



Issues of our Time: Rethinking Agriculture for a Hotter, Drier World

15 June 2010

Nina V. Fedoroff

Science and Technology Adviser to the U. S. Secretary of State

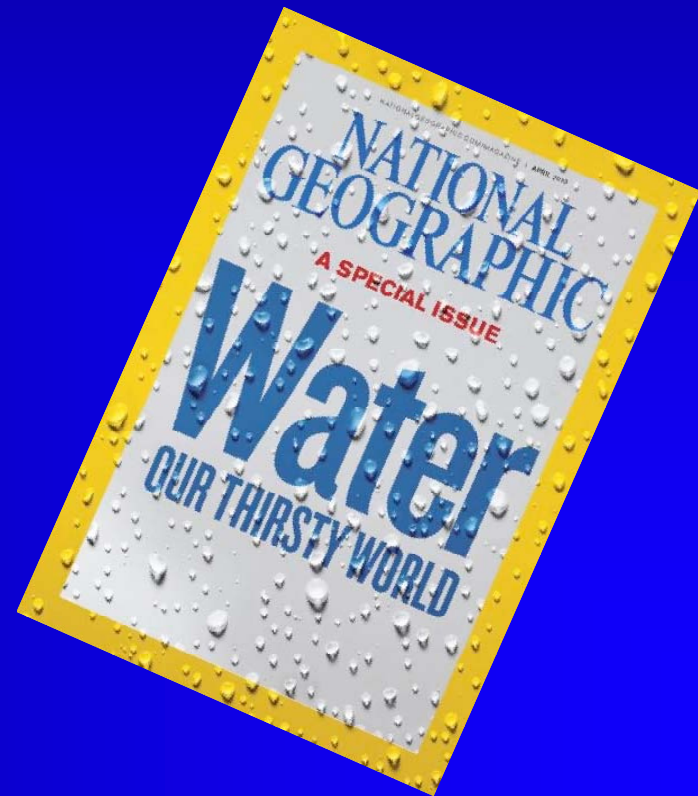
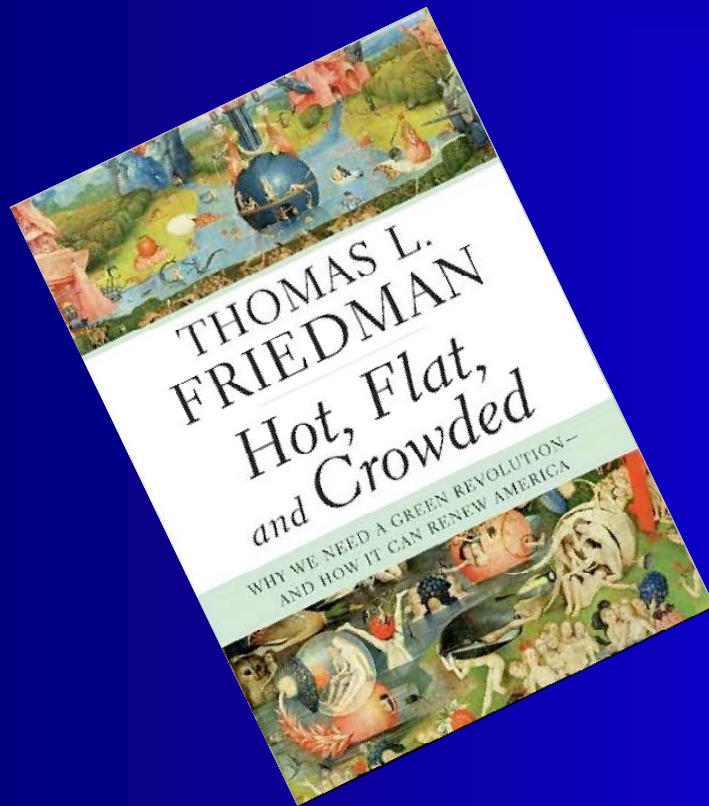
Willaman Professor of the Life Sciences

and Evan Pugh Professor

Penn State University, on leave

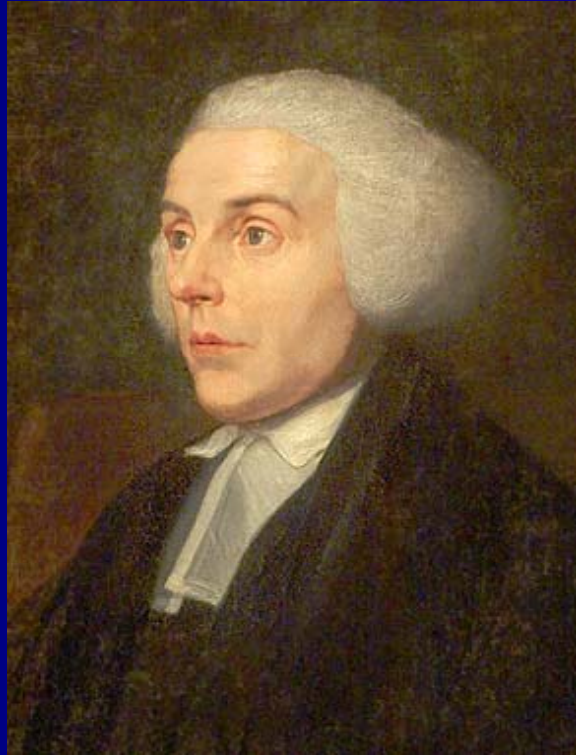


Feeding People and Preserving Biodiversity in a Hot, Crowded and Thirsty World



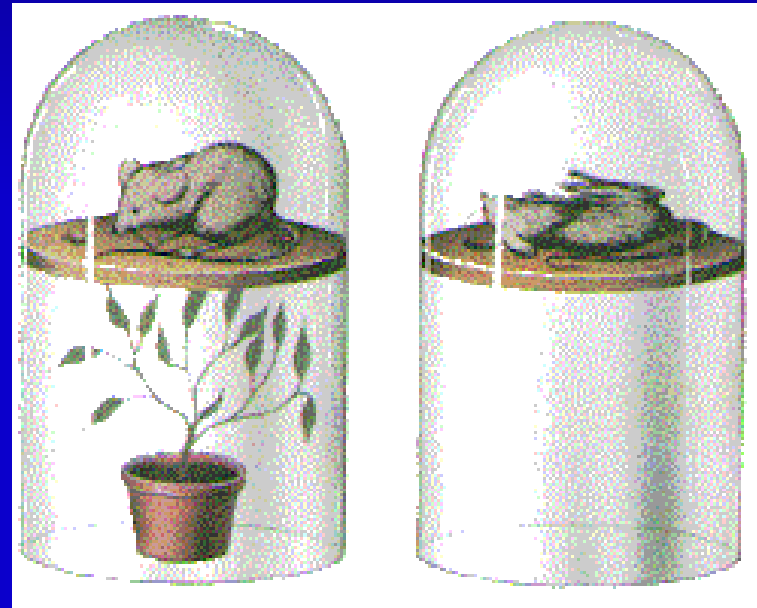


Scientific agriculture



Joseph Priestley

www.chemheritage.org/.../priestley4.jpg



www.juliantrubin.com/.../mouseexperiment.gif



<http://www.bagaiteknik.com/catalog/images/Hyp>



www.johnny

<http://www.248am.com/images/marrybrown.jpg>



bp3.blogger.com/.../s320/Hubert+prouching+2.jpg



iStock photo 00003424427



<http://image.guardian.co.uk/sysimages/Guardian/Pix/pictures/2006/07/18/farm372.jpg>



