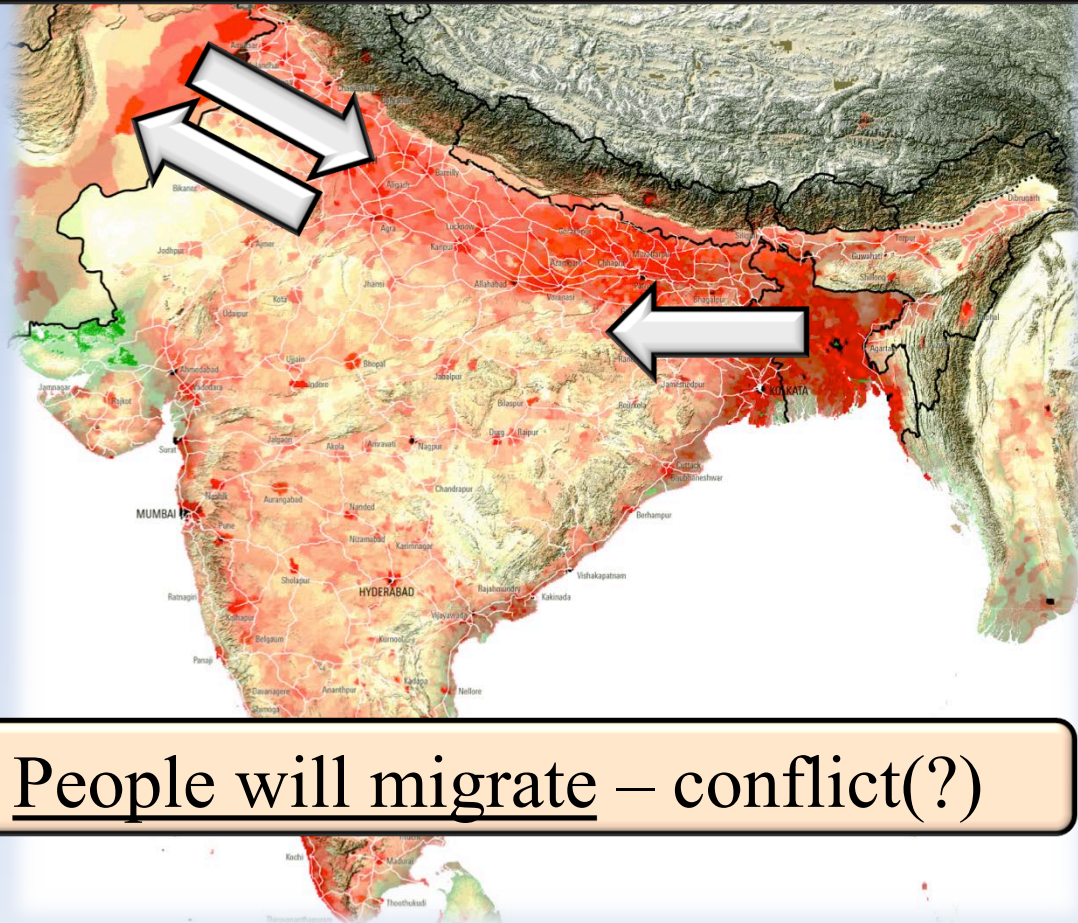
Climate change projections (2012-2050):

1. Bangladesh will lose more land
2. India will become too hot for wheat.

Asia

Region of Concern

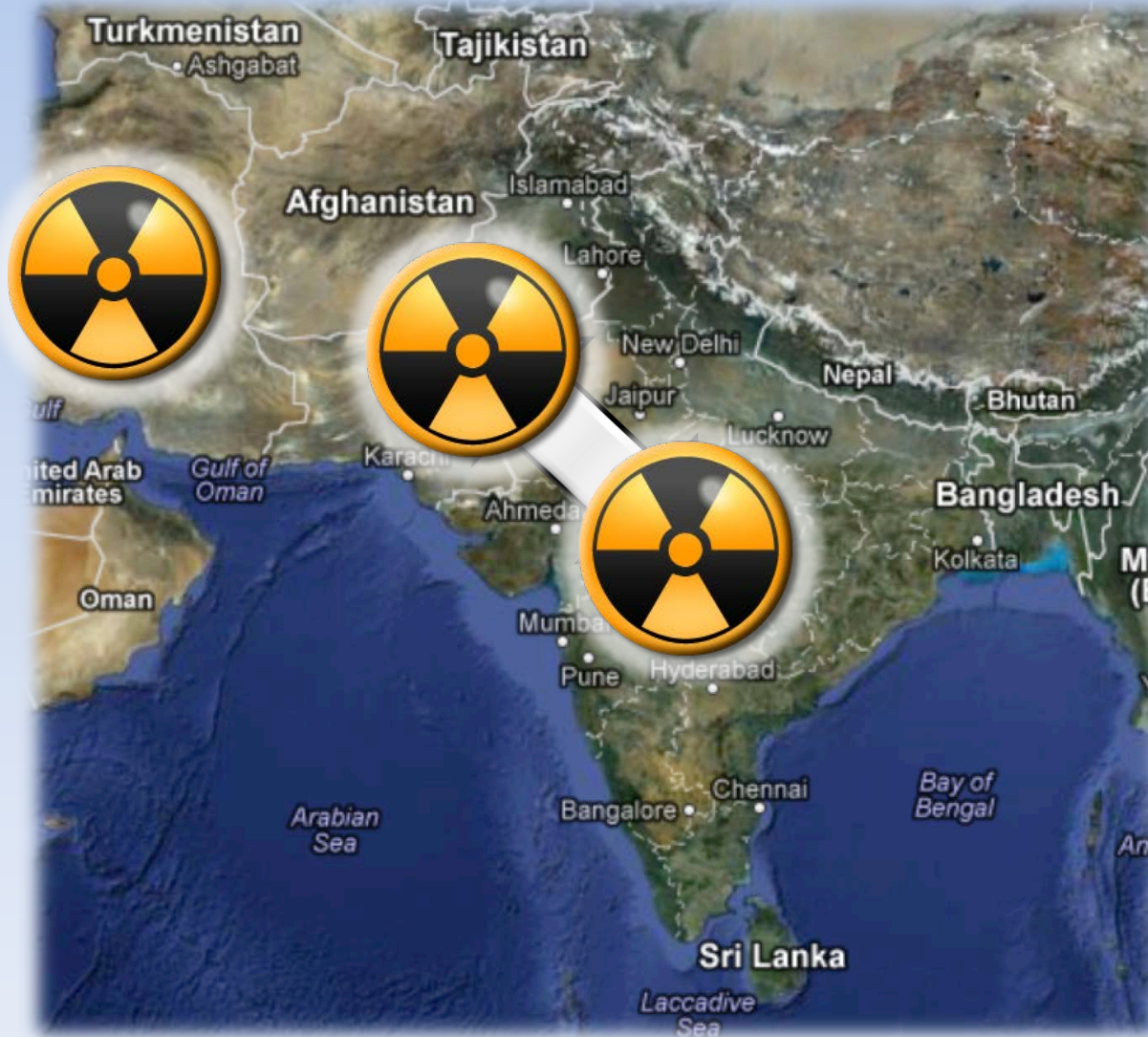
2025 - 2050: Most populous nation will be food insecure



