

Impact case study (REF3)

Institution: University of Birmingham		
Unit of Assessment: 5 – Biological Sciences		
Title of case study: Improving plant genetic resource availability to sustain global food security		
Period when the underpinning research was undertaken: 2000 – 2020		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
Nigel Maxted	Professor of Plant Genetic Conservation	1990 – Present
Period when the claimed impact occurred: August 2013 – December 2020		
Is this case study continued from a case study submitted in 2014? No		
<p>1. Summary of the impact</p> <p>We have been pivotal in changing policy directions globally to maximise Plant Genetic Resource (PGR) conservation by redefining how PGR are understood and managed. This has been achieved: internationally by advising the UN Food and Agriculture Organisation on establishing a global network for PGR conservation; regionally through advice to the European Commission on integrating crop, forest and animal genetic resources conservation; and nationally by contributions to the UK Agriculture Bill on targeted subsidies to boost PGR conservation efficiency. This dramatic policy shift has led to significant impact on the breadth of PGR conserved, so enhancing UK, European and global food security.</p>		
<p>2. Underpinning research</p> <p>Food insecurity, caused by human environmental mismanagement, increasingly threatens the future of humankind. To support increased agricultural production, crops need regular improvement through the directed use of Plant Genetic Resources (PGR), containing novel genes for adaptive traits. PGR provides this genetic diversity that sustains the breeding of new, higher yielding, more nutritious, climate change resilient crop varieties. PGR includes Crop Wild Relatives (CWR — the wild species closely related to crops) and crop landraces (LR — the traditional varieties seed-saved by farmers). Previously, their conservation has been <i>ad hoc</i> and many CWR/LR were under-conserved, threatened by erosion or extinction, and so unavailable for future innovative crop variety development.</p> <p>Maxted's and colleagues' key research findings have laid the scientific foundation for planning and enacting more systematic PGR conservation at global, European, and national levels:</p> <p>KF1: The production of a global, prioritised list of CWR taxa</p> <p>In 2013, Maxted's team identified the CWR related to 173 top globally important crops, creating an inventory of 1,667 priority taxa. It highlighted that the highest concentrations are in western Asia and that urgent germplasm active conservation was needed in China, Mexico and Brazil [R1].</p>		

KF2: Significant gaps exist in global *ex situ* CWR conservation

In 2016, Maxted's team used occurrence data to model the global distribution of 1,076 prioritised taxa related to 81 priority crops. They compared the potential geographical and ecological diversity distributions with actual distributions based on genebank records to determine collections gaps. They found 29.1% of CWR had no representation in genebanks, a further 23.9% were highly under-represented and the genebank holdings of >95% of CWR failed to represent their complete range of geographic and ecological variation, indicating urgent additional collection was required [R2].

KF3: *In situ* conservation gains can be geographically optimised

In 2019, Maxted's team modelled the species distribution for all 667 priority CWR taxa. By combining this with climate change predictions, key geographical areas were identified where *in situ* CWR conservation would yield the greatest conservation impact. The result was a potential global *in situ* network of 150 sites conserving 65.7% of priority CWR diversity, which when implemented would double the diversity currently available for crop improvement [R3].

KF4: Systematic conservation plans are needed at a national scale

At a national scale, Maxted's team identified locations for *in situ* and *ex situ* CWR and LR conservation of priority populations [R4]. They also conducted a regional survey in the UK of exotic LRs and highlighted the importance of maintaining these for use in crop improvement programs [R5].

Overall, Maxted's extensive body of work has highlighted the historic *ad hoc* nature of PGR conservation and that diversity availability has unnecessarily limited crop improvement by restricting breeders' choice of adaptive traits to use in crop improvement. The situation has been compounded by a policy context that is not fit for purpose. Maxted has become sought-after for consultancy, and with extensive research funding, which has made him well-placed to produce materials to underpin international, European and UK PGR science and policy [e.g. R6].

