ECPGR Activity Grant Scheme – Third Call, 2016

Activity Report

Consequences of climate change for conserving leafy vegetable CWR in Europe

CCLEAFY

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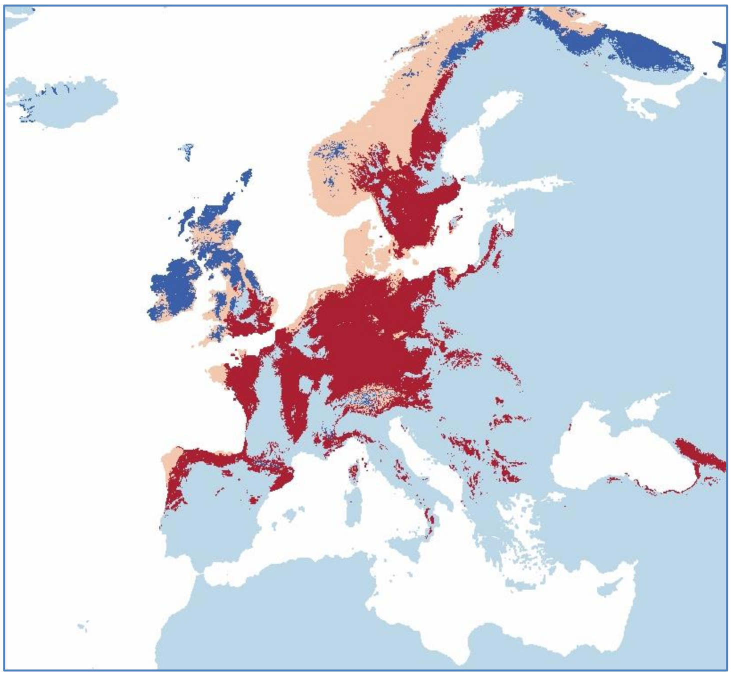

October 2017

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INTRODUCTION

Background

Crop wild relatives (CWR) are an indispensable source of useful traits for crop improvement when these can no longer be found in the cultivated species. Therefore, safeguarding of CWR is widely regarded as a high priority. However, CWR are currently severely underrepresented in *ex situ* genetic resources collections, and their *in situ* survival has become at risk due to various human influences. Especially during the last decades, the survival of CWR in their natural habitats has become a growing concern due to the increasing awareness of climate change and the effects thereof on flora and fauna. Recent predictions by species distribution modelling of eight Dutch IUCN Red Listed CWR revealed large range contractions in Europe as a result of climate change. Two study species were even predicted to go extinct in the Netherlands, notwithstanding their present occurrence in protected areas (Aguirre-Gutiérrez et al. 2017). The study showed that to develop sound conservation measures, the effects of climate change cannot be ignored. Analysis of the expected effects of climate change on the distribution of CWR is fundamental to support *in situ* conservation measures and to decide for which species *ex situ* backing up is essential.

Aims of the Activity[1]

The activity is aimed at studying the expected effects of climate change on the distribution of leafy vegetable CWR that have their main distribution area in Europe, and at recommendations to improve the conservation of leafy vegetable CWR in Europe.

Expected outcomes related to ECPGR objectives

- Inventory of main leafy vegetable CWR occurring in Europe (ECPGR outcome 3, output 3.2, activity 3.2.3: Production of regional (European) CWR inventories).
- Predictions of the future distribution of leafy vegetable CWR in Europe as a result of climate change (ECPGR outcome 3, output 3.2, activity 3.2.4: Diversity and gap analysis of regional (European) priority CWR taxa).
- Recommendations for the conservation of leafy vegetable CWR in Europe (ECPGR outcome 3, output 3.2, activity 3.2.6: Production of regional (European) CWR conservation action plans).

List of partners involved and their respective roles

- Rob van Treuren (Centre for Genetic Resources, the Netherlands) – Coordination, data analysis and reporting.
- Roel Hoekstra (Centre for Genetic Resources, the Netherlands) – Species distribution modelling.
- Ulrike Lohwasser (Leibniz Institute of Plant Genetics and Crop Plant Research) – Inventory crop genepools and species representation in EURISCO.
- Jelka Šuštar-Vozlič (Agricultural Institute of Slovenia) – Inventory distribution areas.
- Filomena Rocha (National Genebank Portugal) – Advisory role.
- Charlotte Allender (University of Warwick) – Advisory role.
- Dionysia Fasoula (Agricultural Research Institute, Cyprus) – Advisory role.