People will migrate – conflict(?)

Asia

Region of Concern



Africa

Region of Concern

Several nations are buying land in Africa to produce food for export.

The scale of foreign land acquisitions dwarfs the level of Official Development Assistance, (5-10 times higher in value than the latter).

Food-Water Nexus

- **The South Centre: ...“oil conflicts were central to 20th century history, the struggle over freshwater ... a new turning point in the world order.”**

Food Security – National Security

THE WATER and FOOD nexus: trends and development of the research landscape (2012),
Nourishing the Planet BY SOPHIE WENZLAU, Worldwatch Institute (2013)

Feeding a Growing Population



UN World Food Program

- “... hunger is tied to civil unrest.”
- “...when people get hungry enough, they move, and populations on the move are prone to conflict.”

1. FAO 2006.

2. Behrman et al. 2004. *Hunger and malnutrition*. Cambridge.

3. UNICEF 1998. *The state of the world's children 1998*. New York.

National Forum on Climate and Pests – October 2016

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Haiti April 2008

Pakistan March 2008

This same scenario played out again in 2010-2011.

Some believe that this will play out regularly over the next 50 years.

Kenya 2008

AFP / Getty

Argentina 2008

NAS: Climate Change and Tipping Points

- The history of climate on the planet (tree rings, ocean sediments, ice cores) is punctuated with large changes that occurred rapidly: **decades to as little as a few years.**
- The current rate of carbon emissions is changing the climate system at an accelerating pace, **making the chances of crossing tipping points all the more likely.**

Source: NAS 2013 *Abrupt Impacts of Climate Change: Anticipating Surprises*

NAS: Climate Change and Tipping Points

- “...abrupt changes in ecosystems, weather and climate extremes, and groundwater supplies critical for agriculture **now seem more likely, severe, and imminent.**”
- “...multiple other stressors are pushing natural and human systems towards their limits, and thus become **more sensitive to small perturbations that can trigger large responses.**”

Source: NAS 2013 *Abrupt Impacts of Climate Change: Anticipating Surprises*

UNCTAD: “Wake up before it’s too late”

- Two global environmental limits that have been crossed were caused by agriculture
 - N contamination of soils and waters
 - biodiversity loss
- Agricultural GHG emissions are the second

Wake up before it is too late: Make agriculture truly sustainable now for food security in a changing climate.

UNCTAD Trade and Environment Review 2013

Source: UNCTAD Trade and Environment Review 2013

Source: WTO <http://unctad.org/en/pages/Statistics.aspx> 14 April 2014

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Concerns

- *Geographic redistribution of pathogens and pests*

These are the same concerns for both climate change and biosecurity.