http://www.iaea.org/NewsCenter/Features/Tsetse/tsetse_gallery/images/006w.jpg

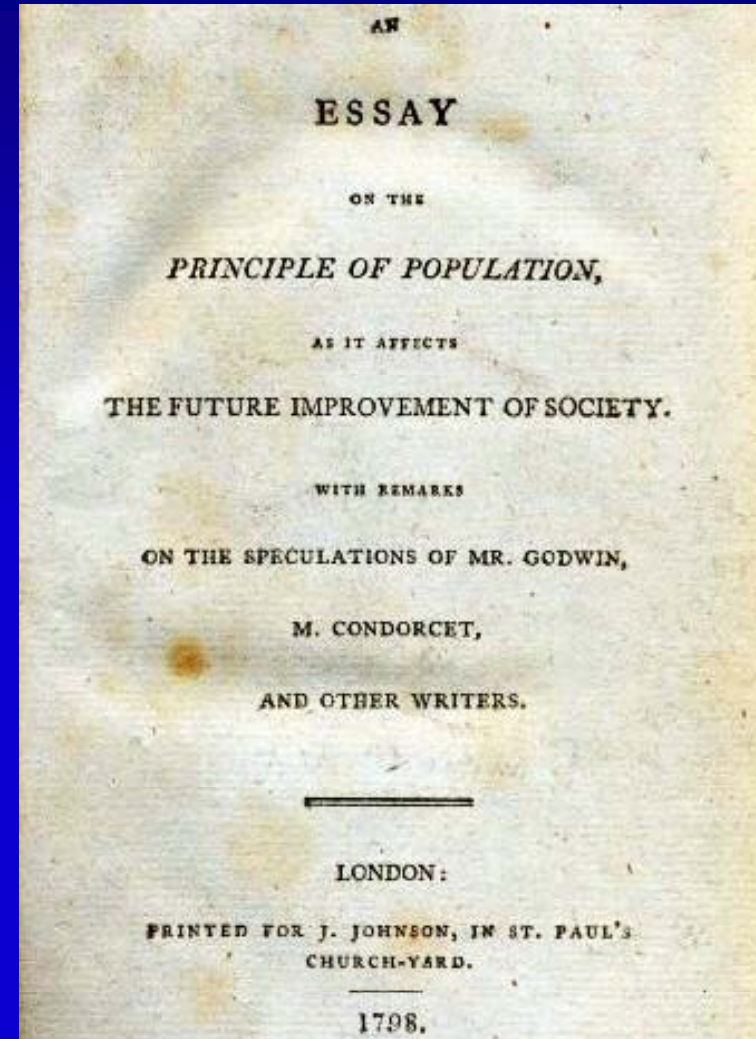


Food security

www.ndb.com/people/250/00024178/malthus.jpg



Thomas Malthus





Chemical fertilization

<http://cache.eb.com/eb/image?id=1308&rendTypeld=4>



Fritz Haber



Carl Bosch

www.eearth.org/media/approved/e/e6/Bosch.jpg



vn.schmidt-clemens.de/vnoffice/data/0/0/0/227..



Precision agriculture



GPS-guided tractors

http://3.bp.blogspot.com/_TGTE52t75H0/SbwqVoOGBrI/AAAAAAAAALo/IYCc8hwNZ5I/s400/gps-tractors.jpg



Soil moisture & weed control

<http://blogs.tampabay.com/.a/6a00d83451b05569e20120a5713600970b-900wi>



Creating corn by genetic modification



www.kukurydza.org.pl/images/teosinte1.jpg



<http://www.arini.ac.uk/pics/maize%20altd.jpg>



www.kukurydza.org.pl/images/teosinte1.jpg



Genetic modification of wheat

http://newsimg.bbc.co.uk/media/images/42352000/jpg/_42352866_wheatbody.jpg



Wild wheat

http://ecoplanet.trustpassing.alibaba.com/.../101642572Wheat_Germ_Oil.jpg



Modern wheat



Genetic modification of rice

www.ricediversity.org/thebasics/



Ancestral rice



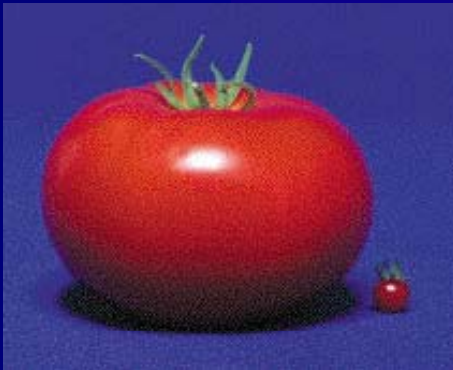
Modern rice

<http://daweab.da.gov.ph/12%20Steps/12steps/rice2.jpg>



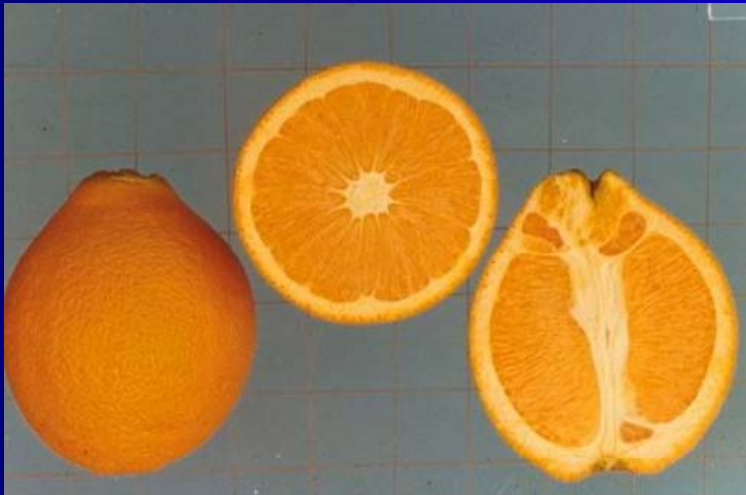
Familiar genetically modified foods

<http://scope.educ.washington.edu/gmfood/>

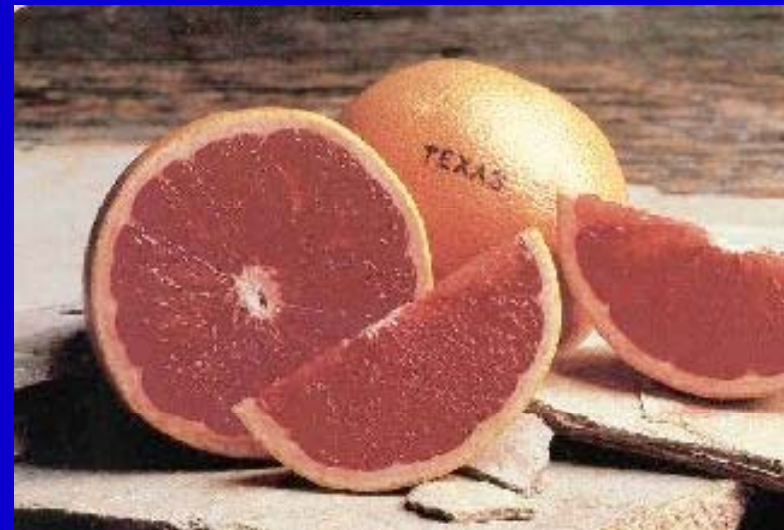


http://www.backyardgardener.com/organic/sept99_files/elephant_lg.jpg

<http://www.mariquita.com/images/photogallery/cauliflower.jpg>



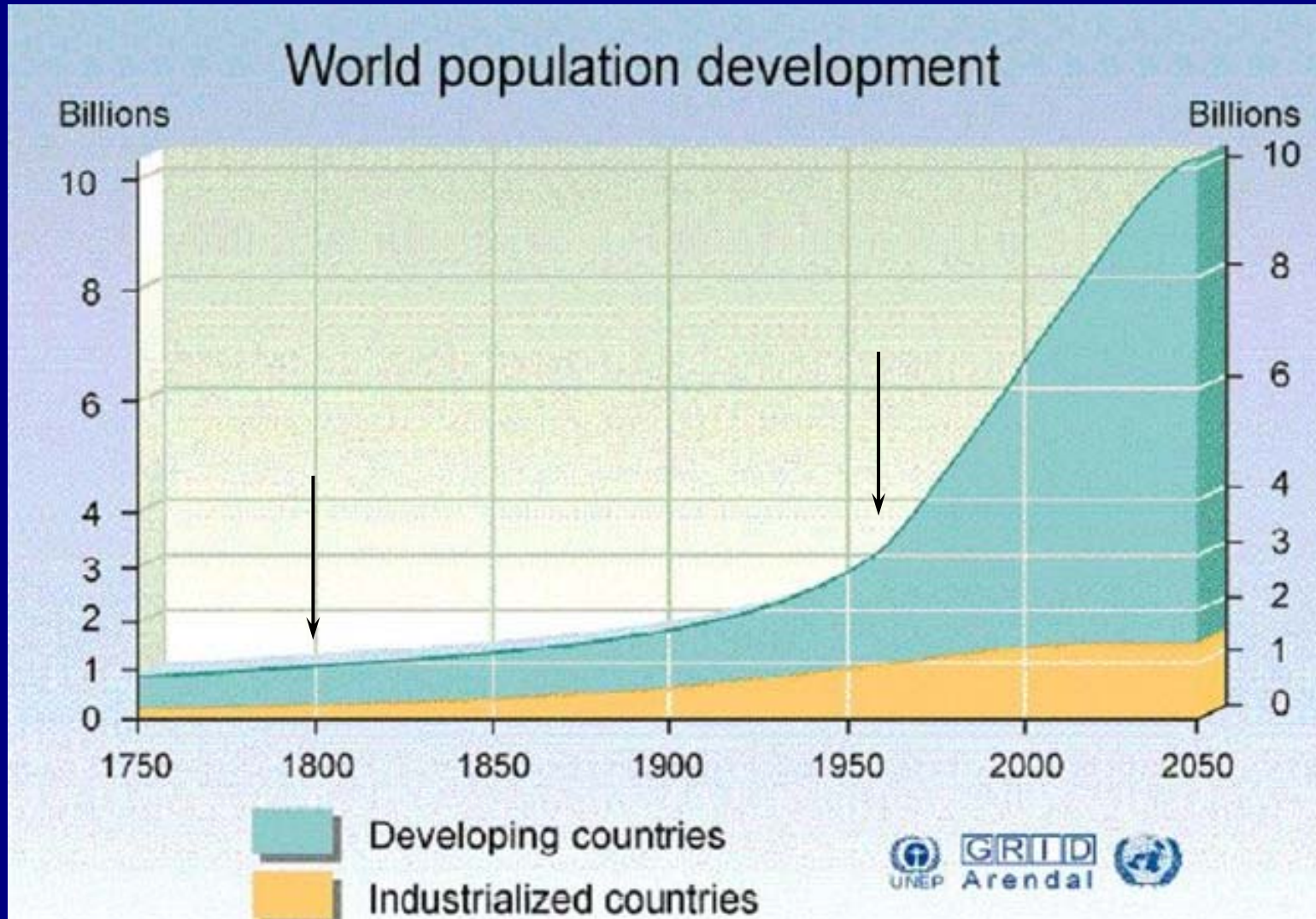
<http://www.hort.cornell.edu/4hplants/Fruits/Images/Navel%20Seedless%20Citrus.jpg>