3. References to the research

R1: Vincent, H., Wiersema, J., Kell, S.P., Dobbie, S., Fielder, H., Castañeda Alvarez, N.P., Guarino, L., Eastwood, R., León, B. & Maxted, N. (2013). A prioritized crop wild relative inventory to help underpin global food security. *Biological Conservation*, 167: 265–275. DOI: 10.1016/j.biocon.2013.08.011

R2: Castañeda-Álvarez, N.P., Khoury, C.K., Achicanoy, H.A., Bernau, V. Dempewolf, H., Eastwood, R.J., Guarino, L., Harker, R.H., Jarvis, A., Maxted, N., Müller, J.V., Ramirez-Villegas, J., Sosa1, C.C., Struik, P.C., Vincent, H. & Toll, J. (2016). Global conservation priorities for crop wild relatives. *Nature Plants*, 2, 16022. DOI: 10.1038/nplants.2016.22

R3: Vincent, H., Amri, A., Castañeda-Álvarez, N.P., Dempewolf, H., Dulloo, M.E., Guarino, L., Hole, D., Mba, C., Toledo, A. & Maxted, N. (2019). Modeling of crop wild relative species identifies areas globally for *in situ* conservation. *Nature Communication Biology*, 2:136. DOI: 10.1038/s42003-019-0372-z.

R4: Maxted, N., Amri, A., Castañeda-Álvarez, N.P., Dias, S., Dulloo, M.E., Fielder, H., Ford-Lloyd, B.V., Iriando, J.M., Magos Brehm, J., Nilsen, L-B., Thormann, I., Vincent, H. & Kell, S.P. (2016). Joining up the dots: a systematic perspective of crop wild relative conservation and use.

In: Maxted, N., Ehsan Dulloo, M. & Ford-Lloyd, B.V. (eds), *Enhancing Crop Gene Pool Use: Capturing Wild Relative and Landrace Diversity for Crop Improvement*. Pp. 87–124. CAB International, Wallingford, UK DOI: 10.1079/9781780646138.0087

R5: Kell, S.P., Rosenfeld, A., Cunningham, S., Dobbie, S. & Maxted, N. (2017). The benefits of exotic food crops cultivated by small-scale growers in the UK. *Renewable Agriculture and Food Systems*, 1–16. DOI: 10.1017/S1742170517000424

R6: Maxted, N., Avagyan, A., Frese, L., Iriondo, J.M., Magos Brehm, J., Singer, A. & Kell, S.P. (2015). Preserving diversity: a concept for *in situ* conservation of crop wild relatives in Europe Version 2. Rome, Italy: In Situ and On-farm Conservation Network, European Cooperative Programme for Plant Genetic Resources, Rome, Italy.

Associated Key Grants:

1: Bioversity International, *Developing CWR conservation strategies in Southern Africa*, EC ACP Programme, January 2014–December 2016, €450K

2: International Union for Conservation of Nature (IUCN), *Safeguarding Mesoamerican crop wild relatives*, UK Darwin Initiative, May 2016–April 2020, £295K

3: Bioversity International, *Building a CWR conservation network in the SADC region*, UK Darwin Initiative, April 2019–March 2022, £477K

4: University of Birmingham, *Implementing a European in situ and on-farm conservation network*, EC H2020 Programme, January 2018–December 2020, €2m

5: European Forestry Institute, *European crop / forestry / animal conservation integration*, EC H2020 Programme, January 2019–December 2021, €3m

4. Details of the impact

The policy and practice of international agencies and institutions, in relation to global Plant Genetic Resources (PGR) and Crop Wild Relatives (CWR) conservation strategies, have been transformed by Maxted's research. Through his leadership of international advisory boards/committees, along with UN-based consultancy work, **management and conservation practices related to food security have become more efficient and effective globally.**

Influencing guidelines and investment decisions to safeguard Crop Wild Relatives across the world

At the global scale, Maxted directly **influenced guidelines and policy decisions** by drafting the Food and Agriculture Organisation of the United Nations (FAO) *Voluntary Guidelines for the Conservation and Sustainable Use of Crop Wild Relatives and Wild Food Plants*, published in 2017 [S1, S2]. These guidelines, based on KF1–3, along with an FAO resource book also written by Maxted [S3], support governments in developing National Action Plans for CWR conservation which all countries are now obliged to implement globally. The impact of these policy tools, and their application, is evidenced by their wide-spread adoption across the world, as testified by the Director General of Alliance of Bioversity International and CIAT:

These activities have had significant global, regional and national impact on PGR conservation, both in terms of the adoption of methodology development and policy support. National conservation strategies now exist across much of Europe (Bulgaria, Cyprus, Czech Rep., Finland, Germany, Ireland, Italy, Poland, Portugal, Norway, Spain, Sweden and United Kingdom) and beyond (Jordan, Mauritius, Mexico, North Africa, Oman, Sri Lanka, Turkey,