[1] See also the Activity webpage (http://www.ecpgr.cgiar.org/working-groups/leafy-vegetables/ccleafy/)

MATERIALS AND METHODS

Study material

The leafy vegetable crops considered in the present study followed the inventory presented by Lebeda and Boukema (2001). Information on crop genepools and the involved species was collected from the Harlan and de Wet Crop Wild Relative Inventory of the Global Crop Diversity Trust (Vincent et al. 2013), GRIN Taxonomy for Plants (GRINTax, 2016), Van Treuren et al*.* (2012), Rottenberg and Zohary (2005) and Mummenhoff et al. (2001). In case of absent genepool data, GRIN Taxonomy for Plants (GRINTax, 2016) and the Plant List (PlantList, 2016) were used to identify taxon group 1 species (Maxted et al. 2006), representing the crop species and their wild relatives with the same species name.
Data on native distribution areas of the CWR were obtained from the Crop Wild Relatives Global Atlas (CWR atlas, 2013), GRIN Taxonomy for Plants (GRINTax, 2017) and the eMonocot portal (Monocot, 2017). Countries belonging to the native distribution area of a species were displayed by three-letter country code (FAO, 2017) and grouped by continent.
Data on *ex situ* conserved accessions of the CWR were obtained from the EURISCO catalogue (EURISCO, 2017). Analyses were restricted to wild, weedy and landrace accessions (sample status 100-300) and to records with geographic information of the origin location (latitude/longitude data or a geographic description of the collecting site). Origin countries located within the European region were recorded and presented by three-letter country code (FAO, 2017). The considered European region comprised the European countries (including Turkey and the Russian Federation), the African and Asian countries alongside the Mediterranean and countries located in the Caucasus area.
The IUCN red list category (Bilz et al. 2011) and the IUCN red list of threatened species (IUCN, 2017) were used to obtain information about the current threat status of the modelled CWR in Europe.
As sometimes a different taxonomy was followed by the different data sources, data for some CWR were collected under synonymous species names, such as for *Blitum bonus-henricus* (*Chenopodium bonus-henricus*) and *Glebionis coronaria* (*Chrysanthemum coronarium*).

Species distribution modelling

The expected effects of climate change on the future distribution of CWR were investigated by means of species distribution modelling (SDM), which basically followed the methods described by Aguirre-Gutiérrez et al. (2017). Data on seven climatic variables, related to temperature and precipitation, and two soil-related variables were used to predict current and future species distributions in the European region. A combination of the algorithms Generalized Linear Models, MaxEnt and Random Forest was used in the modelling. Predicted distributions for the year 2070 were based on 14 global climate models assuming either an optimistic (Representative Concentration Pathway 2.6) or a pessimistic (RCP 8.5) climate change scenario. The percentage range change of a species was determined for the European region, assuming either unrestricted dispersal or no dispersal. A separate analysis was made for the Natura 2000 network of protected European sites assuming unrestricted dispersal.
The Global Biodiversity Information Facility (GBIF) was used to collect geographic occurrence data of the considered species within the European region. For the majority of species, GBIF data were downloaded in April/May 2017. Twenty-six to 3043 records per species, remaining after data cleaning and processing into about 4x4 km grid cells, were used for the modelling. See Aguirre-Gutiérrez et al. (2017) for more details about the used methodologies.

RESULTS

Leafy vegetable CWR

Three main and 16 minor leafy vegetables were considered in the present study (Table 1). Results of the CWR inventory of the study crops are presented in Appendices 1-12.[2] Species belonging to the primary or secondary crop genepool and taxon group 1 species with their main native distribution area in the European region were selected for SDM analysis. However, insufficient occurrence data in GBIF prevented further analysis in some cases, such as for *Asparagus pseudoscaber*. With the exception of New Zealand spinach, Peruvian ginseng and rhubarb, representing crops with no CWR in the European region, SDM analysis was carried out for CWR from all study crops (Table 1). Table 1 includes the tertiary genepool species *Blitum bonus-henricus* for spinach, but this species was selected based on its taxon group 1 status for Good King Henry.

Table 1. Leafy vegetables crops considered in the present study and their wild relatives examined with species distribution modelling.