<http://primera.tamu.edu/kcchome/homeowner/riored.htm>



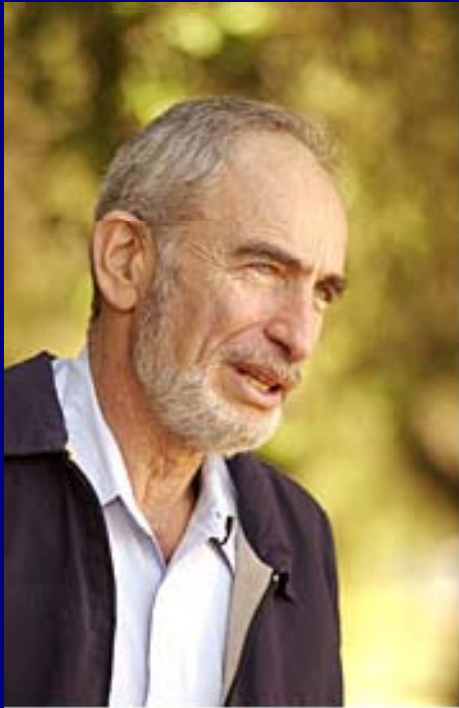
Global population growth



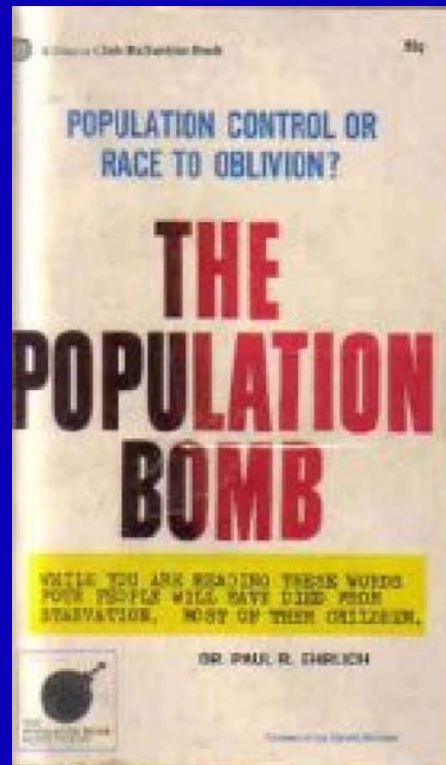
<http://www.sustainablescale.org/images/uploaded/Population/World%20Population%20Growth%20to%202050.JPG>