- *Increase incidence and severity of disease*

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21st Century Challenges

- Water

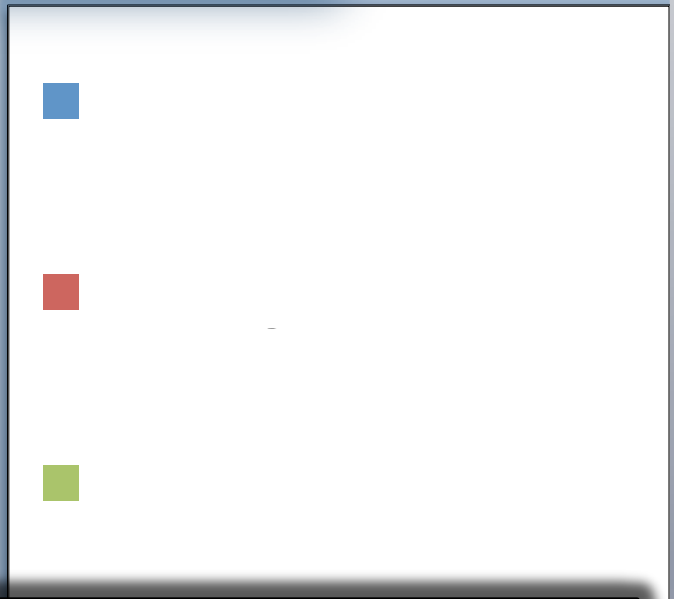
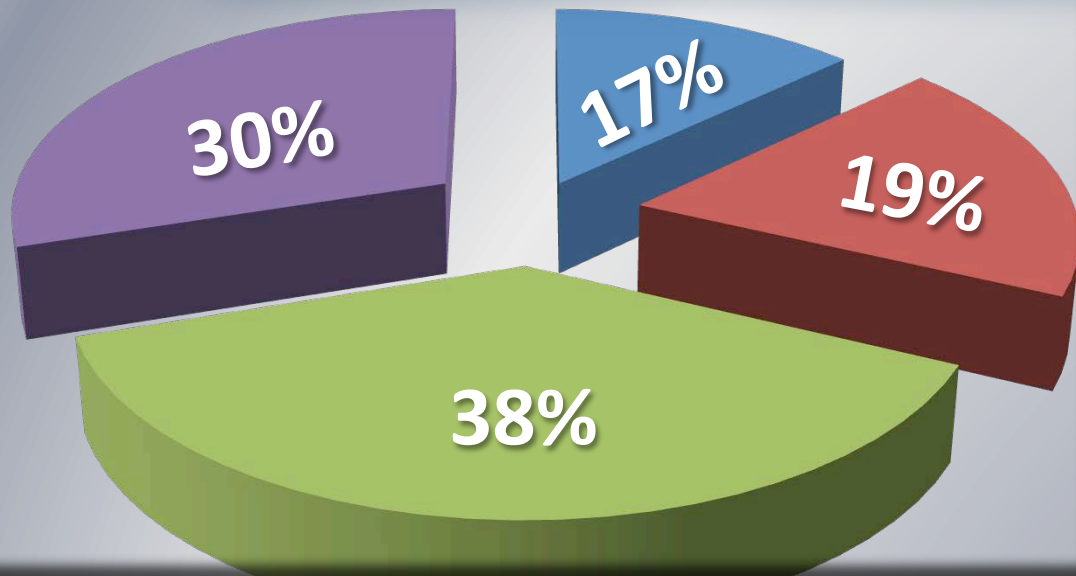
Plant health is prerequisite to public health and human wellbeing.

Plant health is undervalued and at increased risk.

- Biodiversity

Health Status of Plant Ecosystems

Millennium Ecosystem Assessment



Over 2/3 of the plant systems that underpin human health and wellbeing are threatened or endangered.

Frankham et al. 2010. Conservation Genetics, p 4.

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Food security from Plants

Just 5 plant species provide 63% of the calories consumed by humans (2014)

Plant health is essential to food security.

We eat plants and we feed plants to the animals that we eat!

¹FAO, <http://www.fao.org/docrep/x0262e/x0262e02.htm>

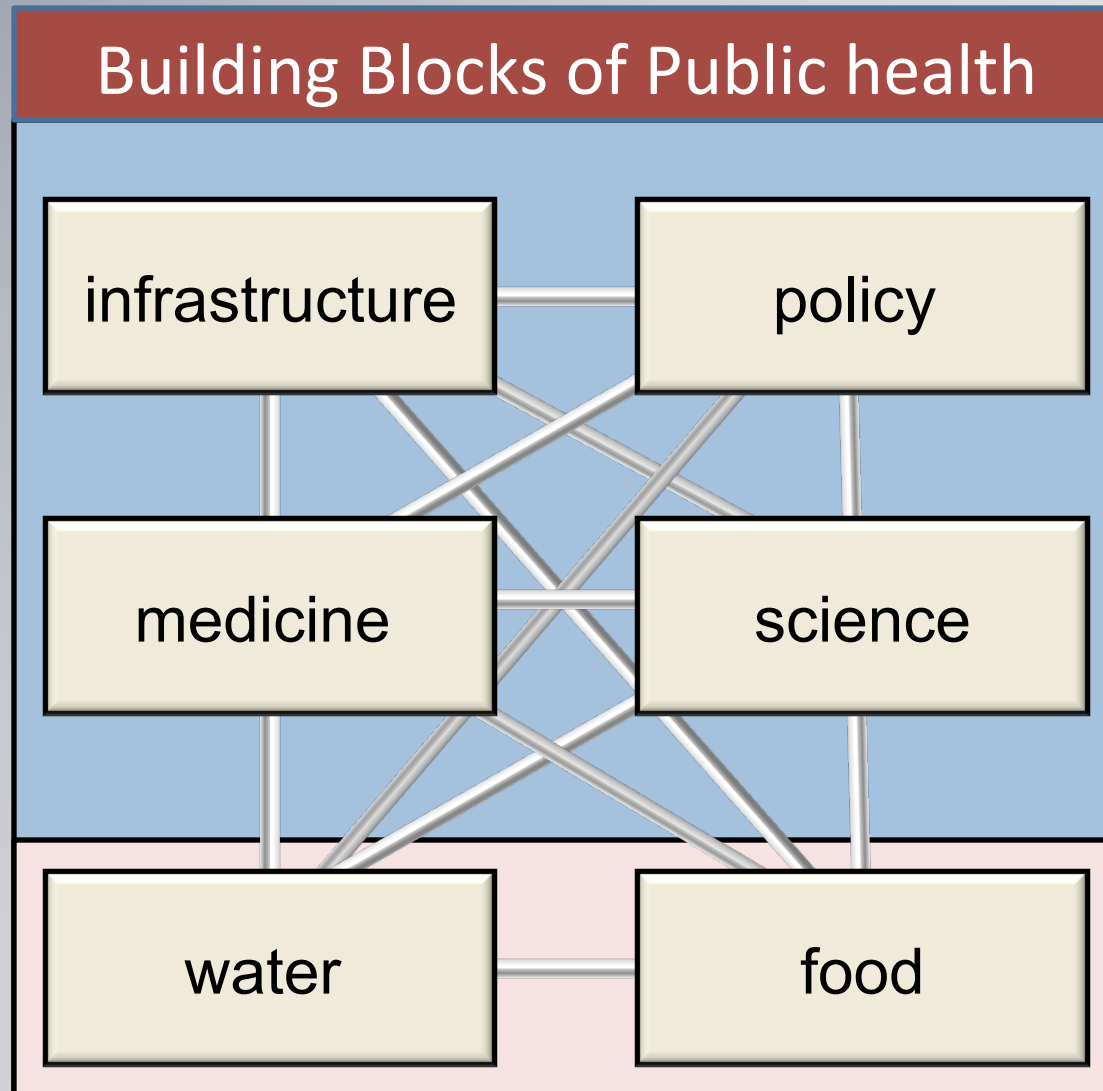
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human health