Crop	CWR examined with SDM	Crop relationship
Main leafy vegetables		
Lettuce	*Lactuca serriola*	Primary genepool
	Lactuca saligna	Secondary genepool
Spinach	*Blitum bonus-henricus*	(Tertiary genepool)
Endive; Chicory	*Cichorium endivia* ssp. *pumilum*.	Primary genepool
	Cichorium intybus	Secondary genepool
	Cichorium spinosum	Secondary genepool
Minor leafy vegetables		
Annual wall rocket	*Diplotaxis muralis*	Primary genepool
Artichoke	*Cynara cardunculus* ssp. *cardunculus*	Primary genepool
	Cynara cardunculus ssp. *flavescens*	Primary genepool
	Cynara algarbiensis	Secondary genepool
	Cynara baetica	Secondary genepool
	Cynara humilis	Secondary genepool
	Cynara tournefortii	Secondary genepool
Asparagus	*Asparagus officinalis*	Primary genepool
	Asparagus aphyllus	Secondary genepool
	Asparagus maritimus	Secondary genepool
	Asparagus prostratus	Secondary genepool
	Asparagus tenuifolius	Secondary genepool
Corn salad; Lamb's lettuce	*Valerianella locusta*	Taxon group 1
Dandelion; Lion's tooth	*Taraxacum officinale*	Taxon group 1
French spinach; Garden orache	*Atriplex hortensis*	Taxon group 1
Garden cress	*Lepidium spinosum*	Primary genepool
Garland chrysanthemum	*Glebionis coronaria*	Taxon group 1
Good king Henry; Mercury	*Blitum bonus-henricus*	Taxon group 1
New Zealand spinach	-	
Perennial wall rocket	*Diplotaxis tenuifolia*	Primary genepool
	Brassica nigra	Secondary genepool
Peruvian ginseng; Maca	-	
Purslane	*Portulaca oleracea*	Taxon group 1
Rhubarb	-	
Rocket salad	*Eruca vesicaria* ssp. *sativa*	Primary genepool
	Diplotaxis tenuifolia	Secondary genepool
Sorrel dock; Sour dock	*Rumex acetosa* ssp. *acetosa*	Taxon group 1
	Rumex acetosa ssp. *hibernicus*	Taxon group 1

[2] Appendices are provided in a separate file; see full list page 8.

Effects of climate change

For most CWR a reduction in occurrence is predicted in the European region, as well as a northward shift of the distribution range under climate change (Appendices 13-41).[3] Compared to the optimistic climate change scenario RCP 2.6 effects were generally more severe under RCP 8.5. Patterns and magnitudes of change were largely similar between predictions for the European region as a whole and Natura 2000 areas in particular (Fig. 1). Clear positive effects of climate change were only observed for *Asparagus prostratus* and *Cichorium spinosum*, that are expected to increase their distribution range irrespective of the climate change scenario. The ability of CWR to migrate to suitable habitats was found to play a key role in the predictions (Appendix 42). In the absence of migration potential the distribution area in the European region is expected to reduce with 25% on average per CWR under RCP 2.6 and with 51% under RCP 8.5.