news-service.stanford.edu/.../Ehrlich-12.jpg

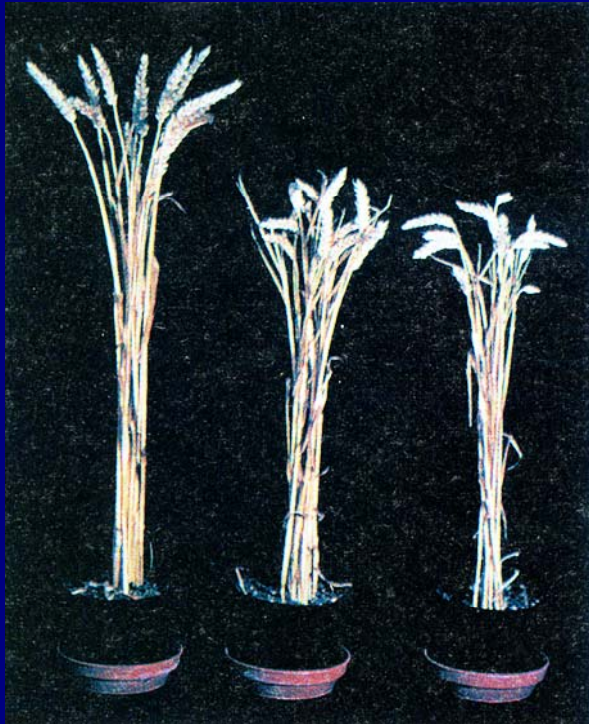


Paul Ehrlich

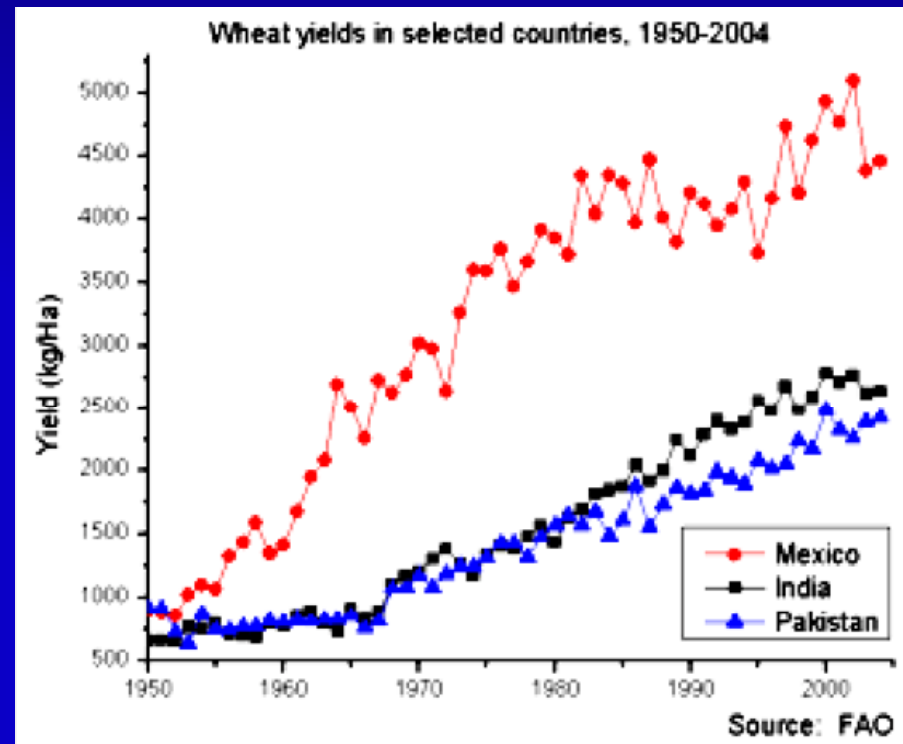


Norman Borlaug
Father of the Green Revolution

http://ecx.imagesamazon.com/images//51ZQ306HVGL_AA240_.jpg



Normal and dwarf wheat



Green Revolution wheat yields, 1950-2004



Molecular crop improvement



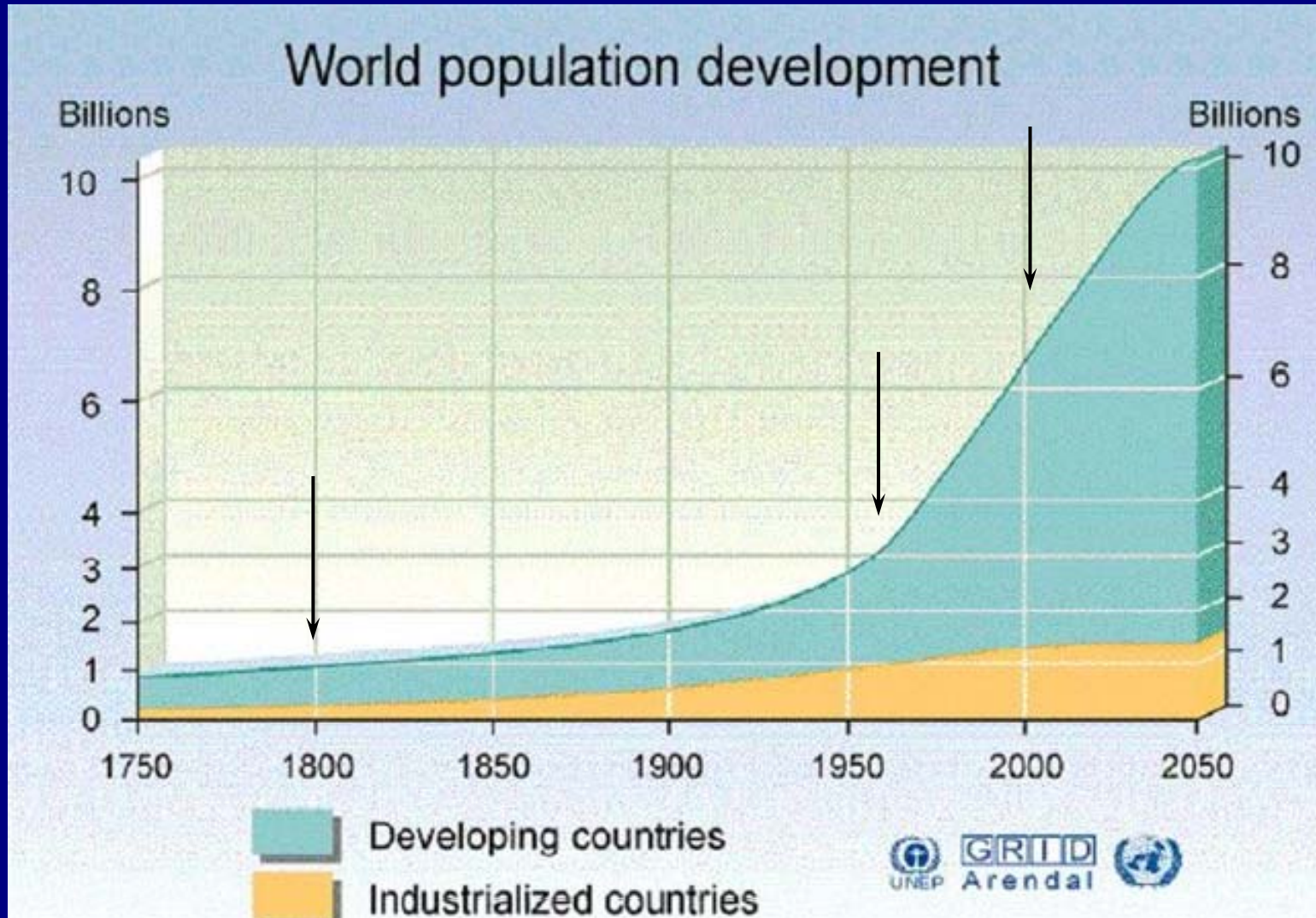
Bt maize



<http://www.apsnet.org/online/feature/BtCorn/Images/healthy%20ear.JPG>



Global population growth



<http://www.sustainablescale.org/images/uploaded/Population/World%20Population%20Growth%20to%202050.JPG>



Agriculture and biodiversity



Peter Raven

Director of the Missouri Botanical Garden

http://www.botany.org/plantsciencebulletin/images/54-2_raven.jpg

"Nothing has driven more species to extinction or caused more instability in the world's ecological systems than the development of an agriculture sufficient to feed 6.3 billion people."



Forest biodiversity



<http://www.lbl.gov/Publications/YOS/Sep/rainforest.jpg>



http://2.bp.blogspot.com/_LIt3WzPmprs/SvqdfZZQGTI/AAAAAAAAAJY/zlgCZLZ3VhU/s400/forest-light-900.jpg



Forest clearing



<http://media.photobucket.com/image/forest+destruction+agriculture/mauriciocordova/Amazon%20Rescue/03.jpg?o=1>



<http://media.photobucket.com/image/forest%20destruction%20agriculture/equal-life/556.jpg>



New Zealand



<http://www.landcoalition.org/cpl-blog/wp-content/uploads/farmland.jpg>

<http://www.davidwallphoto.com/>





United States



<http://scienceblogs.com/worldsfair/upload/2007/05/Aerial%20view%20of%20Indiana%20farms,%20with%20individual%20agro%20land%20plots%20sm.jpg>



<http://www.greenpacks.org/wp-content/uploads/2009/06/Farms-in-California.jpg>



Monoculture



http://awalkabout.files.wordpress.com/2009/06/corn_field339213037_std.jpg



<http://blogs.nationalgeographic.com/blogs/news/chiefeditor/farmland-picture-3.jpg>



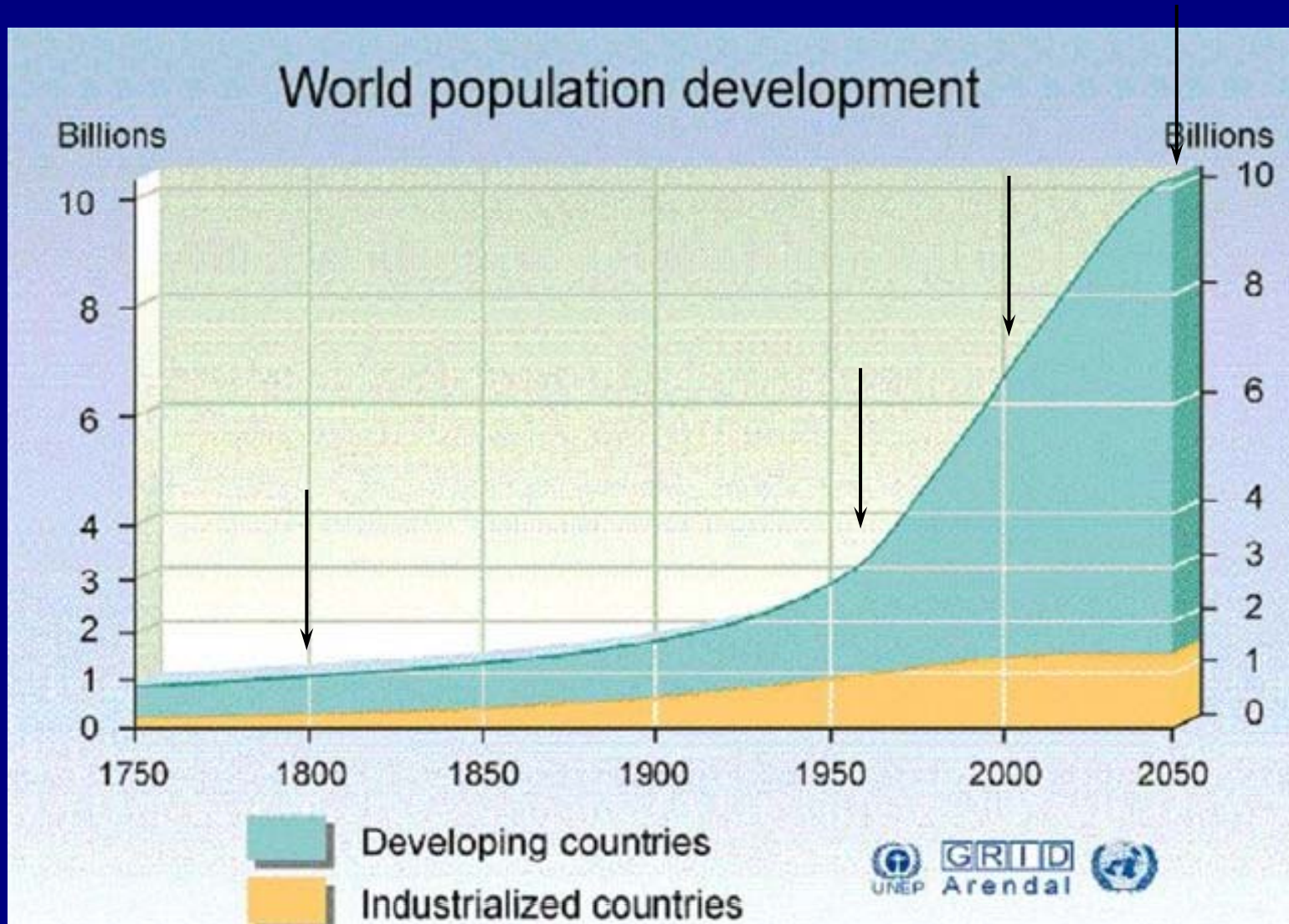
Eutrophication



http://www.marietta.edu/~biol/biomes/images/mangroves/florida_eutrophication_7536.jpg



