What makes a weed a weed ? Towards a functional characterization

Bérenger Bourgeois, Pierre Denelle, François Munoz, Guillaume Fried, Sabrina Gaba, Jonathan Storkey, Cyrille Violle

Functional Ecology and Environment

Toulouse – July 11-12, 2017

What makes a weed a weed ? Towards a functional characterization

Bourgeois Bérenger[1,2], Denelle Pierre[3], Munoz François[4], Fried Guillaume[5], Gaba Sabrina[1], Storkey Jonathan[6] and Violle Cyrille[3]

[1] INRA Dijon, UMR Agroécologie, Dijon

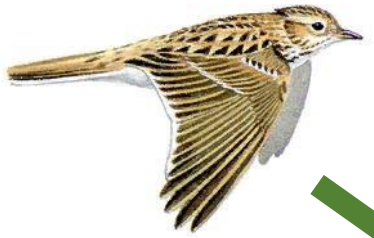
[2] CESAB, Aix-en-Provence

[3] CNRS – CEFE, Montpellier

[4] Université de Montpellier, UMR AMAP

[5] ANSES, Montferrier-sur-Lez

[6] Rothamsted Research, Harpenden, UK



What's a weed ?

A plant that spontaneously grow on a land modified by humans (Godinho, 1984)

Lack of clear, precise and objective definition

TABLE 1. DEFINITIONS OF WEEDS

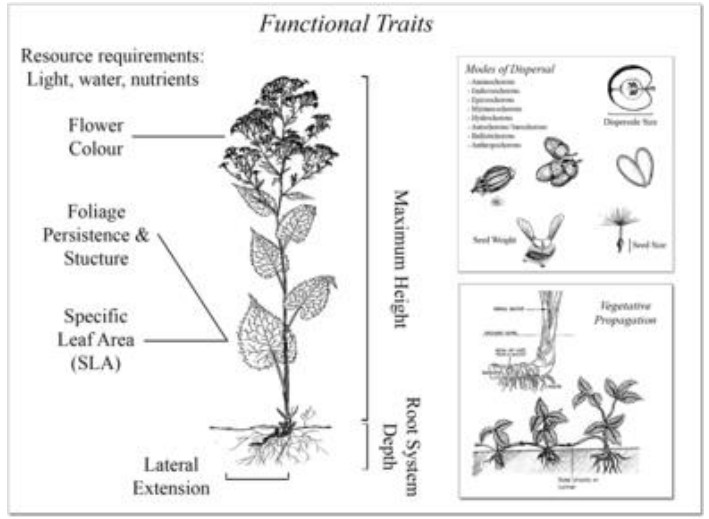
A. By Professional Weed Men		
Blatchley	1912	"a plant out of place, or growing where it is not wanted."
Georgia	1916	"a plant that is growing where it is desired that something else shall grow."
Robbins et al.	1942	"these obnoxious plants are known as weeds."
Fogg	1945	"any plant which grows where it is not wanted."
Muenscher	1946	"those plants with harmful or objectionable habits or characteristics which grow where they are not wanted, usually in places where it is desired that something else should grow."
Harper	1960	"higher plants which are a nuisance."
Isely	1960	"any plant where it is not wanted, particularly where man is attempting to grow something else."
Salisbury	1961	"a plant growing where we do not want it."
Klingman	1961	"a plant growing where it is not desired; or a plant out of place."
Wodehouse	1963	"an unwanted plant."
B. By Enthusiastic Amateurs		
Emerson (in Blatchley)	1912	"a plant whose virtues have not yet been discovered."
Cocannouer	1950	"—This thing of considerin all weeds as bad is nonsensical!"
King	1951	"weeds have always been condemned without a fair trial."
C. By the Ecologically Minded		
Bunting	1960	"weeds are pioneers of secondary succession, of which the weedy arable field is a special case."
Anderson	1953	"artifacts," "camp followers."
Blatchley	1912	"a plant which contests with man for the possession of the soil."
Dayton	1950	"introduced plant species which take possession of cultivated or fallow fields and pastures."
Pritchard	1960	"opportunistic species that follow human disturbance of the habitat."
Isely	1960	"the prime characteristic possessed by all important weeds is their ability to thrive in land subject to the plow."
Salisbury	1961	"the cosmopolitan character of many weeds is perhaps a tribute both to the ubiquity of man's modification of environmental conditions and his efficiency as an agent of dispersal."
Rademacher (in Kurth 1960)	1948	"Biologish gesehen sind die Unkräuter Pflanzen, die gesellschaftsbilden mit den Nutzflanzen zusammen auftreten, deren Kultur für sie erträglich, förderlich oder sogar lebensnotwedig ist. "Wirtschaftlich gesehen die Unkräuter Pflanzen die unerwünschterweise auf dem Kulturlande wachsen und dort mehr Schaden als Nutzen verursachen."

Zohary (1962), Braun-Blanquet (1932), Tansley (1949), Weaver (1954), Clements (1928), Hanson and Churchill (1961), Ashby (1961), Godwin (1960), Haudricourt et Hédin (1943) to cite only a few mention "weeds" in ecological contexts without either defining a weed precisely or mentioning their unwantedness. Clearly, to them, weeds are species with certain ecological characteristics.