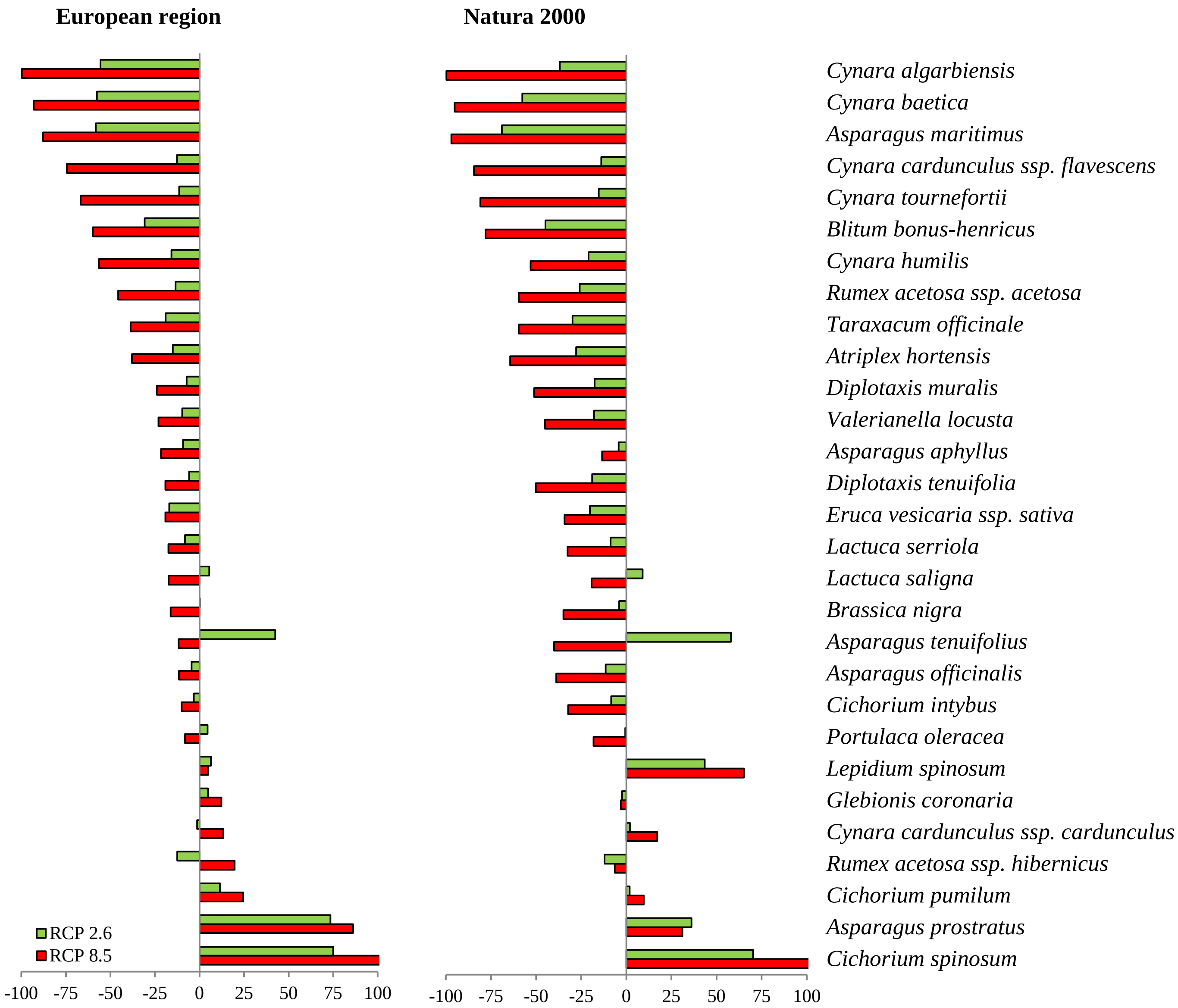

Figure 1. Percentage range change predicted with species distribution modelling for the selected crop wild relatives of leafy vegetables in the entire European region and in the Natura 2000 network of European protected sites for the year 2070 according to climate change scenario RCP 2.6 and RCP 8.5 and assuming unrestricted migration.

[3] Appendices are provided in a separate file; see full list page 8.

Conservation status

A total of 2423 accessions of the examined leafy vegetable CWR were identified in the EURISCO database. However, the number of EURISCO accessions varied widely among the investigated CWR, the majority being represented by less than 20 accessions, while 1017 were observed for *Lactuca serriola* alone (Table 2). Even for species that are represented relatively well, accessibility and conservation quality of the identified accessions can be questioned as only a fraction is part of the Multilateral System (MLS) and even a smaller fraction is included in the European Genebank Integrated System (AEGIS). For many of the examined CWR the sampling of the European region has been rather biased, with many countries represented by none or a few samples (Appendix 43). Active *in situ* conservation is believed to be minimal for leafy vegetable CWR in Europe. None of the studied CWR are currently considered threatened in Europe by the IUCN Red List. Thirteen species are classified as 'least concern', while 12 have not been assessed yet and 3 are data deficient (Table 2).

Table 2. Number of EURISCO entries and IUCN status of the selected crop wild relatives of leafy vegetables. EURISCO data denote the total number, those with MLS status and those with AEGIS status of wild, weedy or landrace accessions originating from the European region.