USA; and regional networks of PGR *in situ* conservation sites are being established in the Southern African Development Countries and Europe. [S4]

Maxted's research and 'stature in the field' [S5] has also **verifiably influenced global commitments to conserve CWR in their countries of origin**. Underpinned by KF1, the Norwegian Government invested US\$50M into a relationship between the Global Crop Diversity Trust and Royal Botanic Gardens, Kew (RBG), to significantly improve the *ex situ* conservation of CWR in genebanks, as well as their utilisation in pre-breeding. The (former) Director of RBG and current Chair of the Executive Board of Global Crop Diversity Trust, testified:

Professor Maxted's work was catalytic and instrumental in providing the scientific basis for a major effort to target the wild relatives of 29 priority crops. That effort involved 53 national and international partners in 32 countries and resulted in diverse CWR (more than 3,500 collections) being conserved in their country of origin, while also being made available internationally. [S5]

Stimulating regional and national policy debate to secure crop biodiversity

In the UK, **policy decisions have been informed by Maxted's research evidence** which now secure the availability and use of UK PGR. KF4 recommended the need for a crop landrace inventory and complementary *in situ* conservation of UK CWR diversity. This advice is now enshrined in the UK Agriculture Act (2020) which outlines:

[new] Secretary of State's powers to give financial assistance [for...] conserving plants grown or used in carrying on an agricultural, horticultural or forestry activity, their wild relatives or genetic resources relating to any such plant. [S6]

This outcome was achieved by Maxted **chairing of the government advisory committee UK PGR Research and Policy Group**, in which he used his research evidence [KF4] to directly stimulate the policy debate and implementation. A senior policy advisor at DEFRA testified:

Professor Maxted's advice and knowledge were, again, key to determining the specific text included within the UK Agriculture Act 2020. A major achievement, this has secured funding that could be used to provide specific support to conserve England's traditional plant varieties, landraces or CWR. [...] Professor Maxted's knowledge and expertise has [also] been instrumental in both securing its [PGR] inclusion in and the creation of, the Genetic Resources section of England's Nature Strategy 2030, currently in draft form, [to be] published in Autumn 2021 [...]. [S7]

Finally, Maxted's UN policy contributions, along with KF1–3, have further **stimulated environmental policy debate** for the conservation of CWR across Europe, where he is chair of the *In Situ* Conservation Working Group of the *European Cooperative Programme for Plant Genetic Resources*. Specifically, Maxted led the task force writing a CWR Policy Concept [R6], which recommended the switch to a more integrated and evidence-based scientific conservation approach. As a result, three EU Directorates-General (ENV, AGRI and SANTE) are establishing a new European Network to conserve agrobiodiversity diversity on-farm and in nature (due to launch in Lisbon, June 2021). This change has the "potential to double the genetic diversity available for crop improvement, underpinning continental food and forestry security in the 21st century" [S8].

5. Sources to corroborate the impact

S1: FAO (2017). [Voluntary Guidelines for the Conservation and Sustainable Use of Crop Wild Relatives and Wild Food Plants](#). Food and Agriculture Organisation of the United Nations, Rome, Italy.

S2: Testimonial from Mr. Chikelu Mbe. Senior Policy Officer, Agricultural Production and Protection Division, Food and Agriculture Organisation of the United Nations, Rome, Italy. [Dated 13 November 2020]

S3: [Resource book for preparation of national conservation plans for crop wild relatives and landraces](#). Commission on Genetic Resources for Food and Agriculture. Food and Agriculture Organisation of the United Nations, Rome, Italy.

S4: Testimonial from Professor Juan Lucas Restrepo. Director General Biodiversity International & CEO-Designate of the Alliance, Consultative Group for International Agricultural Research, Rome, Italy. [Dated 12 November 2020]

S5: Testimonial from Professor Sir Peter Crane. Dean of the School of Forestry & Environmental Studies and Professor of Botany, Yale University, New Haven, CT, USA (former Director of RBG, Kew). [Dated 11 November 2020]

S6: [Agriculture Act 2020](#).

S7: Testimonial from Ms. Rachel Davis. Biodiversity Lead, Department for Environment, Food and Rural Affairs, London, UK. [Dated 18 November 2020]

S8: ECPGR (2017). [ECPGR Concept for on-farm conservation and management of plant genetic resources for food and agriculture](#). European Cooperative Programme for Plant Genetic Resources, Rome, Italy.