animal health

plant health

One Health



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Food security is not about keeping people alive...



...it's about keeping people healthy.

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Food security is not just providing calories
(*kcal/capita/day*)

Can we?

- It's about providing safe, nutritionally balanced, & culturally relevant food to everyone.

...provide safe, nutritionally balanced, culturally relevant food for everyone?

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31 October 2011

7 B

2011

- **2 Billion live in poverty**
- **1 Billion are food insecure**
- **100 Million live at risk of starvation**

<http://www.census.gov/main/www/popclock.html>





Current State of the World

Food Emergencies: 1985 - 2005

In 2010, 93 million people in 70 countries required food aid for survival.

- World Food Program -

Across the world.

IFPRI

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How are we doing with 7 Billion?

For the past 25-30 years we have
been unable to meet the
minimum basic food needs for
20-25% of the world's
population

7 B



2013

<http://www.census.gov/main/www/popclock.html>



K-STATE
Research and Extension

National Forum on Climate and Pests – October 2016

Knowledge
for Life

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Every Year...

- We add ~65 Million more people to our planet
- \approx 9 more New York Cities

<http://www.overpopulation.org/solutions.html>



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- **The population challenge is not just a numbers problem:**
- **It is a demographics problem:**
 - increasing urbanization
 - inverted age structures
 - migrations...

<http://www.census.gov/main/www/popclock.html>





UN Millennium Dev. Goals

- **2000: 189 nations sign UN declaration**
- **Eradicate extreme poverty (<\$0.50US**)**
- **Alleviate extreme hunger (<1600 cal/day)**
- **Improve public health & nutrition**
- **Ensure environmental sustainability**

** This target value has been increased to \$1.25/day.

<http://www.un.org/millenniumgoals/>
UN FAO



Food Security Challenge

Hunger-Poverty Cycle

Alleviate poverty to eradicate hunger

Poverty

Food Security is about the availability of food and the ability to access food.

Hunger

Eradicate hunger to alleviate poverty



UN Millennium Dev. Goals

- **2000: 189 nations sign UN declaration**
- **Eradicate extreme poverty (<\$0.50US**)**

So what should we do?

- **Ensure environmental sustainability**

** This target value has been increased to \$1.25/day.

<http://www.un.org/millenniumgoals/>
UN FAO

Climate Change & Plant Biosecurity

What should we do?

- **Agreement among most GOs & NGOs (food security through trade, aid & intensification)**
 - *Little agreement across scientific community - many conflicting perspectives (e.g., , intensification, GMOs)*

<http://www.overpopulation.org/solutions.html>



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Moving Targets

- FAO: we need to increase food production by:

Our estimates are 24 - 43% depending upon certain assumptions (e.g., food loss, meat consumption)



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Food-Water Nexus

“There is no new land or water to develop so we have to make more use of what we have... That is the only way we are going to feed everyone”

Colin Chartres Director General,
International Water Management Institute

THE WATER and FOOD nexus: trends and development of the research landscape (2012)





Food Security Challenge

2013

- **FAO**: need to increase food production by 70% over next 25 years
- **FAO**: 90% of increase will come from intensification of production systems
- Many nations will remain unable to achieve food self sufficiency

¹FAO, 2006 http://www.fao.org/fileadmin/templates/wsfs/docs/expert_paper/How_to_Feed_the_World_in_2050.pdf

Climate Change & Plant Biosecurity

Intensified Production

Genetically uniform high yielding varieties

More Efficient Fertilizers & Pesticides

Improved Irrigation Systems**

****70 % of earth's fresh water goes to agriculture**



Ecosystem Assessment

- **Intensification of agricultural production is an important solution to the food security challenge (food security agencies)**
- **Intensified agricultural production systems are the single biggest threat to the environment (ecological community)**

FAO



Food Security Challenge

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¹FAO, 2006 http://www.fao.org/fileadmin/templates/wsfs/docs/expert_paper/How_to_Feed_the_World_in_2050.pdf

Feeding a Growing Population



To achieve MD Goals

- . “.... we must open up global markets, boost global trade and make reforms

Food Security through TRADE and AID

Pathogens & Pests!