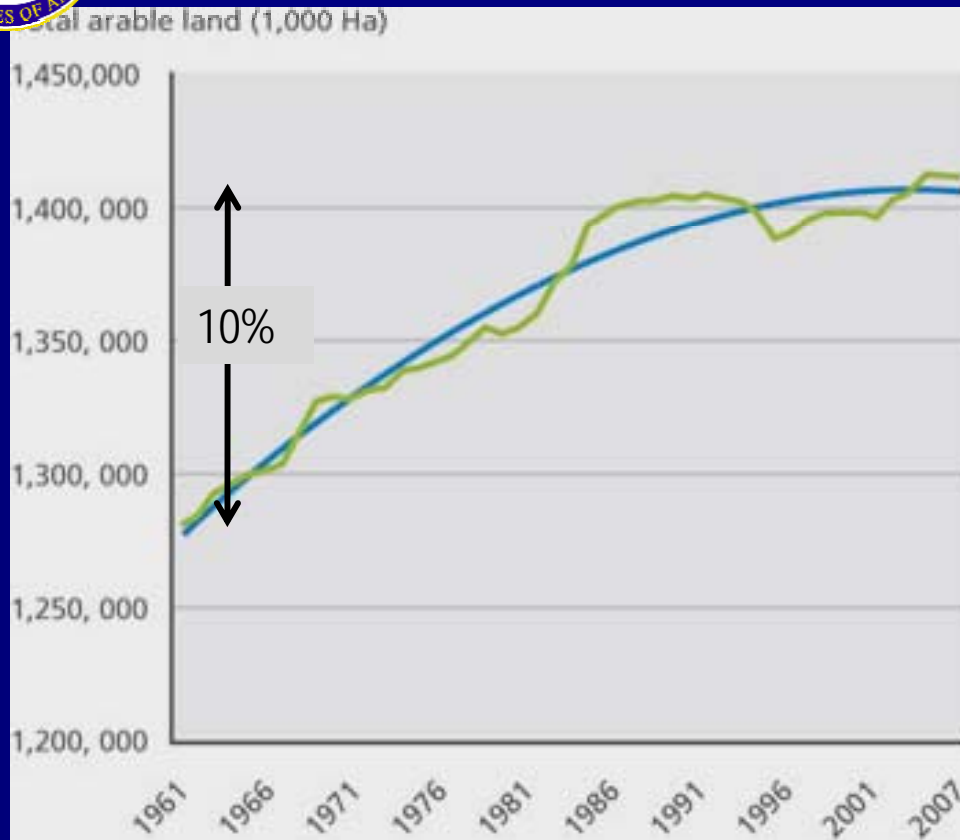
Global population growth



<http://www.sustainablescale.org/images/uploaded/Population/World%20Population%20Growth%20to%202050.JPG>

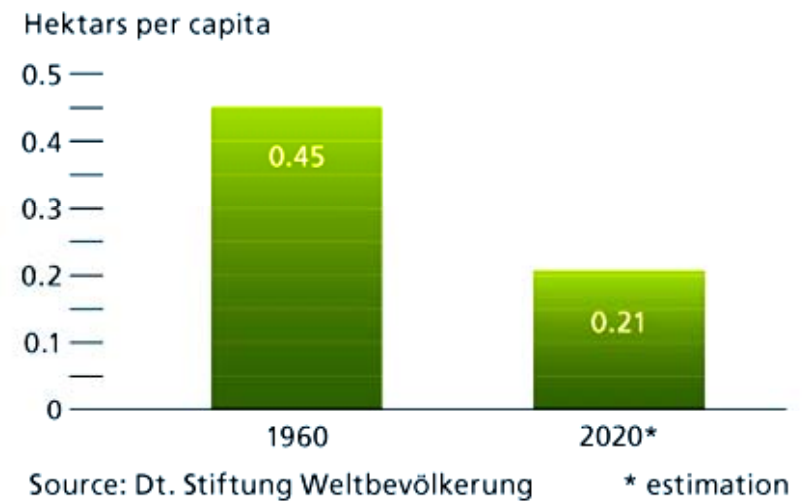


Arable land is limited



http://www.landcommodities.com/assets/images/charts/F1_4small.jpg

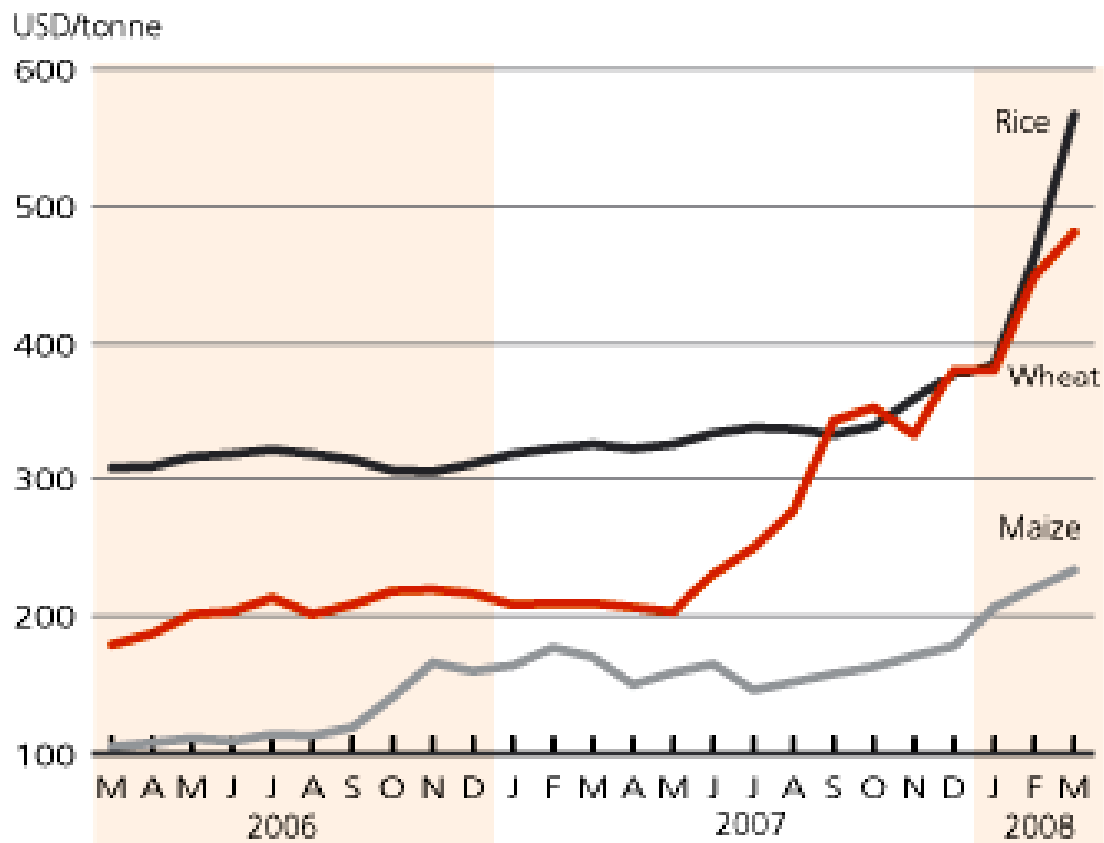
<http://www.ktg-agrar.de/static/common/wfimage/fffc80e53854da31c8cb3cbbdd0f9089.jpg>





