The importance of in-situ conservation

Five reasons for promoting *in situ* conservation of crop genetic resources:
1. Key elements of crop genetic resources *cannot be captured and stored off-site*.
2. *Agroecosystems* continue to generate new genetic resources.
3. A *backup to gene bank* collection is necessary.
4. Agroecosystems in *centers of crop diversity/evolution* provide natural laboratories for agricultural research.
5. The *Convention on Biological Diversity* mandates *in situ* conservation.

*Stephen B. Brush (2000)*

GENES in the FIELD On-Farm Conservation of Crop Diversity, IPGRI, Lewis publisher, London.

1. Key elements of crop genetic resources cannot be captured and stored off-site.

A. Because ecological relationships such as *gene flow* between different populations and species, *adaptation* and *selection to predation and disease*, and *human management* of diverse crop resources are components of a common crop evolutionary system that generate crop genetic resources.

B. Maintenance of large area of crop diversity cannot be contained in ex situ facilities

e.g. Allopolyploidy and hybridization, wild relative introgression
2. Agroecosystems continue to generate new genetic resources: e.g. Wheat diversity

The hexaploid wheat (Triticum aestivum) is derived from two relatively recent polyploidization events between three clearly identified diploid species. The first event, which involves Triticum monococcum and (putatively) Aegilops speltoides, occurred about 0.5 million years ago, and led to the appearance of hard wheat (Triticum dicoccoides).

The second polyploidization event took place about 9000 years ago, between hard wheat (tetraploid) and a third diploid (Triticum tauschii).

Besides these natural polyploids, new varieties of wheat (Triticum) with different levels of polyploidy can be "synthesized" by crossing different diploid Triticum species.
3. A backup to gene bank collection is necessary.

In situ conservation of crop resources has been criticized because of its potential vulnerability to technological innovation and diffusion, economic and political change, and environmental factors.

Nevertheless, complementarity between in situ and ex situ conservation goes beyond a simple backup role for the former. Ex situ collections and their associated crop improvement programs give rise to one type of diversity.

4. Agroecosystems provide natural laboratories for agricultural research.

First, the understanding of crop evolutionary processes, such as gene flow between wild and cultivated plants, is best carried out in centers of crop origins, diversity, and evolution.

Second, agricultural science has become increasingly aware of the importance of broad ecological processes in the design of technology for sustainable production.

5. Convention on Biological Diversity

This convention, originally negotiated in 1992 and ratified by over 160 countries, specifically includes crop genetic resources and indigenous knowledge as items that require in situ conservation.

Article 8 addresses in situ conservation and, within the article, 8(j) identifies “Knowledge, innovations and practices of indigenous and local communities embodying traditional lifestyles relevant for the conservation and sustainable use of biological diversity ...” (Convention on Biological Diversity 1994:9).
In-situ conservation

1. The importance of in-situ conservation

2. World crop distribution and centers

3. Concept of genetic diversity and conservation

4. In-situ conservation strategies

Vavilou, 1926 “center of crop origin”

6-8 centers

China
India
Central Asia
Near East
Mediterranean
Ethiopia
Mesoamerica
South America: Andes of Peru, Ecuador, Bolivia; Chiloe; lowlands: Brazil, Paraguay

Zhukovsky, 1975 World diversity center
Hotspot of ancient cultivation center (after Vavilov 1929)

1. East-Asian:
   (1.) Chinese,
   (2.) Japanese
2. South-Asian tropical, including the following foci:
   (1.) Indian,
   (2.) Indo-Chinese,
   (3.) Insular, including the whole Malayan archipelago
3. South-West-Asian:
   (1.) Caucasian,
   (2.) Middle-East,
   (3.) Nort-West-Indian

World Centers of diversity of cultivated plants (after Vavilov 1929)

4. Mediterraneae
5. Ethiopian: Adjacent to this is the mountainous Arabian, or Yemen, focus
6. Central American, including South Mexico. This is divided into
   (1.) Mountainous South Mexico,
   (2.) Centroamerican,
   (3.) West-Indian insular foci
7. Andian, within the South America. It includes
   (1.) Andian,
   (2.) Chiloanian or Araucanian, and
   (3.) Bogotan foci.

Maize (central America, Mexico)

Cereals: Asian rice, proso and foxtail millets
Pulses: soybean, adzuki bean
Root & tuber crops: turnip, yams
Oil crops: rape seed
Fruits & nuts: Chinese hickory, chestnut, quince, persimmon, litchi, apricot, peach
Vegetables & spices: Chinese cabbage, ginger
Stimulants: tea, ginseng, camphor
The origin of agriculture

- The invention and development of agriculture was accomplished independently in several places in the world, but within a relatively narrow time period following the end of the Pleistocene period — 8,000 to 10,000 years before the present (Harris and Hillman 1989).
Human migrations may contribute to crop diversity

In-situ conservation
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The spread of crops out of Asia
Far Eastern agriculture had very little dispersal until well into modern historic times

<table>
<thead>
<tr>
<th>Direction</th>
<th>Crop/Region</th>
<th>Date or Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Westward</td>
<td>To Persia along the silk routes (rice)</td>
<td>after 350 BC</td>
</tr>
<tr>
<td></td>
<td>To India (peach)</td>
<td>AD 150</td>
</tr>
<tr>
<td></td>
<td>To Africa, Madagascar (banana)</td>
<td>AD 700-1000</td>
</tr>
<tr>
<td></td>
<td>To Southern Europe along Northern Africa with Islam (citrus)</td>
<td>7th century AD</td>
</tr>
<tr>
<td>Eastwards</td>
<td>Cereal culture declined and root crops increased such as taro, breadfruit, sago, banana</td>
<td></td>
</tr>
<tr>
<td></td>
<td>To Philippines</td>
<td>3000 BC</td>
</tr>
<tr>
<td></td>
<td>To Eastern Polynesia and Hawaii</td>
<td>AD 300</td>
</tr>
<tr>
<td></td>
<td>To New Zealand (Maori)</td>
<td>AD 1050</td>
</tr>
</tbody>
</table>
Ways of altering genetic diversity