Impacts of Global Plant Trade

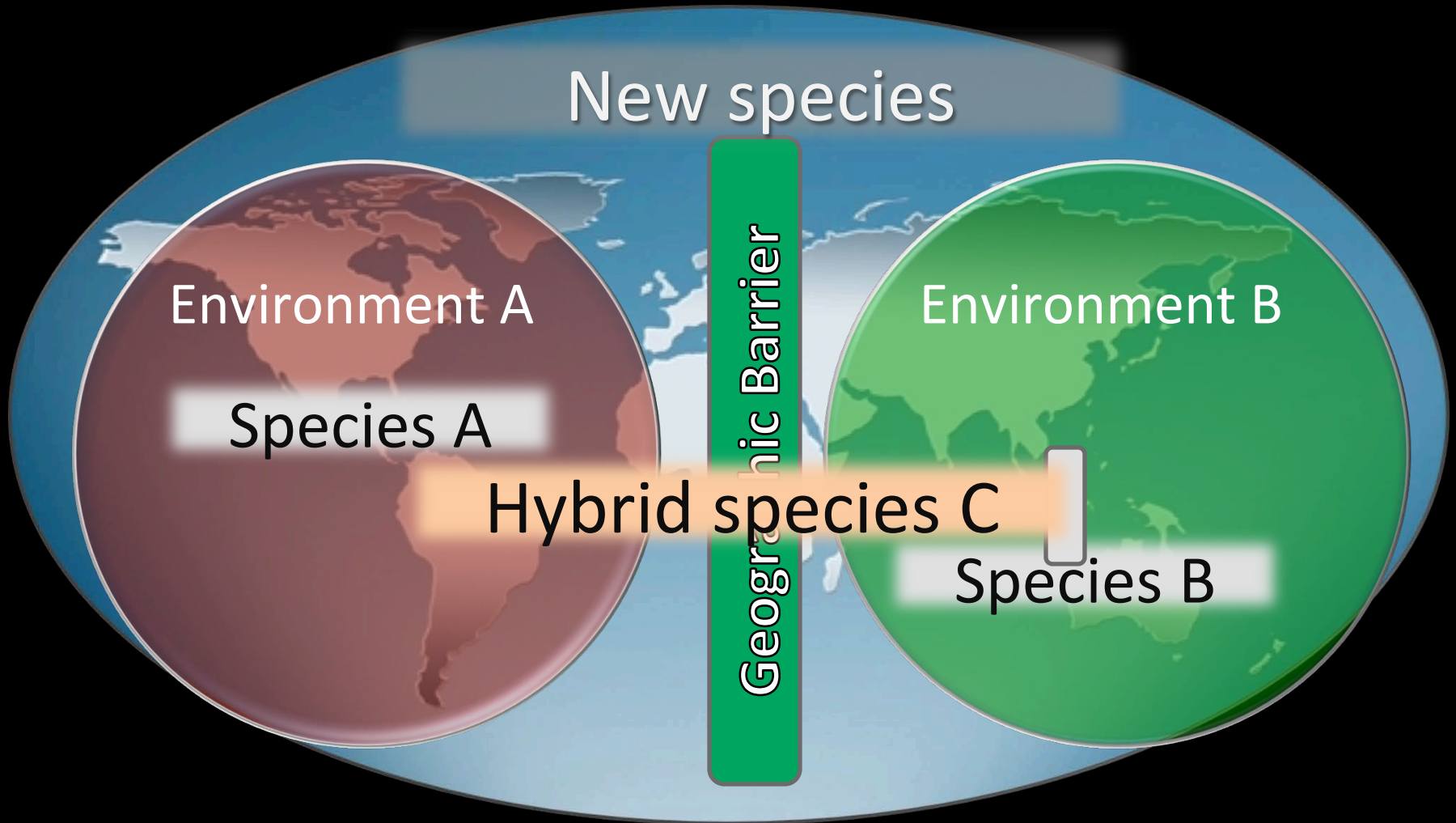
Evolution of new species

- Plant trade has resulted in the evolution of new plant pathogen species with novel host range and virulence patterns that could not have been predicted from the parental phenotypes.

Clive Brasier 2001. BioScience Vol. 51 No. 2
Man in't Veldt et.al. 1998. Phytopathol. 88:
922–929

¹FAO, <http://www.fao.org/docrep/x0262e/x0262e02.htm>

Plant Health – Public Health Interface



Impacts of Global Plant Trade

Hybrid species has unique phenotype

Host range of hybrid species not predicted by host range of parental phenotypes

Brasier 2001. *BioScience* 51(2):123-133.

¹FAO, <http://www.fao.org/docrep/x0262e/x0262e02.htm>

Impacts of Global Plant Trade

Evolution of new species

- “... two grass adapted MSVs recombined to produce a new “wide-host range” strain that could infect a greater variety of other plants than its parents.
- “... chance recombination could be the reason MSV has become such a serious problem.”

Darren Martin, University of Cape Town J. General Virology 2008.

Our food comes from the grocery store.

But where does the grocery store get the food?



But where does the grocery store get the food?



From all over the world!





Peppers are produced for sale in Europe.

Plant Health – Public Health Interface

It takes energy to move food...

**↑ Food
55-70%**

**Energy ↑
40-60%**

Food security through trade & aid

**Water ↑
50-75%**

...when you move food you move water.

The Silk Route(s)

206 BC to 1153 ACE



Global trade is not new.