The food price crisis of 2008

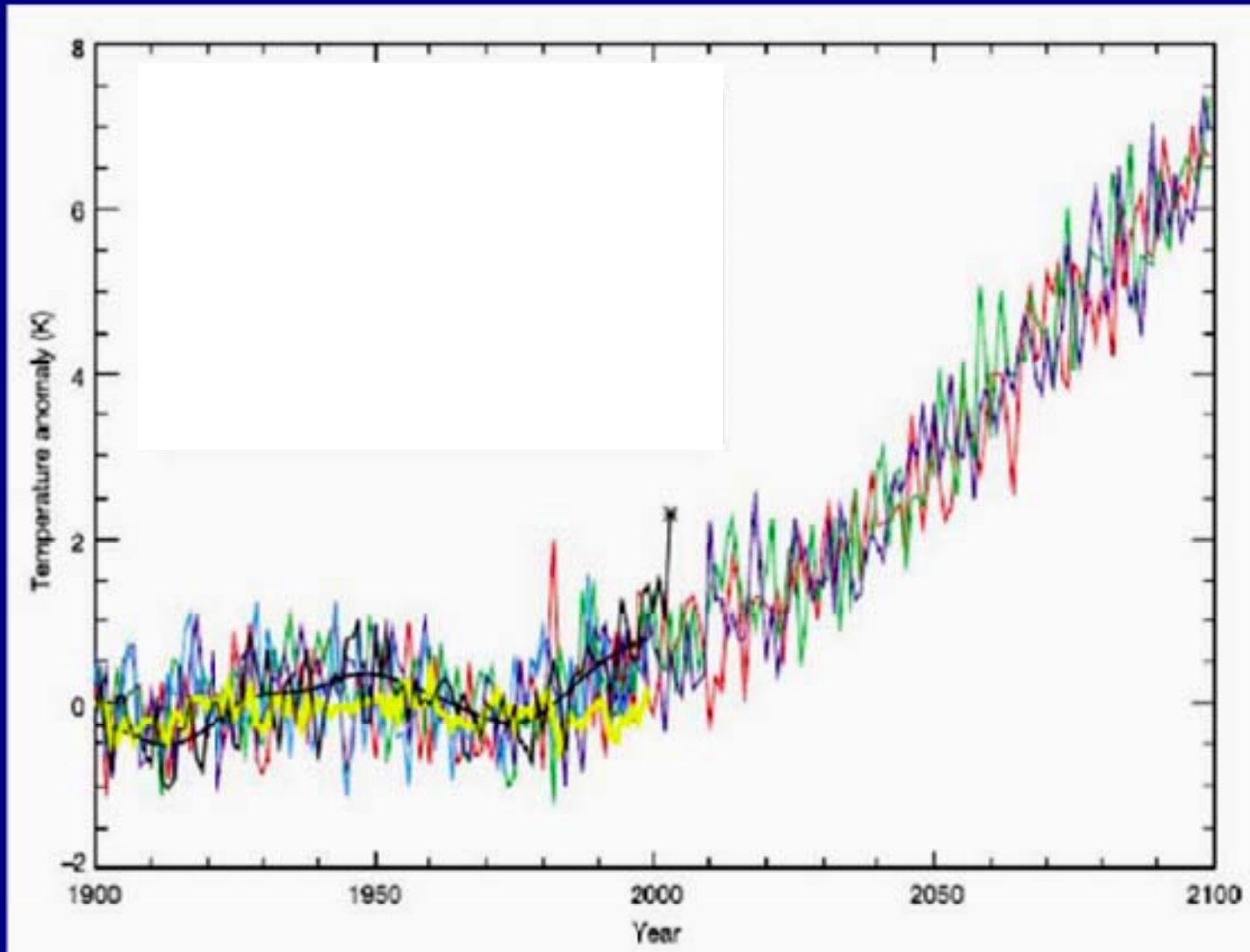
Selected international cereal prices



Source: FAO



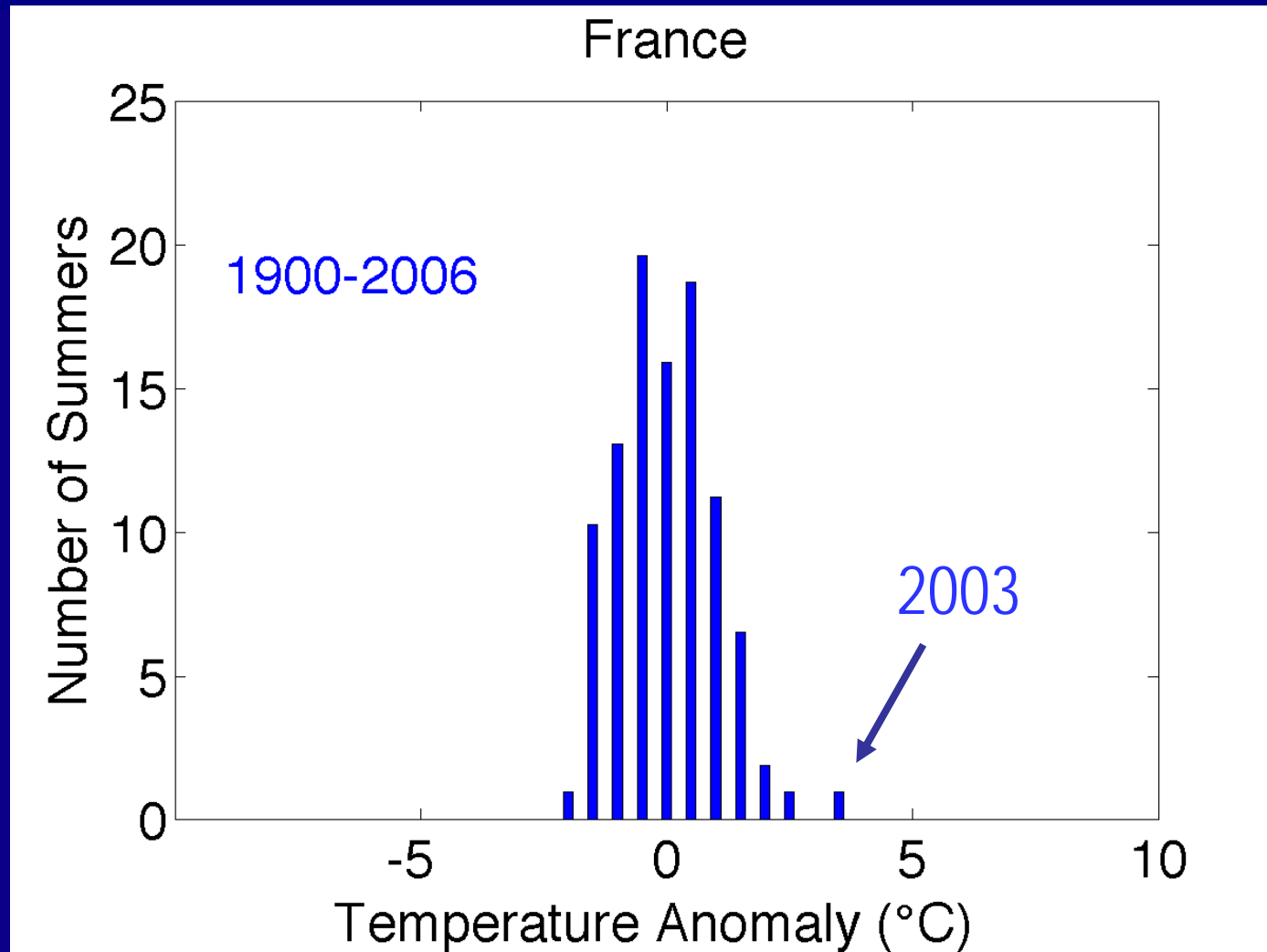
Increasing global temperatures



Stott et al, Nature 432:610 (2004)



