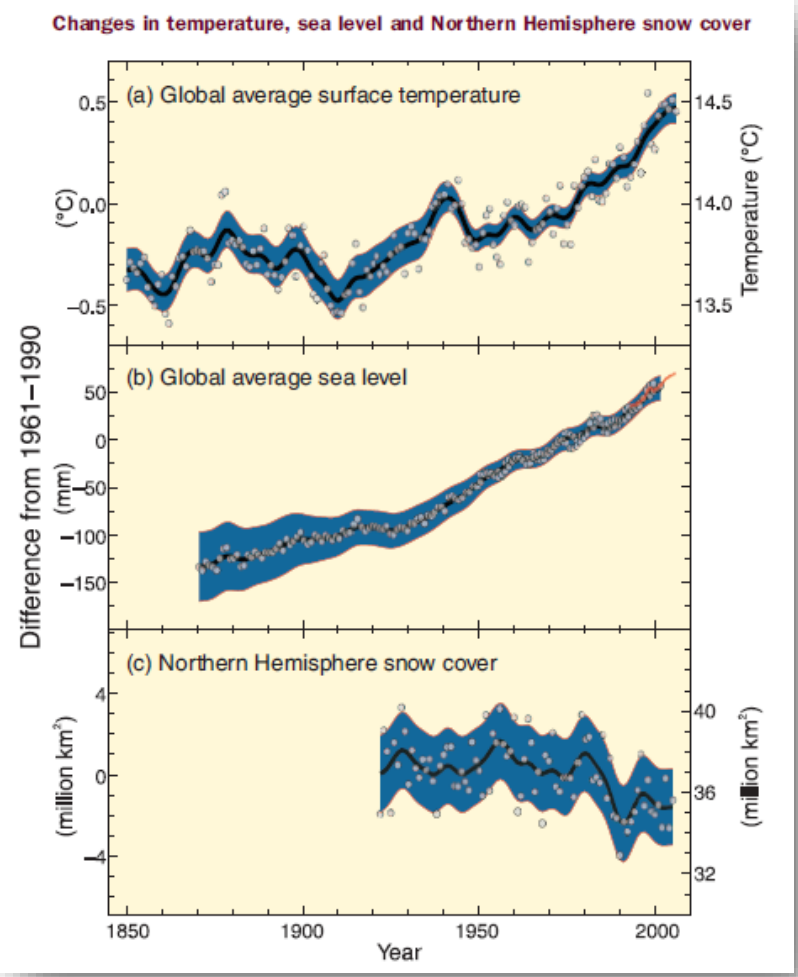
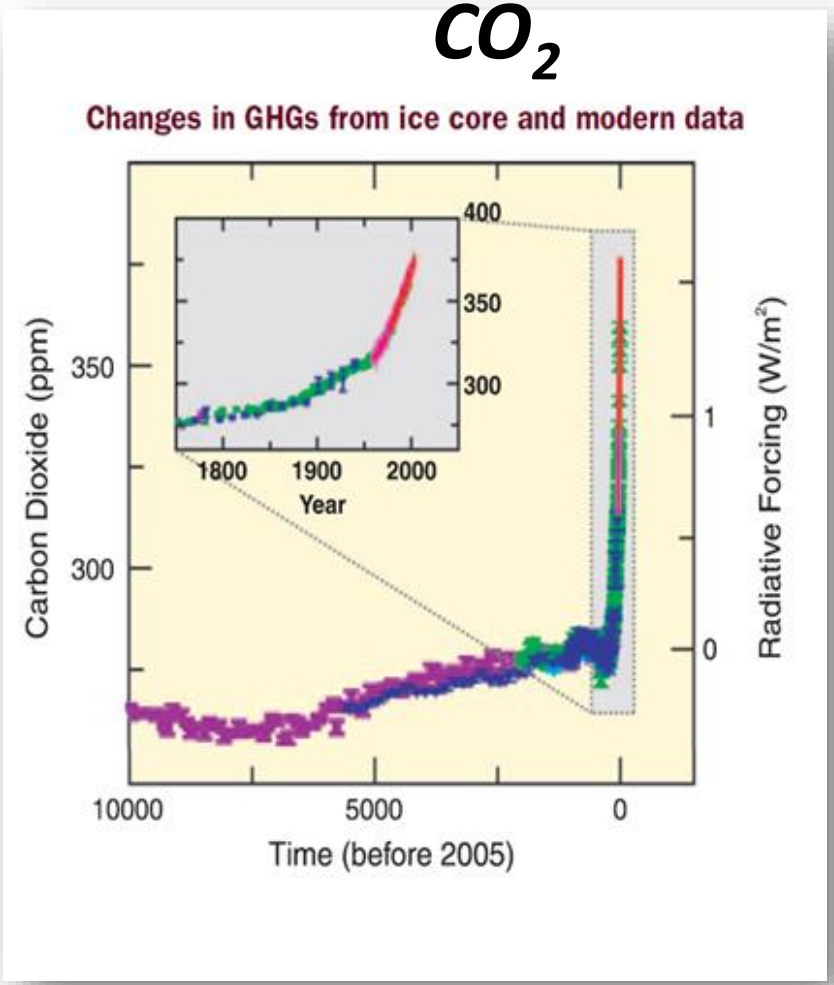
Climate change and pollen