Passenger and Commercial Air Traffic

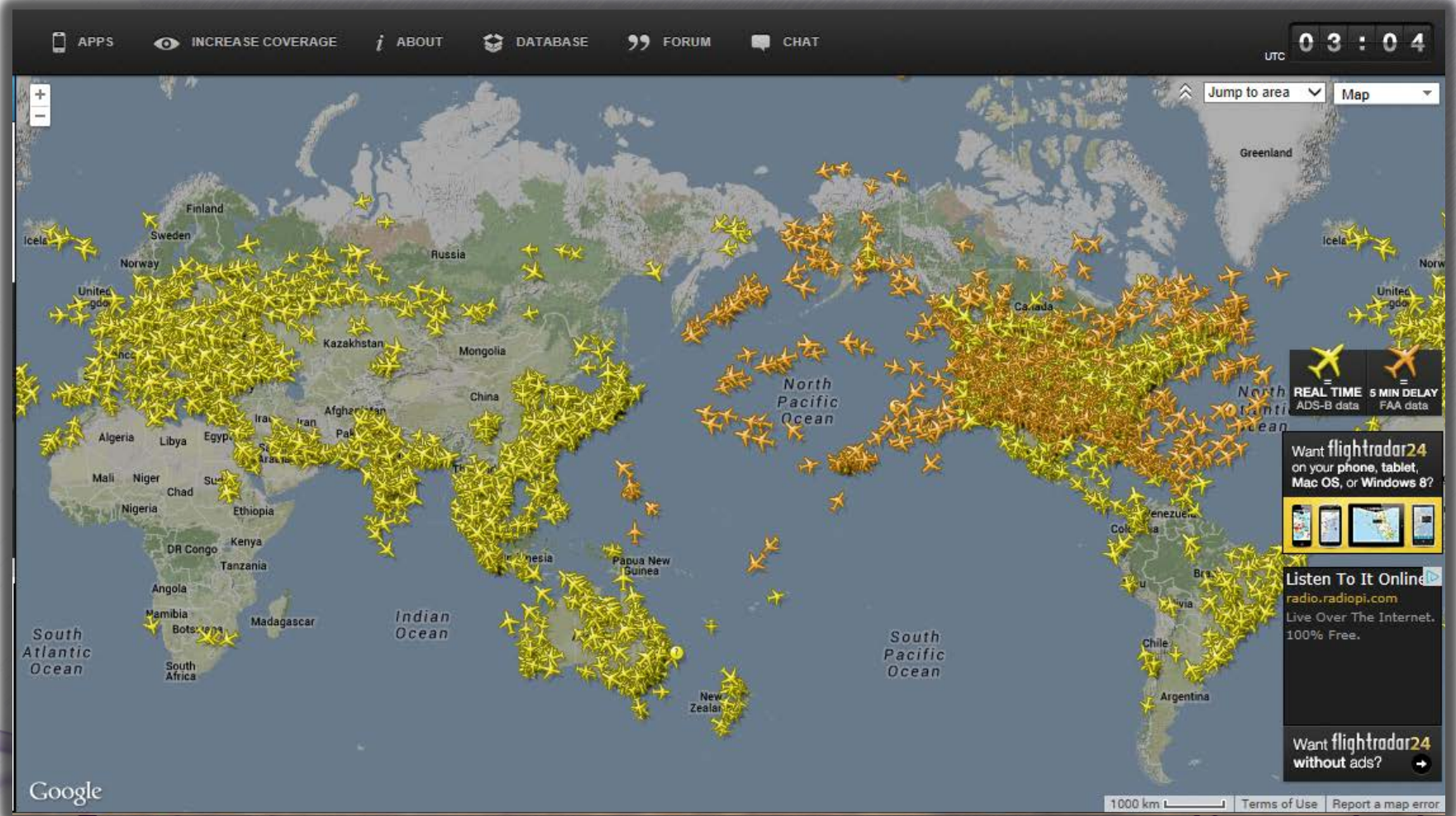
<http://www.flightradar24.com/42.57,-100.05/3>



Each airplane icon represents an actual flight in progress at 8:00 PM on 11 Feb 2014.

Passenger and Commercial Air Traffic

<http://www.flightradar24.com/42.57,-100.05/3>



World Trading Routes



Every day there are 6 million cargo containers on ships on the oceans and seas across the world.

Feeding a Growing Population

Trade Pathways – Nature 2014

• Economic islands net

The risks from aid are higher than the risks from trade..

Moving a cargo container contains a sample of organisms at each location

Charles Perrings (Invasive Species Economist)

Heimus et al. 10.1038 2014 Nature

FAO: *Plant protection systems are failing*

- **Reason for failure of national and International Plant Protection systems**
 - **Failure of detection techniques**
 - **Insufficient area monitored**
 - **Inspection fails because of large volume of entry, poor sampling, etc.**
 - **Pest/disease is in cryptic stage at the time of entry or is difficult to identify or diagnose**

Global Dispersal of Plant Pathogens

Challenges:

Symptom-based inspection and interception protocols will miss many of the bad pathogens and pests.

Feeding a Growing Population



Plant Disease 1st Reports

- Diseases caused by Bacteria & Phytoplasmas

Phytosanitary policy is based on

The rate of evolution of science & technology has far outpaced the evolution of policy.

way we name

- 5 countries, 4 continents

Food Security- Plant Biosecurity Paradox

**Plant biosecurity is essential
to food security**

The solution is the problem.

**Trade & aid undermine plant
biosecurity**



Food Security- Plant Biosecurity Paradox

Invest in plant biosecurity infrastructure before bringing those nations into the global economy.