Impact of climate change on crops

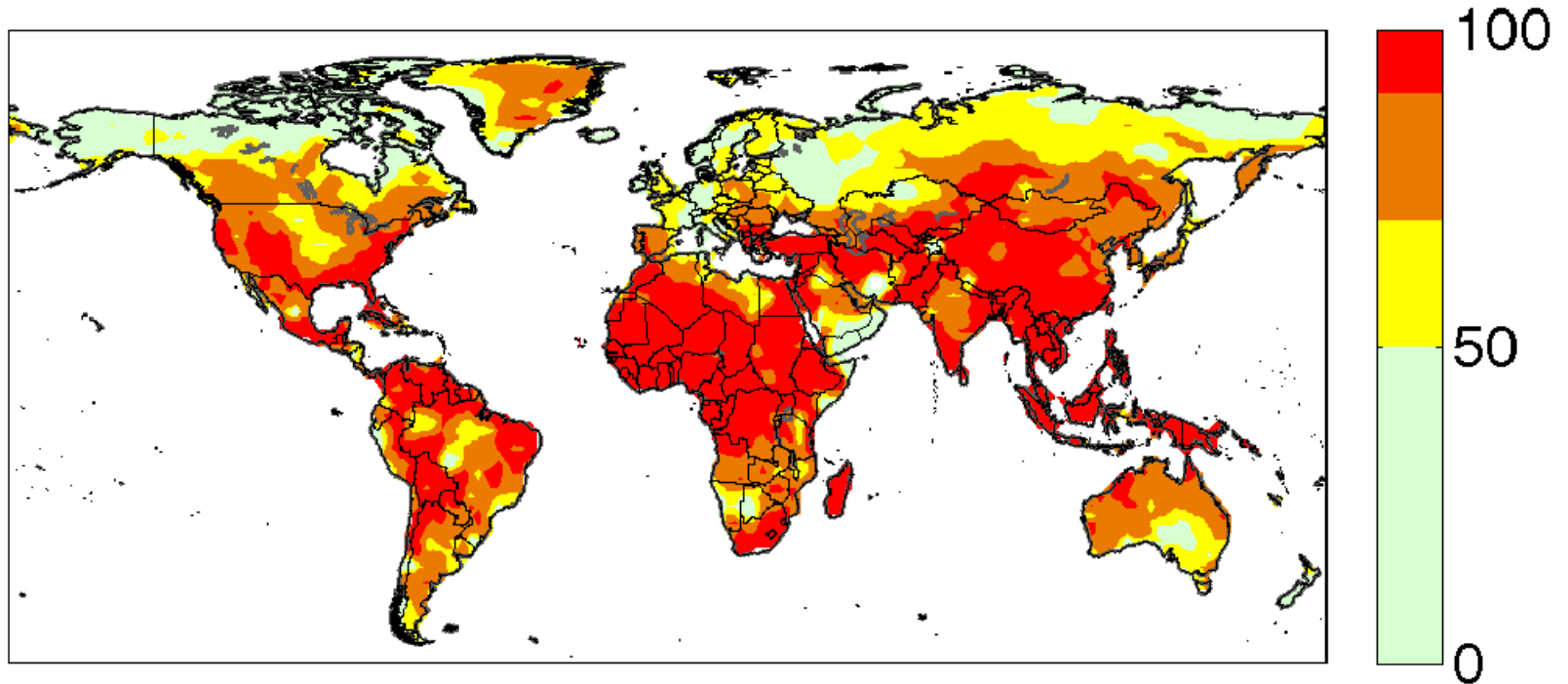


Slide courtesy of Dr. David Battisti



Projected growing season temperatures

Percent of Summers in 2090 Warmer than Warmest on record

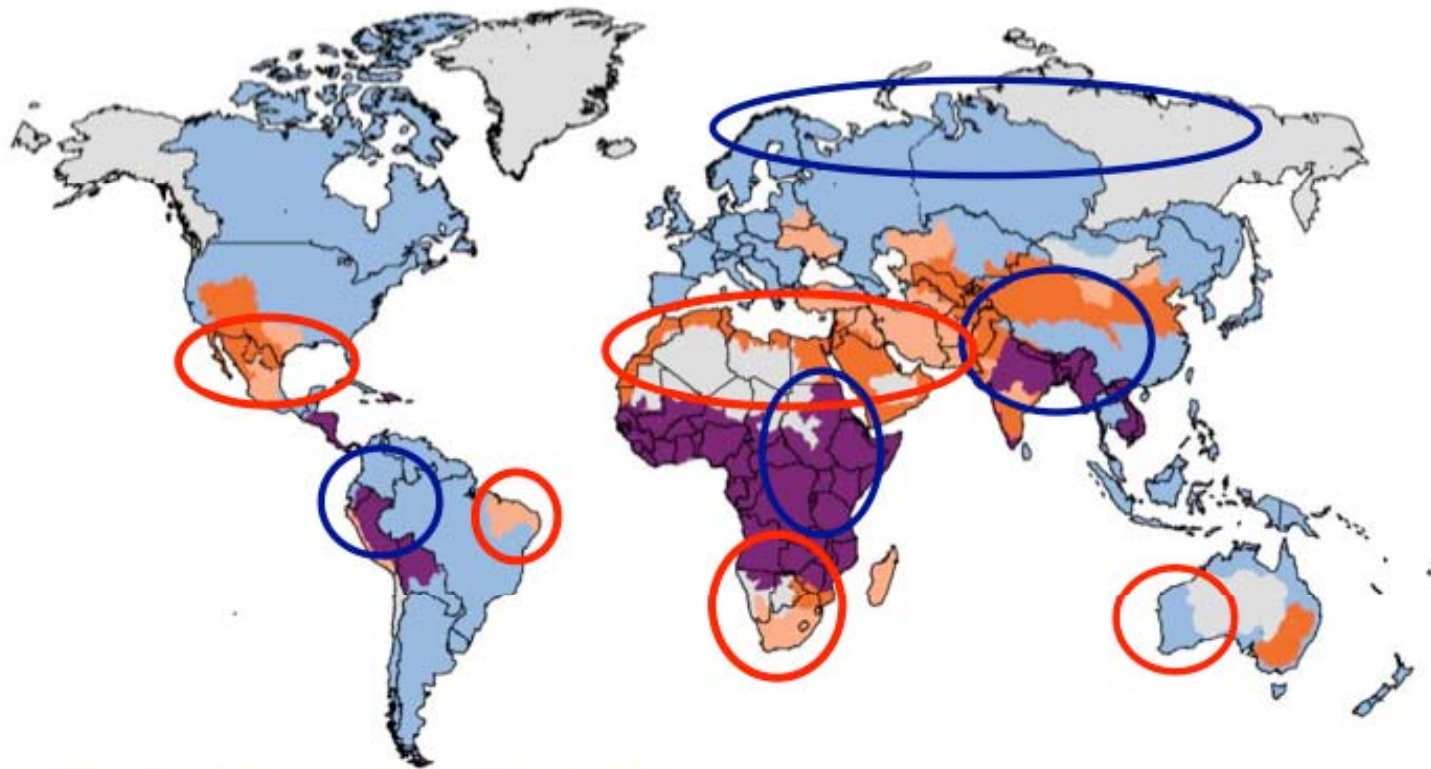
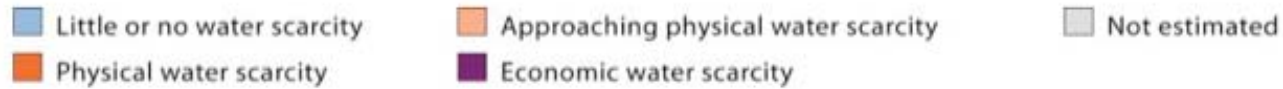


Battisti and Naylor 2008



Water scarcity will increase in many places

Water Scarcity and Climate Change



Some areas wetter, some areas drier



Slide courtesy of Dr. David Molden, International Water Management Institute



What we'll need to do in the 21st century

- Reduce agriculture's ecological footprint
- Decrease agriculture's use of fresh water
- Reduce agricultural pollution of air, land and water
- Adapt crops to a hotter, drier world
- Double the food supply by 2050