- **Mutation**
- **Gene flow**
- **Nonrandom mating**
- **Genetic drift**
- **Selection**

### Table 21.1 Agents of Evolutionary Change

<table>
<thead>
<tr>
<th>Factor</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mutation</td>
<td>The ultimate source of variation. Individual mutations occur so rarely that mutation alone usually does not change allele frequency much.</td>
</tr>
<tr>
<td>Gene flow</td>
<td>A very potent agent of change. Populations exchange members or gametes.</td>
</tr>
<tr>
<td>Nonrandom mating</td>
<td>Inbreeding is the most common form. It does not alter allele frequency but changes the proportion of heterozygotes.</td>
</tr>
<tr>
<td>Genetic drift</td>
<td>Statistical accidents. The random fluctuation in allele frequencies increases as population size decreases.</td>
</tr>
<tr>
<td>Selection</td>
<td>The only agent that produces adaptive evolutionary changes.</td>
</tr>
</tbody>
</table>
**Nonrandom mating**

- **Classified mating:**
  - Positive: mating among individuals with similar phenotypes
  - Negative: mating among individuals with dissimilar phenotypes
- **Inbreeding:**
  - Mating among relatives

**Genetic drift**

- Describes how allele frequencies can fluctuate unpredictably from one generation to the next
  - Tends to reduce genetic variation

---

**Sex recombination through generations**

<table>
<thead>
<tr>
<th>Generation</th>
<th>Selfed genotypes</th>
<th>Homozygosity (%)</th>
<th>Heterozygosity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( G_0 )</td>
<td>Aa</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>( G_1 )</td>
<td>1AA, 2Aa, 1aa</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>( G_2 )</td>
<td>6AA, 4Aa, 6aa</td>
<td>75</td>
<td>25</td>
</tr>
<tr>
<td>( G_3 )</td>
<td>28AA, 8Aa, 28aa</td>
<td>87.5</td>
<td>12.5</td>
</tr>
<tr>
<td>( G_4 )</td>
<td>120AA, 16Aa, 120aa</td>
<td>93.75</td>
<td>6.25</td>
</tr>
<tr>
<td>( G_5 )</td>
<td>496AA, 32Aa, 496aa</td>
<td>96.875</td>
<td>3.125</td>
</tr>
<tr>
<td>( G_6 )</td>
<td>2016AA, 64Aa, 2016aa</td>
<td>98.4375</td>
<td>1.5625</td>
</tr>
<tr>
<td>( G_7 )</td>
<td>8128AA, 128Aa, 8128aa</td>
<td>99.21875</td>
<td>0.78125</td>
</tr>
<tr>
<td>( G_8 )</td>
<td>32640AA, 256Aa, 32640aa</td>
<td>99.60938</td>
<td>0.390625</td>
</tr>
</tbody>
</table>

- \( p = 0.5 \)
- \( q = 0.5 \)
- \( p = 1.0 \)
- \( q = 0.0 \)
Major ways of changing

Forces shaping genetic diversity

- Mutation
- Migration
- Recombination
- Selection
- Drift

In-situ conservation

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Human preferred traits during domestication

- Fully domesticated plants are characterized by a similar set of traits that confer adaptation to the human environment and human’s preference.

Adaptation to human’s eye and tastes

Cucumber and wild

Loss of sex during domestication

- The two most important traits of the domestication syndrome are loss of seed dispersal and seed dormancy, as well as sex.

Considerations of conservation

Two critical population parameters are identified by Marshall and Brown (1975):
(1) the extent of genetic divergence among populations and
(2) the level of genetic variation of a population.

Like collectors for ex situ collections, planners for in situ conservation will be concerned with these parameters in selecting target areas.

Conservation criteria 1

- Focus first on alleles which are common among populations but localize in small area

Fig. 1 in Chap 1, Stephen B. Brush (2000)
Conservation criteria 2

- Second, consider to select a local community intensifying on target crops and growing in variable habitat

Encouraging in-situ conservation: 1. market methods

Two general market methods are available for increasing the direct and option values of local crops and management.

One depends on developing market channels for local produce to increase the value of crops that have genetic resources. (green farm…)

The other relies on legal mechanisms for restricting the supply of genetic resources, thereby raising their value for sale as genetic resources. (Pharmaceutical usage, government financing) (Stephen Brush 2000)

Varieties of lettuce

However, some wild varieties are fascinated!
Encouraging in-situ conservation: 2. nonmarket methods

Two non-market approaches have been developed for promoting in situ conservation:

(1) educational or promotional campaigns (diversity fairs, agricultural school)

(2) increased use of local crop resources and farmer participation in crop breeding and improvement programs. (Participatory plant breeding thus means farmer participation is selection at the F2 level and above, while participatory varietal selection means farmer participation at the F5 level and above.

http://www.agronomy.ucdavis.edu/pepts/pb143/lec08/pb14308.htm
Seed protein analysis

Where was common-bean domesticated?

http://www.agronomy.ucdavis.edu/gepts/pb143/lec01/machu_p.gif

IPGRI provides guidelines for in-situ conservation

Brassica domestication - diversity is important

Broccoli  Cauliflower  Collards  Cabbage  Brussels Sprouts  Kale  Kohlrabi

Molecular technologies for biodiversity evaluation: Opportunities and challenges

New technologies for detecting variation in DNA complement traditional methods in biodiversity.
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