Feeding a Growing Population



UN Millennium Dev. Goals

UN Ecosystem Assessment

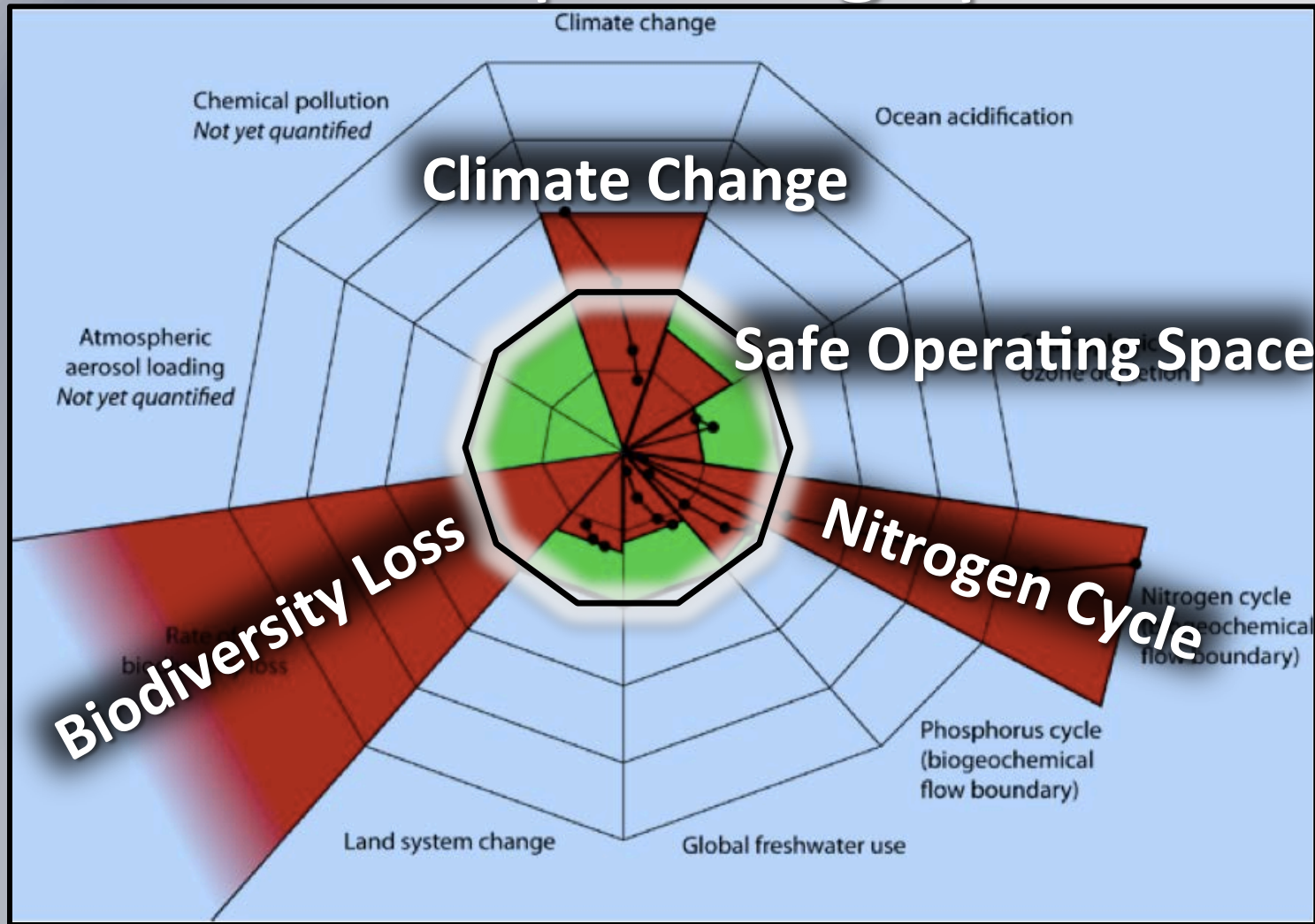
One third of the world's plant systems are endangered

One third of the world's plant systems are threatened

** This target value has been increased to \$1.25/day.

<http://www.un.org/millenniumgoals/>
UN FAO

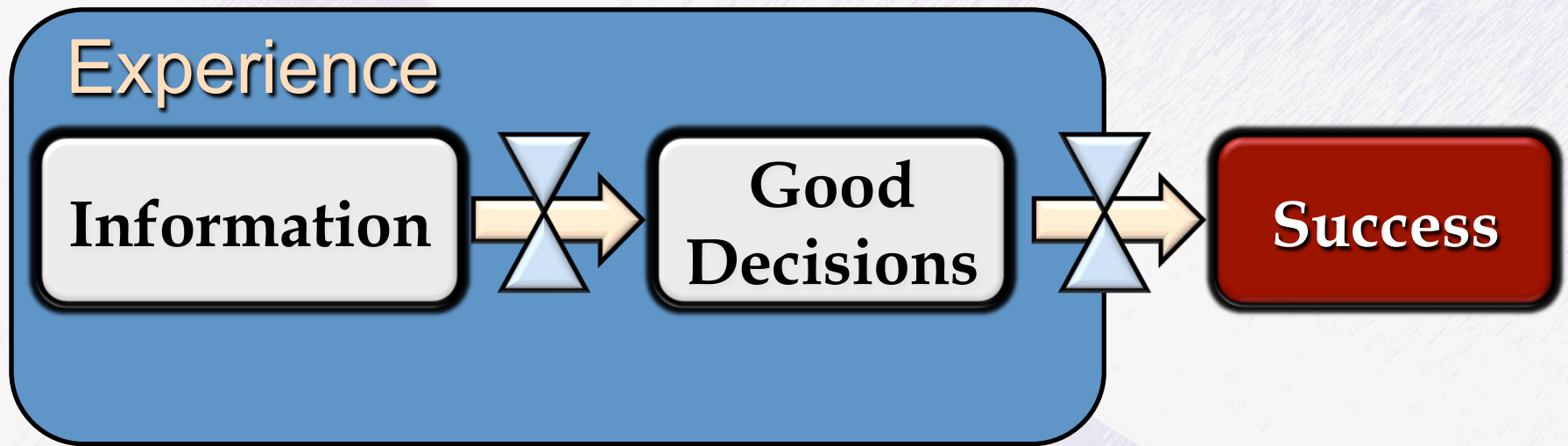
A Safe Operating Space



Rockström et al. 2009. Planetary boundaries: exploring the safe operating space for humanity. *Ecology and Society* **14(2)**: 32.