From Harlan & deWet, 1965 – *Economic Botany*

Aim

Identify the functional specificities of weeds using a comparative approach



Two species lists

Cropland species

= Biovigilance-Flore + LTER ZAPVS

~ 4400 arable fields sampled over 10 years

Grassland species

> 51,000 plots in permanent grasslands over France

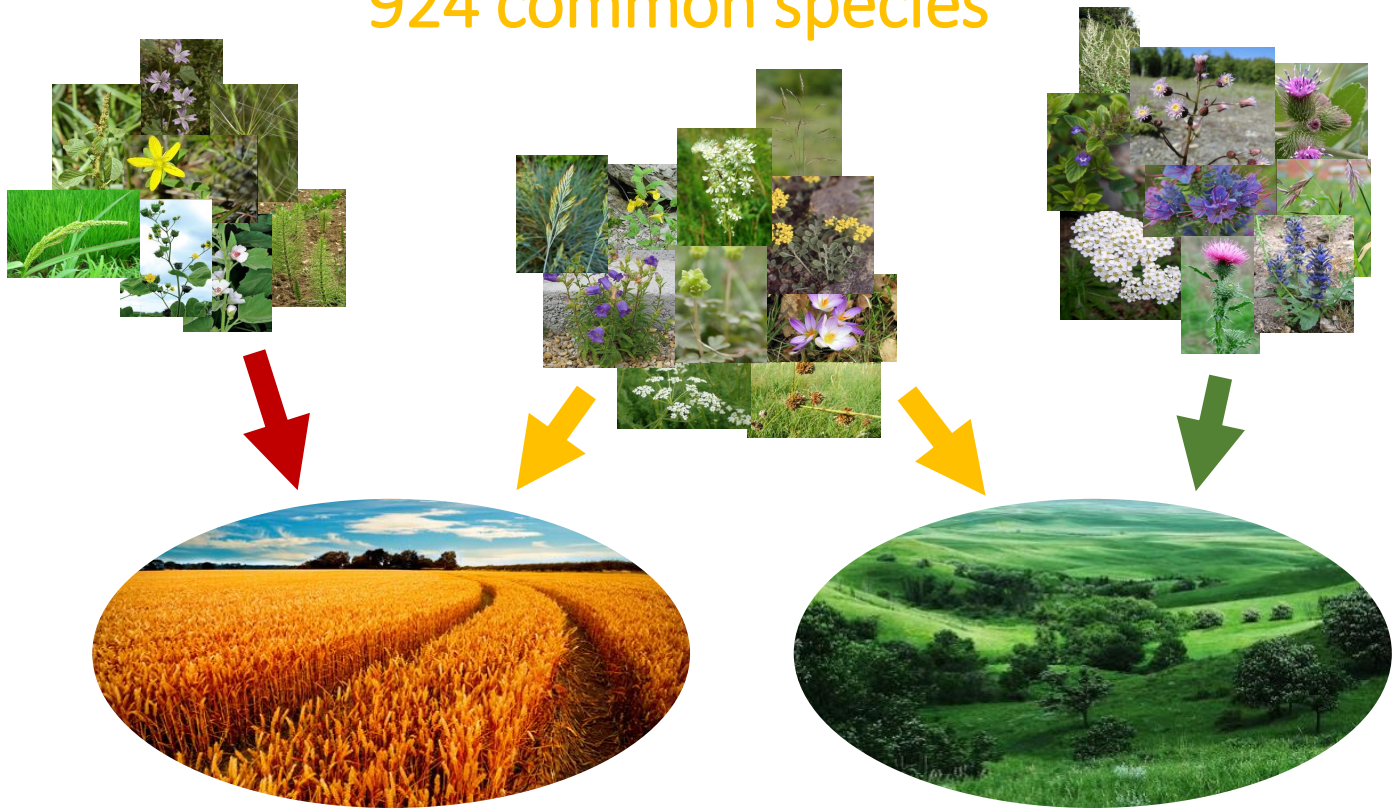
Nine plant traits

LHS = Height, Seed Mass, Specific Leaf Area
Reproduction = Flowering onset, Flowering duration
Autoecology = Ellenberg Nitrogen, Light and Moisture
Raunkier biological types

397 cropland species

924 common species

1374 grassland species



Functional comparisons of species pools

Trait-by-trait: permutational approach or χ^2 tests

Set of traits: hypervolumes – LHS, reproduction, autoecology

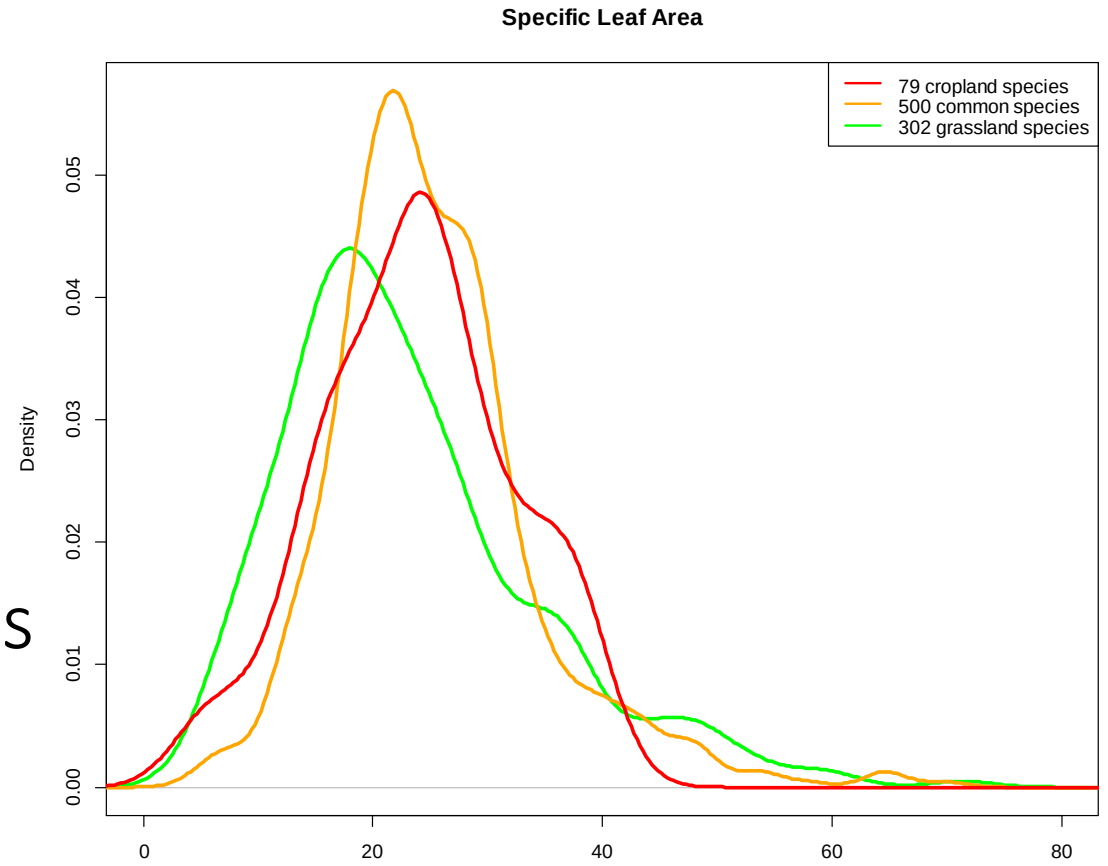
Resource acquisition

Specific Leaf Area

Weeds:

- have higher SLA

than grassland species



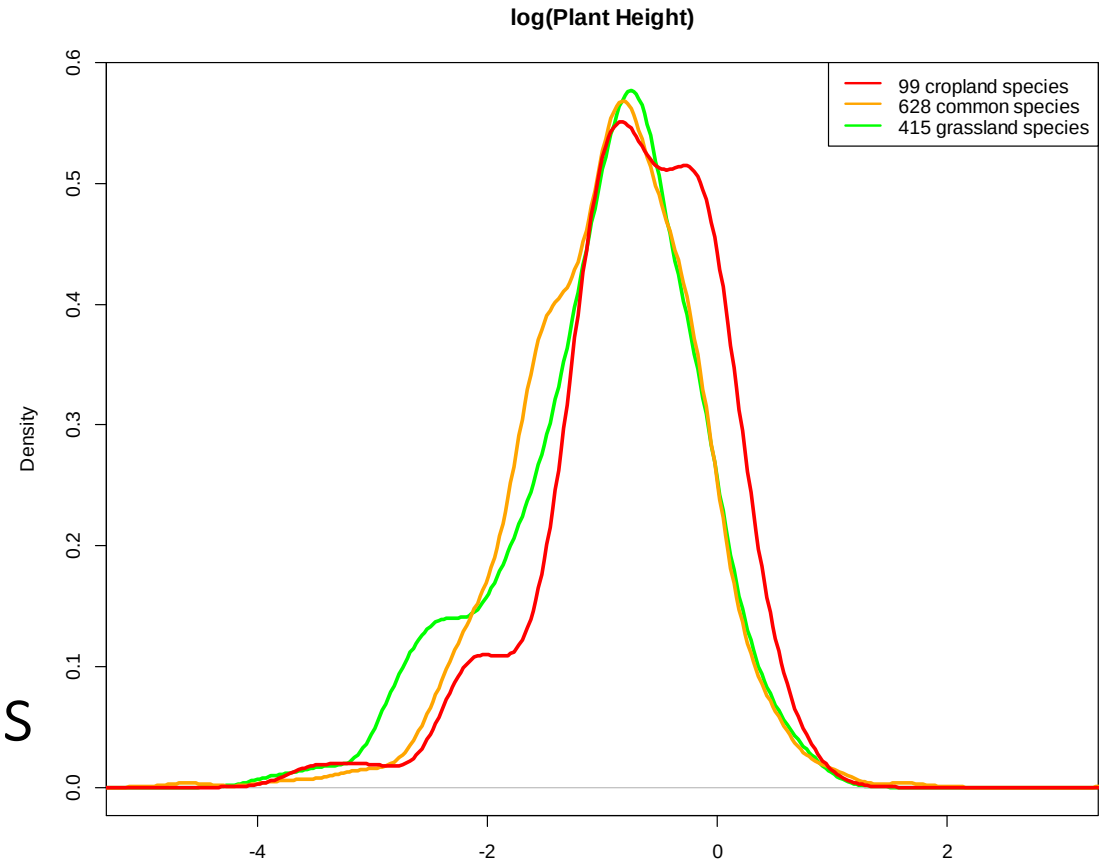
OVERLAP	SLA
Cropland vs. Grassland species	**80 %**
Cropland vs. Common species	86 %
Grassland vs. Common species	**77 %**

Competitive ability
Plant height

Weeds:

- have higher SLA
- are taller

than grassland species



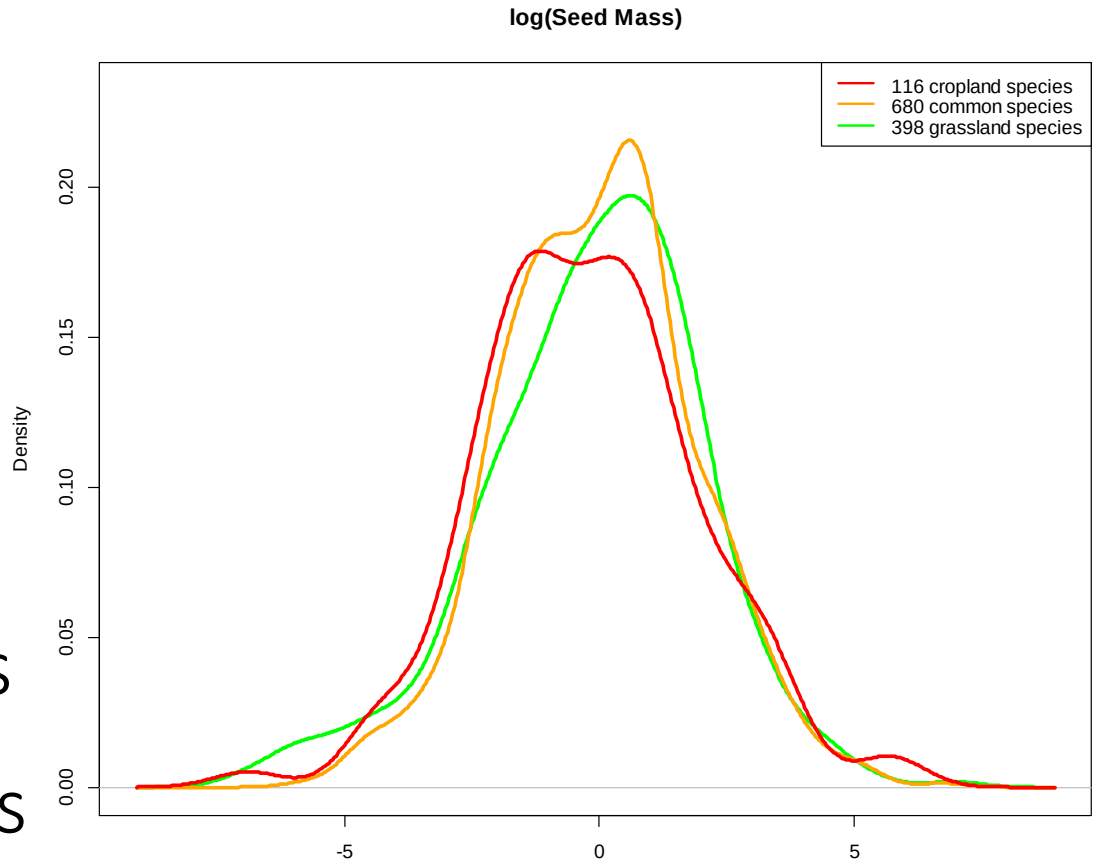
OVERLAP	SLA	log(Plant Height)
Cropland vs. Grassland species	**80 %**	**86%**
Cropland vs. Common species	86 %	**85%**
Grassland vs. Common species	**77 %**	93%