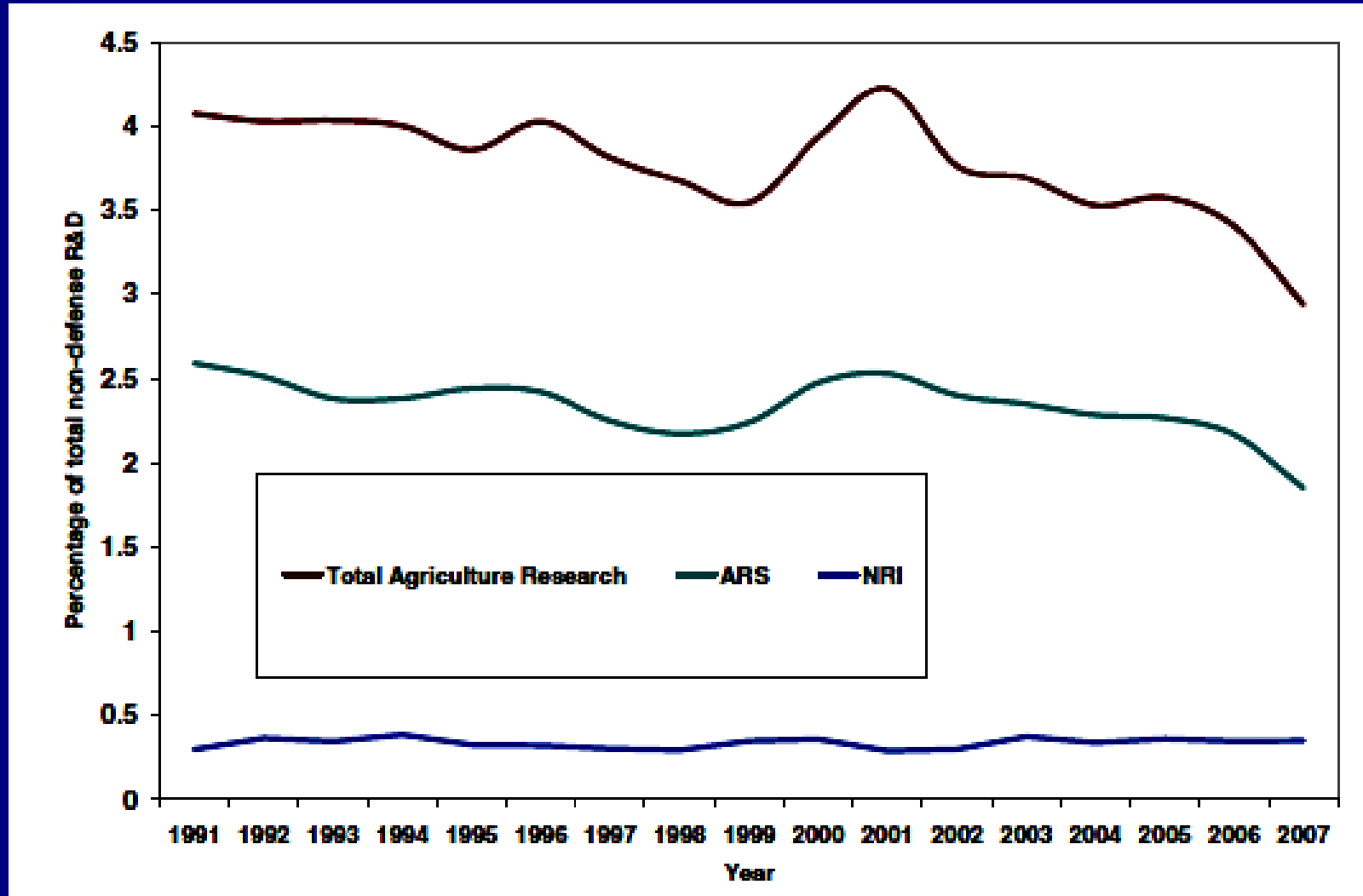


The objectives

- Increase tolerance to heat and drought
- Increase tolerance to flooding and salinity
- Enhance pest and disease resistance biologically
- Increase crop productivity
- Increase nitrogen utilization efficiency
- Increase the efficiency of photosynthesis
- **New crops, new methods, new systems**



The obstacles



Source: 2009 FASEB report on Federal Funding for Biomedical and Related Life Sciences Research



The obstacles



www.greenpeace.org/raw/image_full/france/



cujtokyo.files.wordpress.com/2007/10/gmo-prot...



http://www.bayweekly.com/year01/issue9_38/images9_38/lead04protestors.jpg



Biotechnology and biodiversity



Peter Raven

Director of the Missouri Botanical Garden

“To assert that GM techniques are a threat to biodiversity is to state the exact opposite of the truth.”

“The less focused and productive this agriculture is, the more destructive its effects will be.”



Desert agriculture



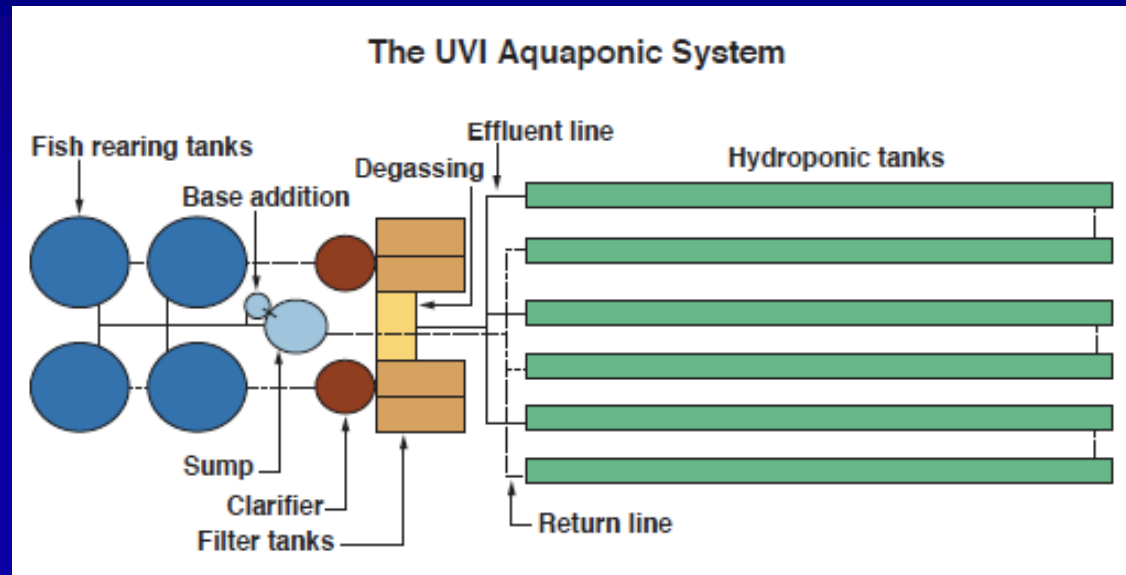
Photo courtesy of Dr. Avigad Vonshak,
Jacob Blaustein Institute for Desert
Research, Ben-Gurion University of the
Negev



<http://www.hos.ufl.edu/ProtectedAg/images/Arava-2a.jpg>



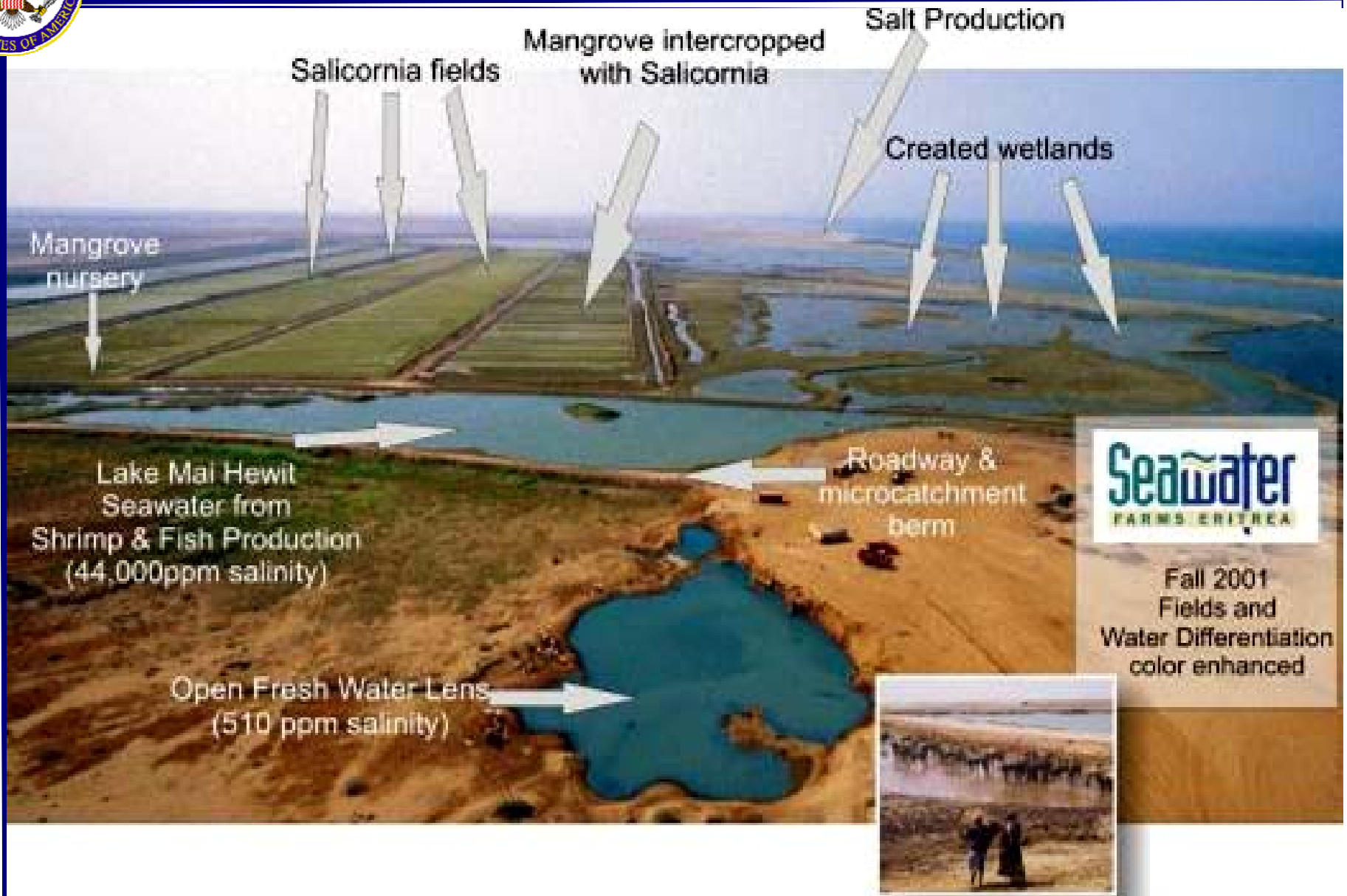
Integrated aquaculture/agriculture systems



From SRAC pub 454, University of the Virgin Islands Agricultural Experiment Station



Integrated aquaculture and saline agriculture



Photos courtesy of Dr. Carl Hodges, The Seawater Foundation