Need Informed & Balanced Policy

We are rich in experience of hunger in the world.



Need Informed & Balanced Policy

1845-47 Irish Potato Famine



1 Million died & 1 Million emigrated

Need Informed & Balanced Policy

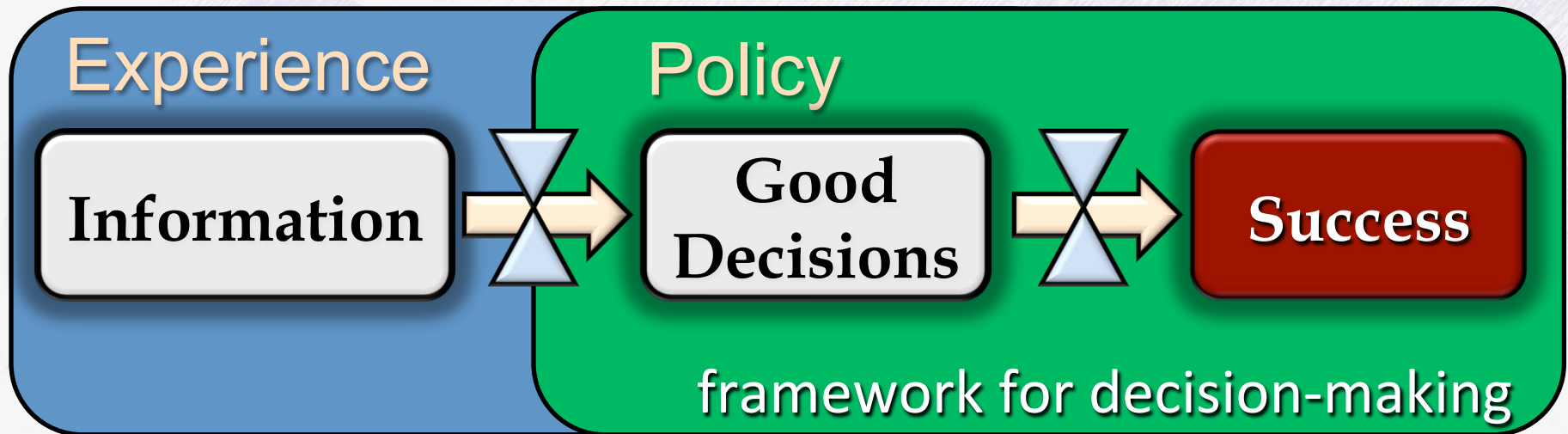
1943: Bengal Rice Famine



3 Million died of hunger and related illnesses

Need Informed & Balanced Policy

We are rich in experience of hunger in the world.



Policy often generates unintended consequences.

Need Informed & Balanced Policy

During 1845-47, Ireland was producing abundant cereals, eggs, meat, and fish - all for export markets.

While people were literally starving to death, food was being exported out of Ireland.

1845-47: Irish Potato Famine
1 Million died & 1 Million emigrated

Need Informed & Balanced Policy

Threats to Plant Systems



While people were literally starving to death, food imports to Bengal were restricted.

1943: Bengal Rice Famine
2-3 Million died

Climate Change & Plant Biosecurity

Need Informed Policy

- **2000-2001 Nebraska: severe drought – 0”**

Why?

It was more profitable to lose money growing corn than to keep land in CRP

- **Farmers/ranchers were ripping up CRP land and planting corn**

BBC.com



Ecosystem Assessment

- **Intensification of agricultural production is an important solution to the food security challenge (food security agencies)**
- **Intensified agricultural production systems are the single biggest threat to the environment (ecological community)**

Food - Water - Environment



Ecosystem Assessment

That will undoubtedly
redistribute pathogens and pests.

- **Restoration ecologists propose establishing global plant rescue sites**

Need informed & balanced policy

Frankham et al. 2010. Conservation Genetics, p 4.

Wardle et al. 2011. Science 329:1273

Feeding a Growing Population

Good News

Investment in Ag Research



Cost of food



Poverty & hunger



Plant Biosecurity: Why does it matter?

Bad News

Poverty & hunger

We need to sustain poverty & hunger in order to maintain investment in the agricultural research necessary to reduce poverty and hunger!

Poverty & hunger

World Bank Report 2009.

National Forum on Climate and Pests – October 2016

*Knowledge
for Life*



K-STATE
Research and Extension

Policy Challenge

- *Perhaps the most significant outcome from this group would be recommendations for a policy framework and a research agenda to address climate change and plant health.*

Climate Change and Plant Biosecurity

*Thank you &
Have a nice day!*

US Dept of State Geographer
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Image Landsat
Data SIO, NOAA, U.S. Navy, NGA, GEBCO

Google earth

Feeding a Growing Population in a Shrinking World

*Can we? Will we?
Should we?*