Dispersal
Seed mass

Weeds:

- have higher SLA
- are taller
- have similar seed mass

than grassland species



OVERLAP	SLA	log(Plant Height)	log(Seed Mass)
Cropland vs. Grassland species	**80 %**	**86%**	90 %
Cropland vs. Common species	86 %	**85%**	92 %
Grassland vs. Common species	**77 %**	93%	93 %

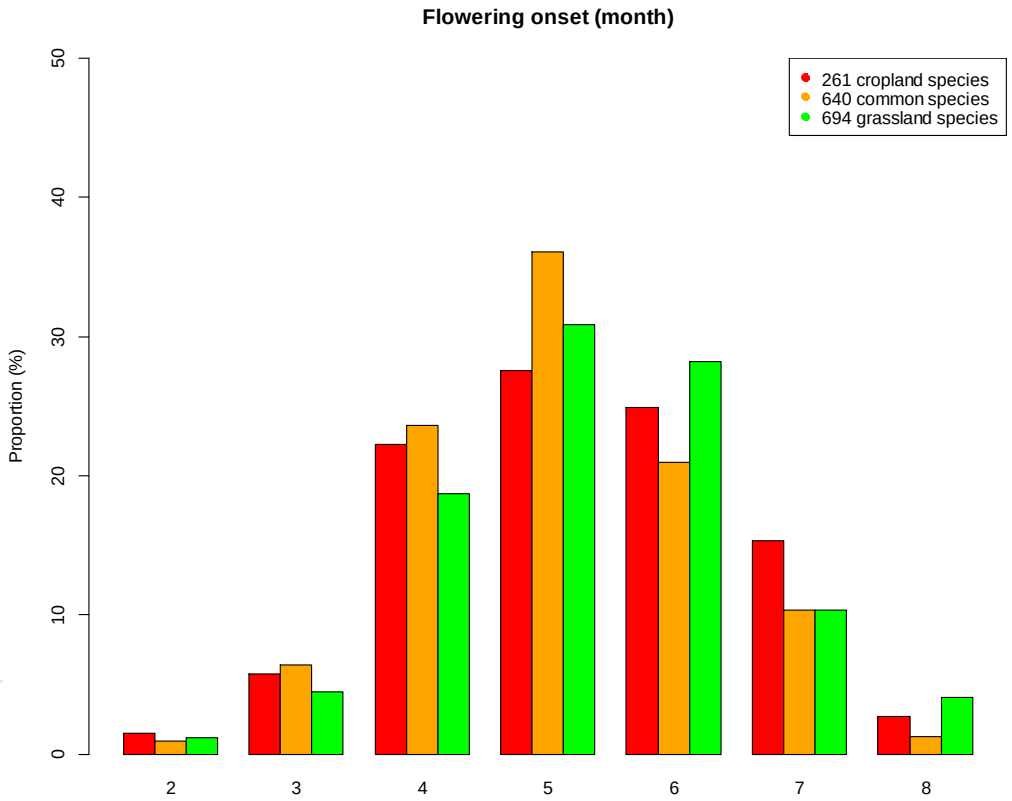
Reproductive strategy
Flowering onset

Weeds:

- start flowering

during the same month than grassland species

χ^2 test	Flowering onset
Cropland vs. Grassland species	0.2225
Cropland vs. Common species	0.0537
Grassland vs. Common species	**0.0003**



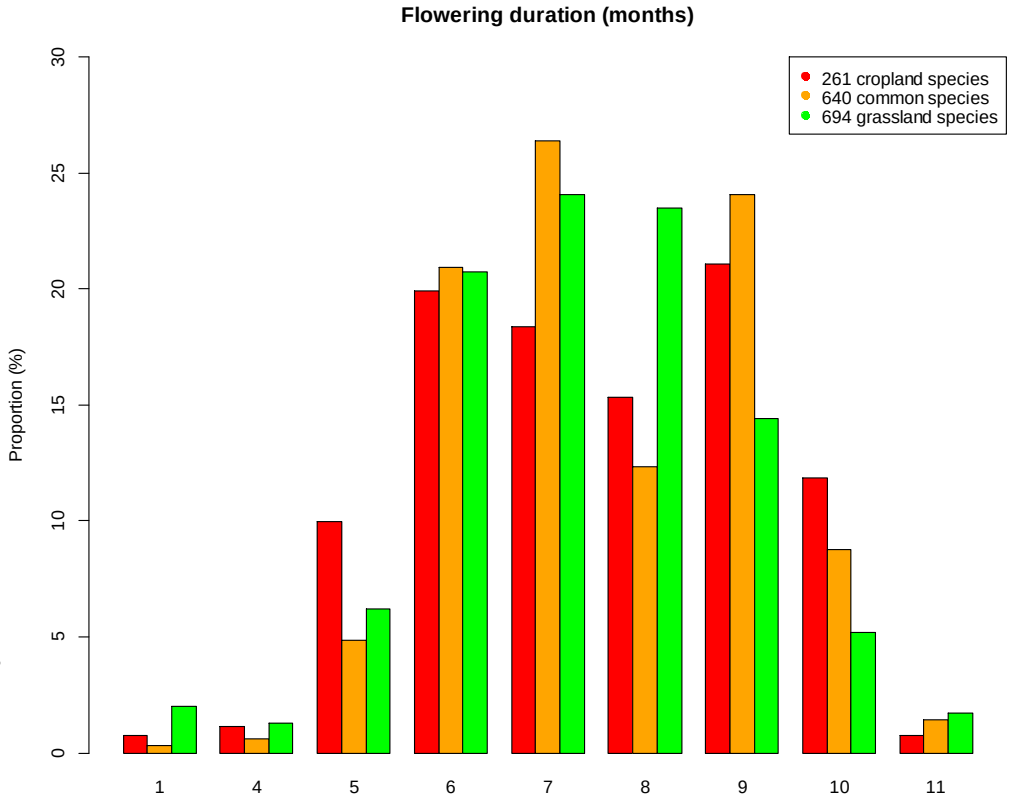
Reproductive strategy
Flowering duration