	EURISCO			
CWR	**Total**	**MLS**	**AEGIS**	**IUCN status**
Cynara algarbiensis	0	0	0	Not yet assessed
Cynara baetica	0	0	0	Not yet assessed
Cichorium pumilum	0	0	0	Least concern
Cichorium spinosum	0	0	0	Data deficient
Rumex acetosa ssp. *hibernicus*	0	0	0	Not yet assessed
Asparagus maritimus	1	0	0	Data deficient
Cynara tournefortii	1	0	0	Not yet assessed
Cynara humilis	2	0	2	Not yet assessed
Lepidium spinosum	2	0	0	Data deficient
Asparagus prostratus	4	4	0	Not yet assessed
Asparagus tenuifolius	4	3	0	Least concern
Chenopodium bonus-henricus	9	0	1	Not yet assessed
Asparagus aphyllus	10	2	0	Least concern
Valerianella locusta	13	0	0	Not yet assessed
Diplotaxis muralis	19	3	2	Least concern
Diplotaxis tenuifolia	19	9	2	Least concern
Glebionis coronaria/ Chrysanthemum coronarium	24	0	0	Not yet assessed
Portulaca oleracea	31	0	1	Not yet assessed
Taraxacum officinale	42	0	0	Least concern
Asparagus officinalis	84	32	1	Least concern
Atriplex hortensis	106	6	2	Not yet assessed
Lactuca saligna	123	24	29	Least concern
Brassica nigra	136	50	0	Least concern
Cynara cardunculus	136	0	3	Least concern
Rumex acetosa	139	1	0	Not yet assessed
Eruca vesicaria/Eruca sativa	220	47	13	Least concern
Cichorium intybus	281	4	69	Least concern
Lactuca serriola	1017	256	252	Least concern
Total	**2423**	**441**	**377**	

CONCLUSIONS AND RECOMMENDATIONS

The European region represents an important distribution area for CWR of leafy vegetables. None of the examined CWR are considered threatened in Europe by the IUCN Red List, superficially indicating low current threat levels. However, as 12 of the included CWR have yet to be assessed and 3 were found to be data deficient, further assessment is required using the climate change information provided here. Climate change is expected to reduce the future distribution of the majority of the examined CWR in the European region, 'pushing' species towards more northern locations. The severity of these effects will depend on the development of the level of greenhouse gas emissions in the forthcoming decades and on the ability of species to disperse to climatically suitable locations. In terms of conservation status, leafy vegetable CWR are poorly conserved *ex situ* and not actively conserved *in situ*. Based on EURISCO records, *Lactuca serriola* seems to be the only leafy vegetable CWR that is relatively well conserved *ex situ* in Europe. For the other CWR examined it is recommended to increase the number of accessions with MLS and AEGIS status to ensure both accessibility and proper conservation of existing samples. This will necessarily involve more representative *ex situ* collections throughout the species range. A high priority for *ex situ* conservation should be given to CWR that have their distribution in the southern part of the European region and that are not expected to migrate in northward directions, such as nearly all artichoke CWR and *Asparagus maritimus* that also are severely underrepresented in European genebanks. While there is believed to be minimal active *in situ* conservation of leafy vegetables in Europe, many populations will be present in existing protected areas, including the Natura 2000 network, but here *in situ* conservation will be passive and so not meet the accepted *in situ* standard for population management (Iriondo et al*.* 2012). Considering that climate change is expected to shift the distribution range of many species northwards, the expected effects of *in situ* conservation on the survival of species in southern regions need to be examined on a case by case basis. *In situ* sites where leafy vegetable populations, ideally containing multiple target taxa, are currently thriving and where climate change is likely to have least impact should be identified and *in situ* management and monitoring commence. Climate change will increase the importance of north-western Europe as *in situ* conservation area because of its refuge function for migrating species.

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LIST OF APPENDICES

The appendices listed below are provided in a separate file, available from the Activity webpage (http://www.ecpgr.cgiar.org/working-groups/leafy-vegetables/ccleafy/).

Appendix 1. Overview of the lettuce genepool and the native distribution area of the crop wild relatives

Appendix 2. Overview of the spinach genepool and the native distribution area of the crop wild relatives

Appendix 3. Overview of the endive/chicory genepool and the native distribution area of the crop wild relatives

Appendix 4. Overview of the annual wall rocket genepool and the native distribution area of the crop wild relatives

Appendix 5. Overview of the artichoke genepool and the native distribution area of the crop wild relatives

Appendix 6. Overview of the asparagus genepool and the native distribution area of the crop wild relatives

Appendix 7. Overview of the garden cress genepool and the native distribution area of the crop wild relatives

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Appendix 9. Overview of the Peruvian ginseng/maca genepool and the native distribution area of the crop wild relatives

Appendix 10. Overview of the rhubarb genepool and the native distribution area of the crop wild relatives

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Appendix 42. Percentage range change predicted with species distribution modelling for the selected crop wild relatives of leafy vegetables in the European region for the year 2070 according to climate change scenario RCP 2.6 and RCP 8.5. Results for the European region assuming unrestricted migration are compared to those of a model with no migration and to those for the Natura 2000 network of European protected sites

Appendix 43. Number of accessions (wild, weedy or landrace) of the selected crop wild relatives of leafy vegetables, originating from countries within the European region and included in the EURISCO database