Plant Genetic Resources for a Hot and Crowded Planet
(A global integrated system for crop diversity conservation and why it’s important in a changing climate)

Charlotte Lusty and Hannes Dempewolf
Global Crop Diversity Trust
Introducing the Trust

• Aims: “to ensure the conservation and availability of crop diversity for food security worldwide”

• Goal: “to advance an efficient and sustainable global system of ex situ conservation by promoting the rescue, understanding, use and long-term conservation of valuable plant genetic resources”

• Public-private partnership raising an endowment fund to provide continuous funding for key international ex situ collections (eg. international collections maintained by CGIAR Centres, SPC)

• Essential element of the funding strategy of the International Treaty for Plant Genetic Resources for Food and Agriculture (ITPGRFA)
Global System Project Activities

Regeneration

Evaluation

Duplication

Conservation Research

Information systems
Approximate world holdings

World holdings: 7.4 million accessions

World unique holdings: 2 million accessions

Unique, threatened, needing regeneration: 168,000 accessions

Global System Project Activities

Regeneration projects:

- 95,000 accessions
- 246 collections
- 86 institutes
- 77 countries

Accessions in National Institutes

Source: Direct communication between Trust and national partners
In the Caribbean

• Coordinated by CARDI – Herman Adams
• INIFAT Cuba: 370 Common Beans and 77 Lima Beans
• INRA Guadeloupe: 150 Yam accessions of which 120 in vitro and 30 field
• NARI Guayana: 47 Cassava
• MALMR Trinidad & Tobago: 55 Sweet Potato
Global System Project Outcomes

Regeneration results:

• 64,500 accessions regenerated and now available through the MLS
• 3,038 put in vitro
• 32,000 duplicated (into international collections)
• >10,000 not viable
- FAO’s State of the World Report lists 1700 facilities
- Holding 7.4 Million accessions of which about 2 million may be unique
- Costs > $12/accession to conserve a seed sample
- many of those facilities stocked with samples already being stored elsewhere
- professional and financial capacity often insufficient to ensure effective conservation over time
Towards a truly global system

• National genebanks, with their intimate knowledge of indigenous experience and wisdom, local conditions and needs, move even closer to farmers, breeders and researchers and actively search out, acquire, screen, develop, store and distribute diversity of particular and current relevance to those clients

• Conservation and availability on the long-term and at the global level is ensured by genebanks holding large and international collections at agreed standards

• Global back-up – Svalbard Global Seed Vault

• Enabling environment – the Treaty
The Trust’s endowment fund

- Long-term grants for 10 international genebanks (CGIAR and SPC) and the Svalbard Global Seed Vault
- Provided in-perpetuity support to 17 major food crops: rice, cassava, wheat, barley, sweet potato, faba bean, pearl millet, maize, chickpea, forages, banana, bean, edible aroids, grasspea, sorghum, yam and lentil
- US$ 130 million in the endowment to date
- The CGIAR Fund Council has asked the Trust to manage the total budget for genebank operations of all international collections over the coming 5 years
Impact of humans on the planet

Crop and forage species now cover roughly half of the Earth's land surface (Kareiva et al. 2010)
Likelihood (in percent) that the summer average temperature in 2050 will exceed the highest summer temperature ever observed (1900-2006).


**Impact of climate change on food security**

**Summers in 2040-2060 Warmer than Warmest on Record**
Likelihood (in percent) that the summer average temperature in 2090 will exceed the highest summer temperature ever observed (1900-2006).

Climate change and crop yields

Nonlinear heat effects on African maize as evidenced by historical yield trials

David B. Lobell, Marianne Bänziger, Cosmos Magorokosho & Bindiganavile Vivek

Affiliations  |  Contributions  |  Corresponding author

Nature Climate Change (2011)  |  doi:10.1038/nclimate1043
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![Graph showing nonlinear heat effects on African maize](image-url)
Shifts in African crop climates


Fig. 2. Percentage overlap between historical and 2025 (left), 2050 (middle), and 2075 (right) simulated growing season average temperature at over African maize area. Dark blue colors represent 100% overlap between past and future climates, dark red colors represent 0% overlap.
Crop wild relatives

Table 2. Important genes in wheat that were found in related species (12)

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<thead>
<tr>
<th>Trait</th>
<th>Locus</th>
<th>Source</th>
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<tbody>
<tr>
<td><strong>Disease resistance</strong></td>
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<td>Leaf rust</td>
<td>Lr9</td>
<td><em>Aegilops umbellulata</em></td>
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<td><em>Triticum timopheevi</em></td>
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<td><em>Ag. elongatum</em></td>
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<td>Lr29</td>
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<td>Lr32</td>
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<td><strong>Stem rust</strong></td>
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<td></td>
<td>Sr2</td>
<td><em>T. turgidum</em></td>
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<td>Sr22</td>
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<td>Sr36</td>
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<td><strong>Stripe rust</strong></td>
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<td>Yr15</td>
<td><em>Triticum dicoccoides</em></td>
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<td>Pm12</td>
<td><em>Aegilops speltoides</em></td>
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<td>Pm21</td>
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<td>Pm25</td>
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<td><strong>Wheat streak mosaic</strong></td>
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<td>virus</td>
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<td><strong>Karnal bunt</strong></td>
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<td>Quantitative trait loci</td>
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<td><strong>Pest resistance</strong></td>
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<td>Hessian fly</td>
<td>H21</td>
<td><em>S. cereale</em></td>
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<td><em>T. tauschii</em></td>
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<td>H27</td>
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Folke 2001

Hoisington et al 1998
Impact of climate change on CWR diversity

- 16-22% (depending on migration scenario) of these species predicted to go extinct
- Most species losing over 50% of their range size
- Wild peanuts were the most affected group, with 24 to 31 of 51 species projected to go extinct
- For wild potato, 7 to 13 of 108 species were predicted to go extinct
- Vigna was the least affected of the three groups, losing 0 to 2 of the 48 species in the genus
Targeting threatened diversity

Jarvis et al. 2008
The Trust’s CWR initiative

- Identify, collect, conserve, document and use key crop wild relative diversity for climate change adaptation (in developing countries)
- $50 million over 10 years pledged by Norwegian government, starting 2011
- 26 target crops: alfalfa, apple, bambara groundnut, banana, barley, bean, carrot, chickpea, cowpea, eggplant, faba bean, finger millet, grasspea, lentil, oat, pea, pearl millet, pigeon pea, potato, rice, rye, sorghum, sunflower, sweet potato, vetch and wheat
Possible prebreeding strategy options

• First evaluate CWRs, then pick most promising genotypes and use in pre-breeding with cultivated lines, evaluate again
• Assess genetic diversity of accessions, pick set of diverse CWR genotypes and cross with cultivars, create BCs and RILs and evaluate
• QTL (and MAS) approaches
• Candidate gene approaches and allele mining in CWRs
Genomics and Genebanks

“It is now possible to examine genome-wide patterns of natural variation and link sequence polymorphisms with downstream phenotypic consequences.”

The Trust engaged in a short-term consultancy to produce a “Technical appraisal of strategic approaches to large-scale germplasm evaluation”

(Sarah Ayling (The Genome Analysis Centre, UK))
Genomics and Genebanks

“Previously seen as “warehouses” where seeds were diligently maintained, but evolutionarily frozen in time, genebanks could transform into vibrant research centers that actively investigate the genetic potential of their holdings.”

(McCouch et al. 2012)
Thanks to our collaborators

Thank you for your attention!

Image credits: Neil Pamer (CIAT), NASA, AVRDC, GCDT, Nik Tyack and CIP