Weeds:

- flower longer

than grassland species

χ^2 test	Flowering duration
Cropland vs. Grassland species	**< 0.0001**
Cropland vs. Common species	**0.0164**
Grassland vs. Common species	**< 0.0001**



Resource requirements

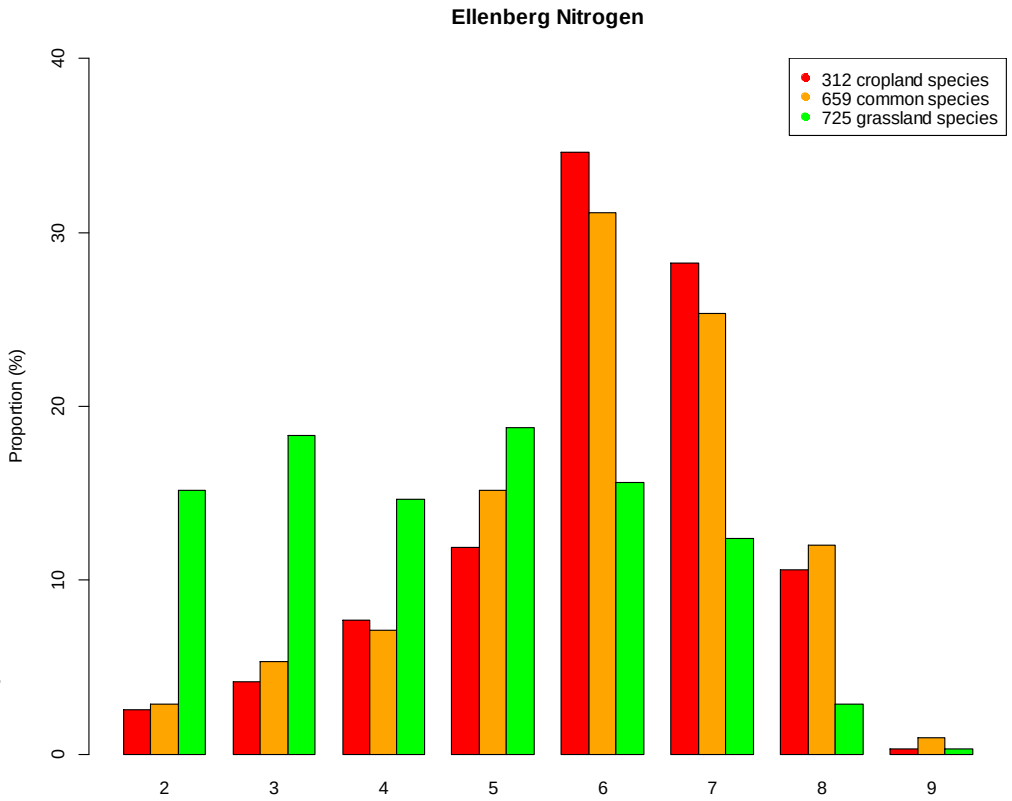
Ellenberg nitrogen

Weeds:

- occur in environment richer in Nitrogen

than grassland species

χ^2 test	Ellenberg N
Cropland vs. Grassland species	**< 0.0001**
Cropland vs. Common species	0.6315
Grassland vs. Common species	**< 0.0001**



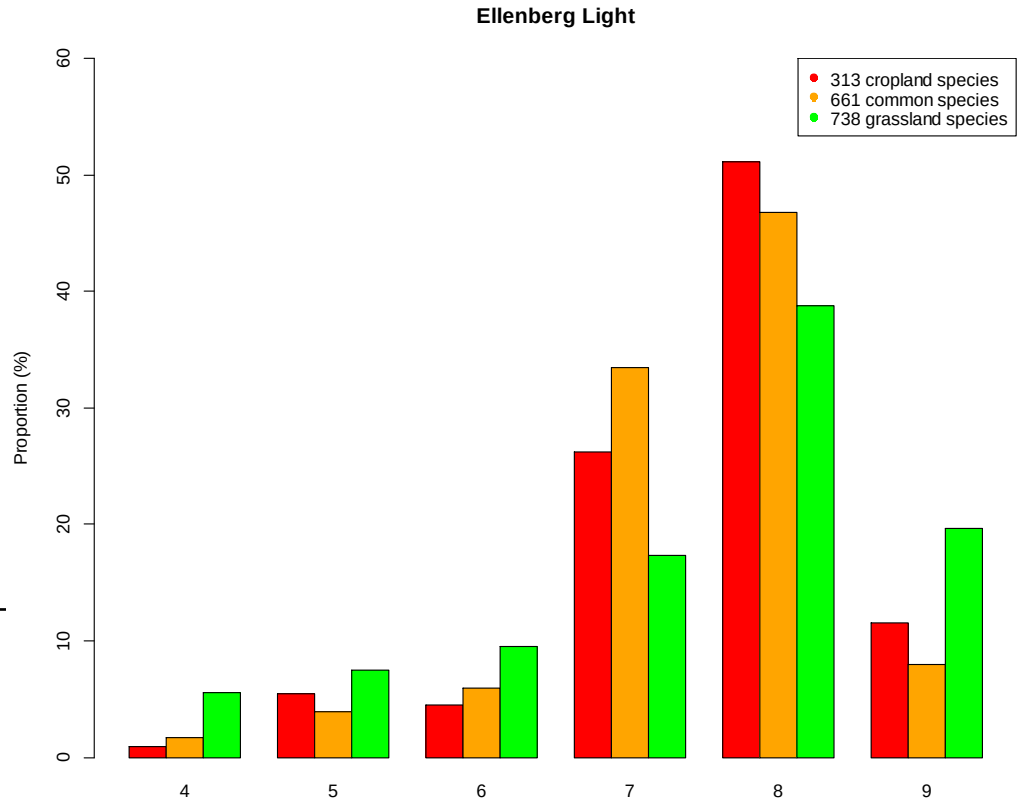
Resource requirements
Ellenberg light

Weeds:

- occur in more shaded areas

than grassland species

χ^2 test	Ellenberg L
Cropland vs. Grassland species	**< 0.0001**
Cropland vs. Common species	0.0796
Grassland vs. Common species	**< 0.0001**



Resource requirements

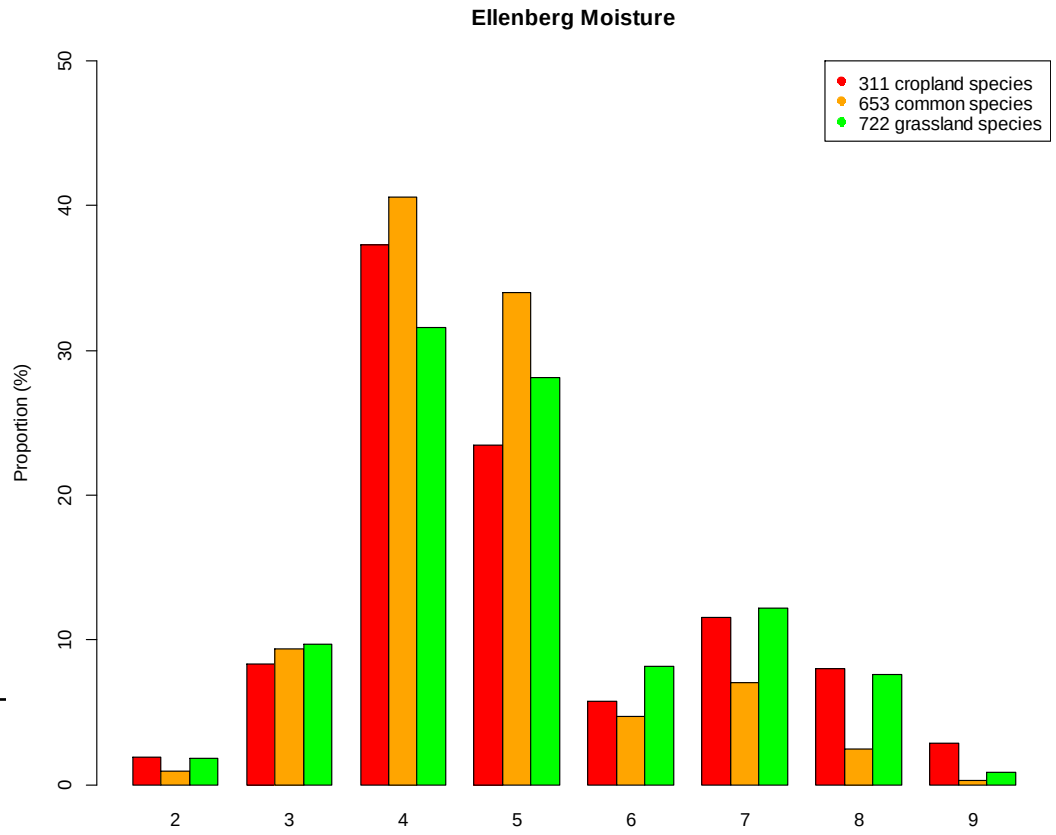
Ellenberg moisture

Weeds:

- have similar soil moisture requirements

than grassland species

χ^2 test	Ellenberg F
Cropland vs. Grassland species	0.0854
Cropland vs. Common species	**< 0.0001**
Grassland vs. Common species	**< 0.0001**



Response to disturbances

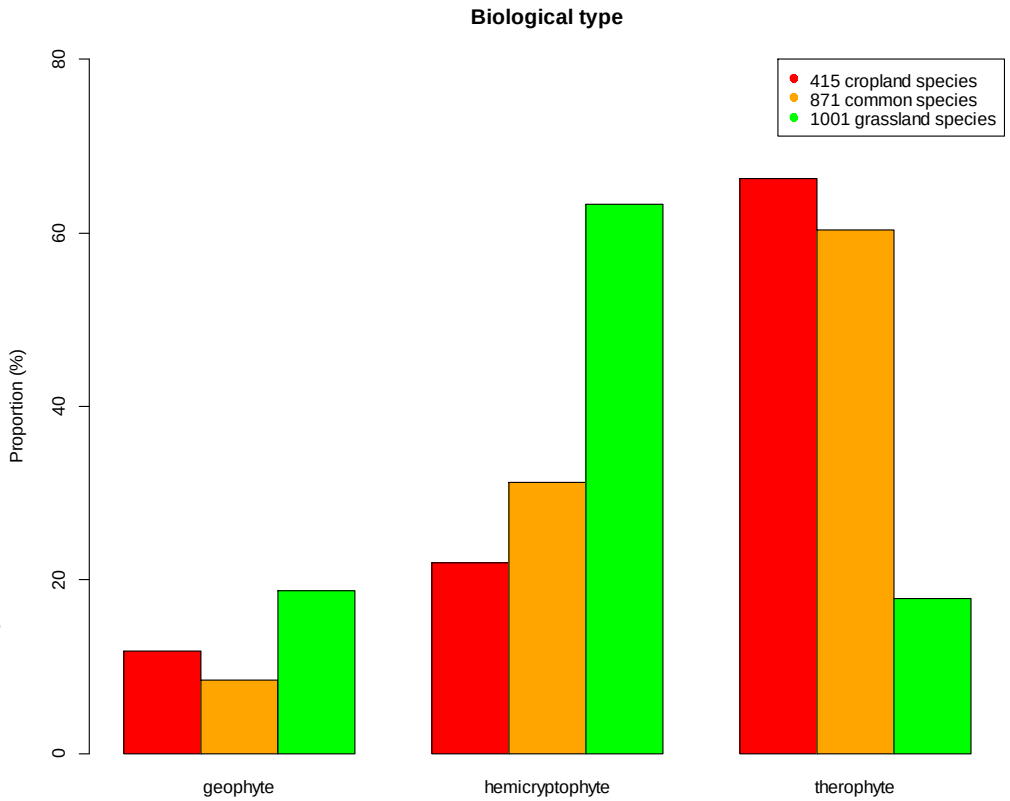
Biological types

Weeds:

- are mainly therophytes

while grassland species are mainly hemicryptophytes

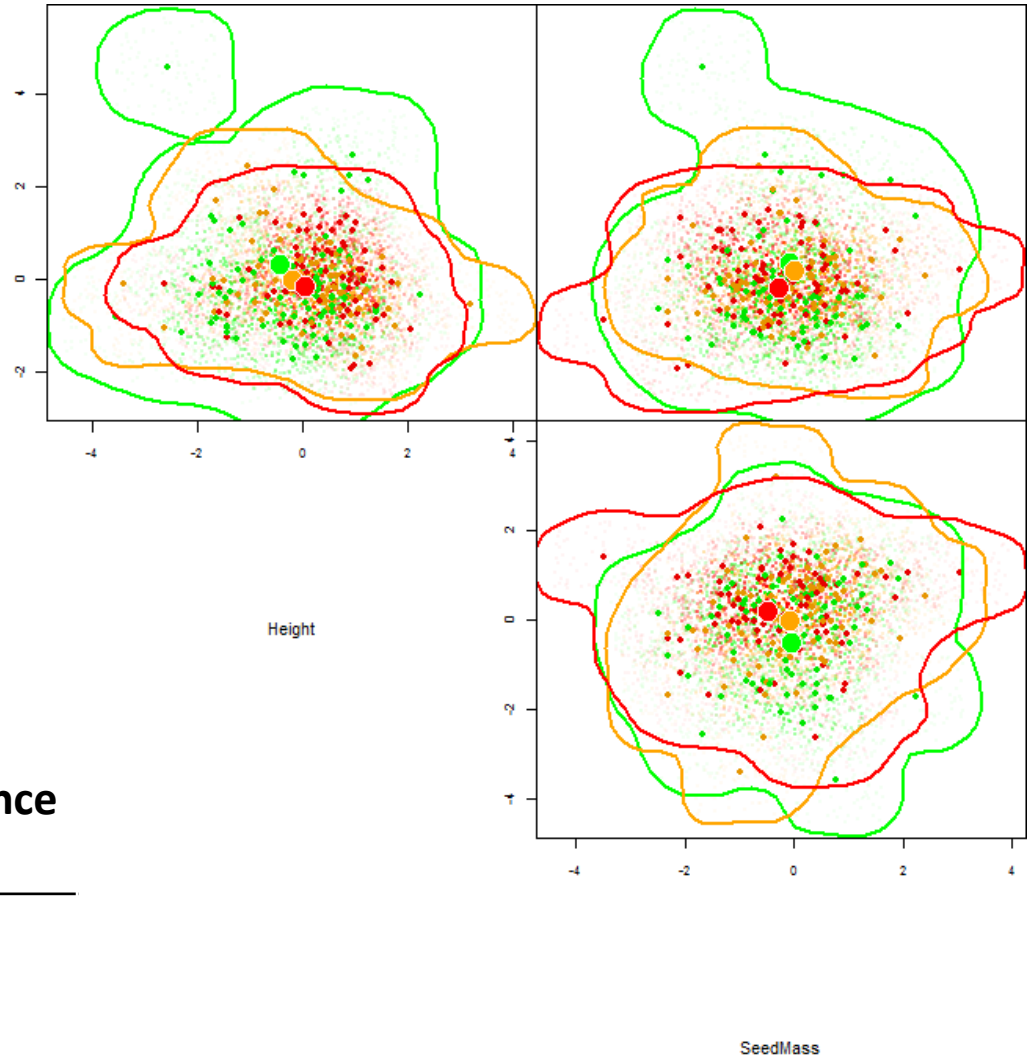
χ^2 test	Biological type
Cropland vs. Grassland species	**< 0.0001**
Cropland vs. Common species	**0.0011**
Grassland vs. Common species	**< 0.0001**



LHS hypervolume

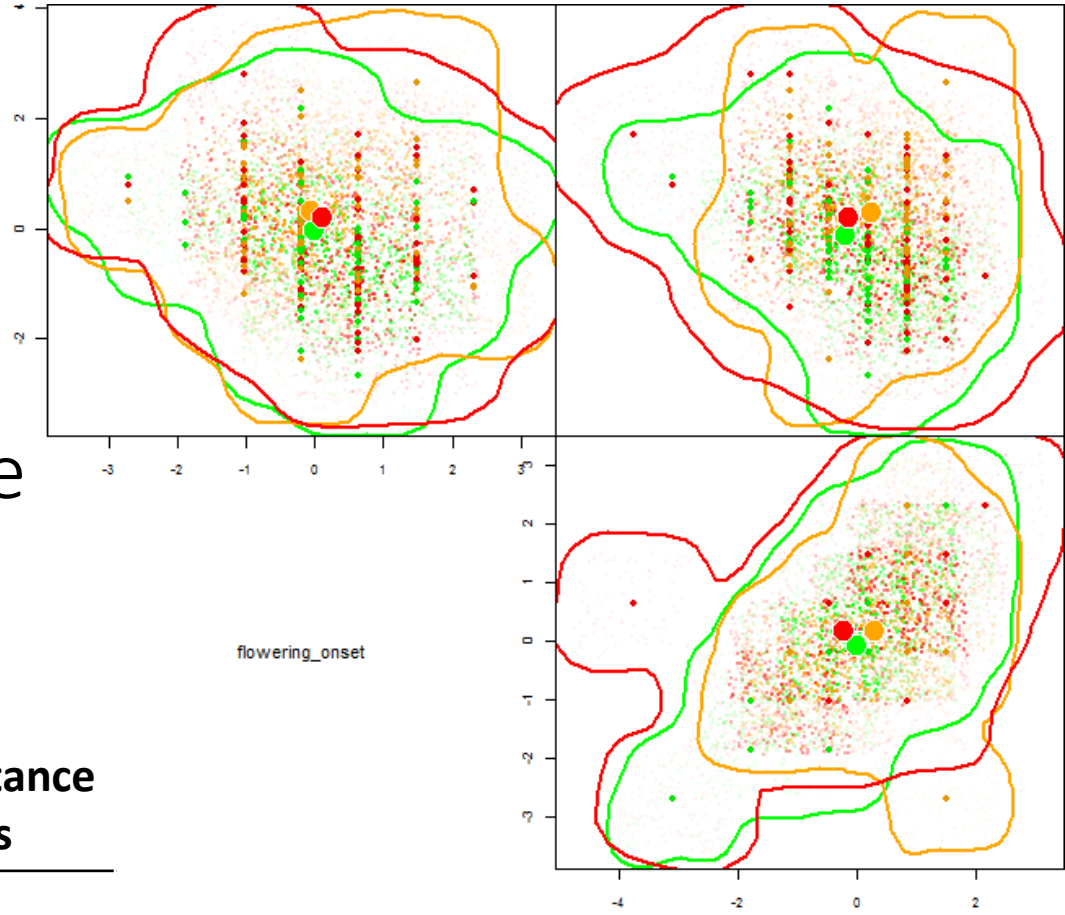
Weeds:

- have a narrower LHS niche than grassland species



	Volume	Overlap with weeds	Centroid distance to weeds
Weeds	93		
Common	90	68%	0.65
Grassland	142	72%	0.57

Reproductive hypervolume

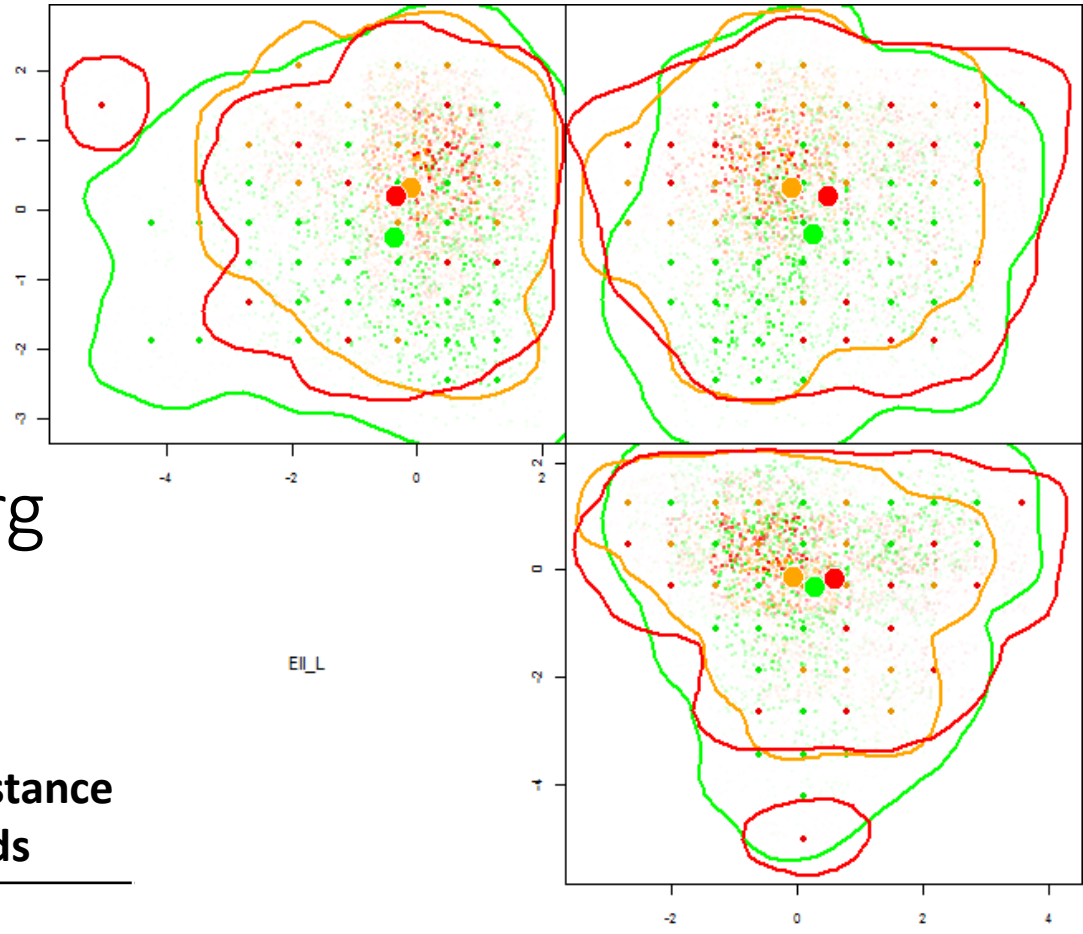


Weeds:

- have a larger reproductive niche than grassland species

	Volume	Overlap with weeds	Centroid distance to weeds
Weeds	115		
Common	92	71%	0.60
Grassland	95	73%	0.41

Autoecological hypervolume



Weeds:

- have a narrower ellenberg niche than grassland species

	Volume	Overlap with weeds	Centroid distance to weeds
Weeds	83		
Common	60	73%	0.53
Grassland	112	73%	0.48

Weeds

Longer flowering duration

Therophytes

Lower Ell-L

Higher height

Higher SLA

Higher Ell-N

…compared to grassland species

…but still strongly overlap with grassland species in terms of physiological, reproductive and autoecological niches

Synthesis

Longer flowering duration

Therophytes

Lower Ell-L

Higher height

Higher SLA

Higher Ell-N

Weeds do not differ that much from grassland species,
but in fact seem better adapted to agricultural disturbances,
like regular tillage, fertilization or competition with crops.

Some species with similar traits are habitat specialists…why ?

Thank you for your attention !