Łukasz Grewling
Laboratory of Aeropalynology

Lecture 3

Mean global air temeprature increased by 0.7°C during last 100 years





Intergovernmental Panel on Climate Change (IPCC) Climate Change 2007: Impacts, Adaptation and Vulnerability.

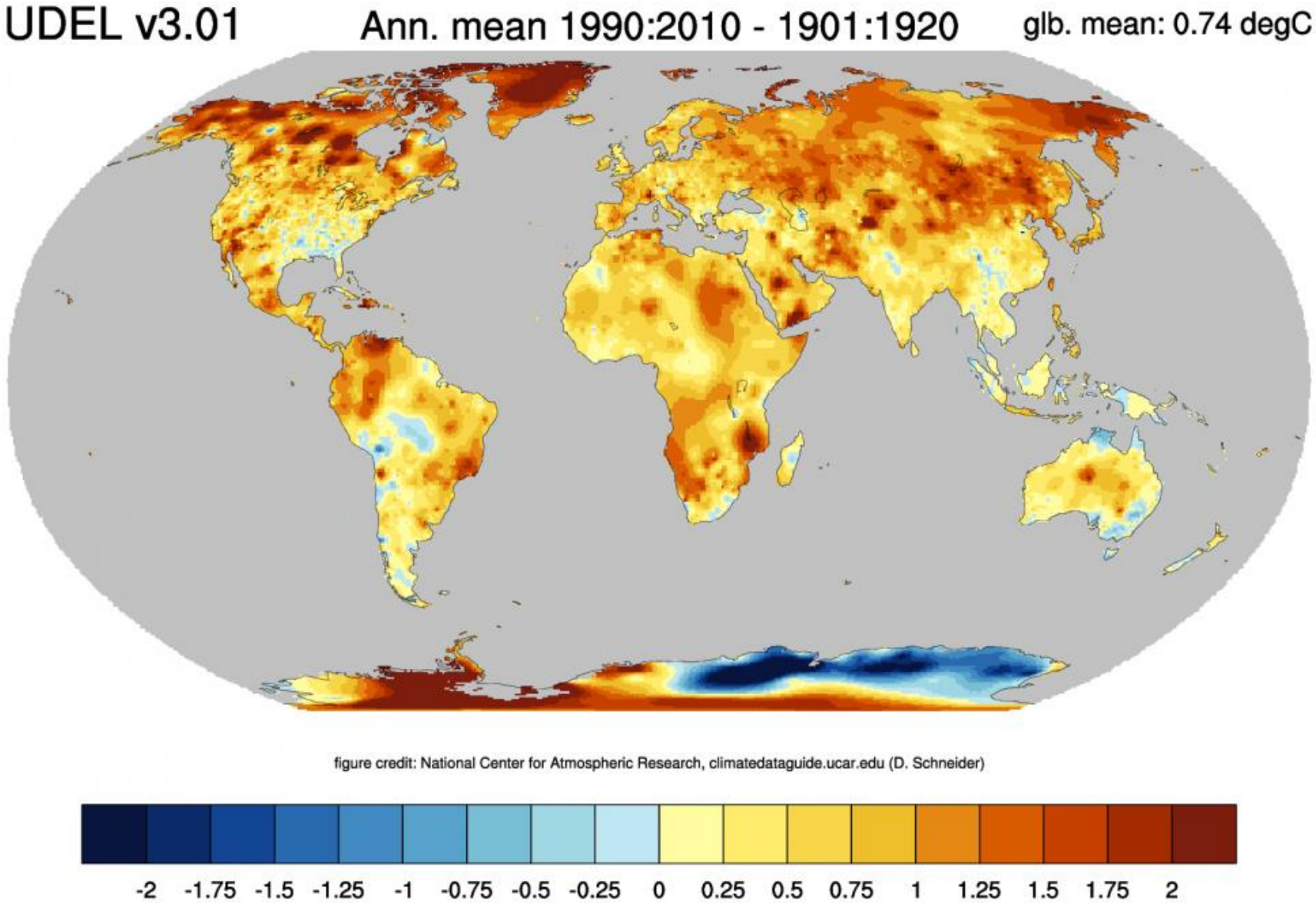
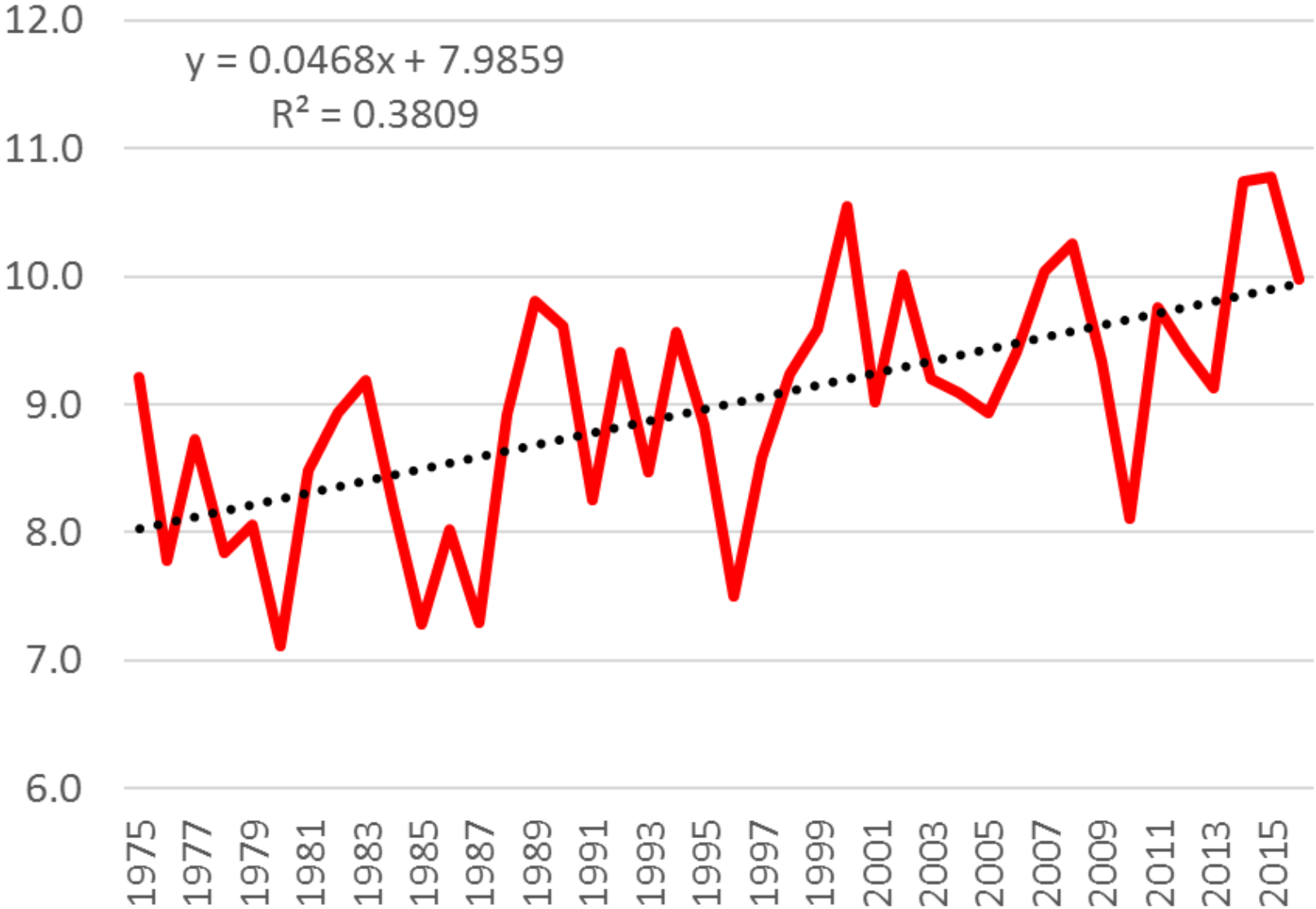
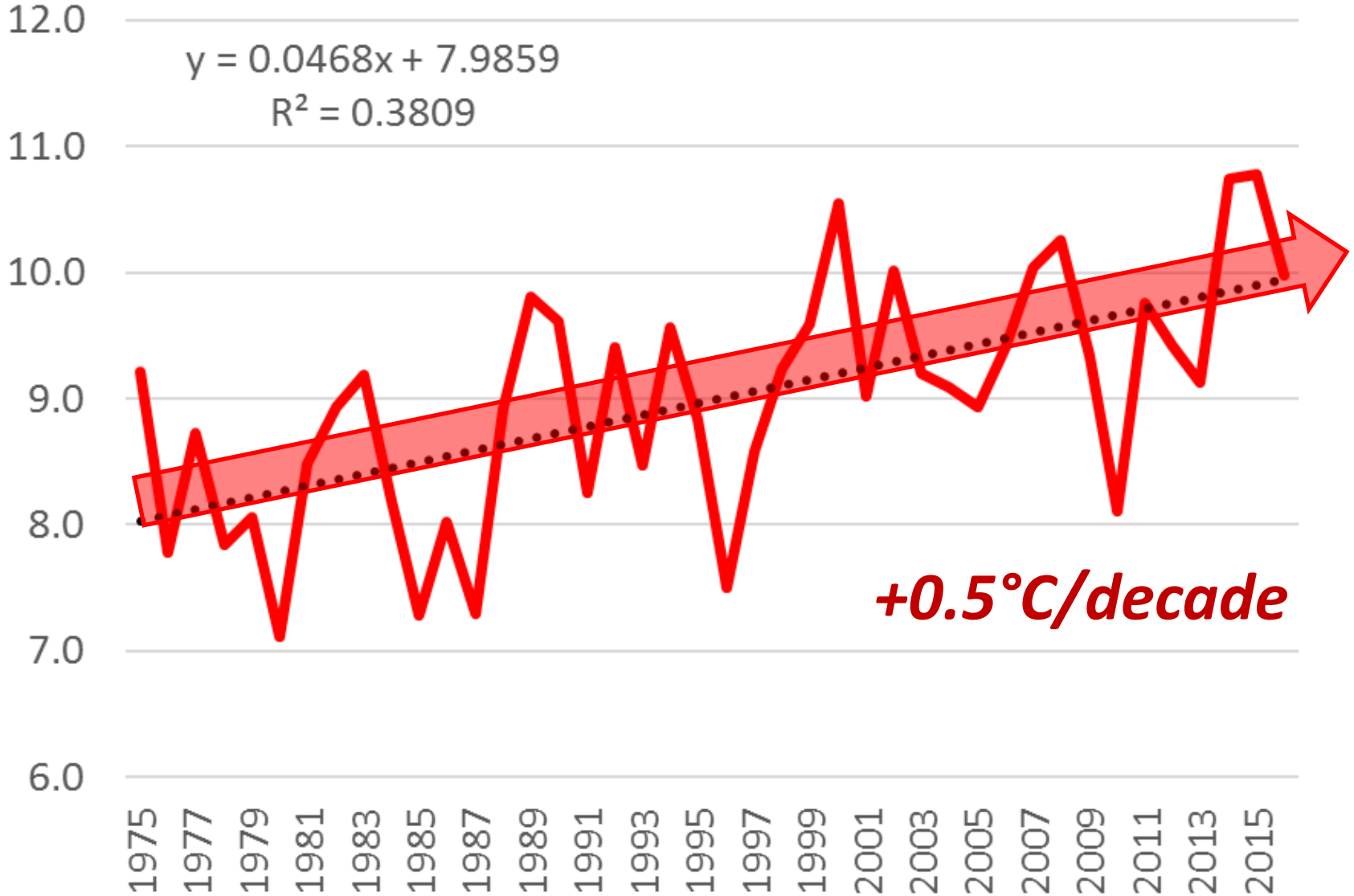


figure credit: National Center for Atmospheric Research, climatedataguide.ucar.edu (D. Schneider)

Annual mean temerature in Poznań increased by around 2.0°C



Annual mean temerature in Poznań increased by around 2.0°C



Start/End

Duration

Intensity

Climate change is a health threat

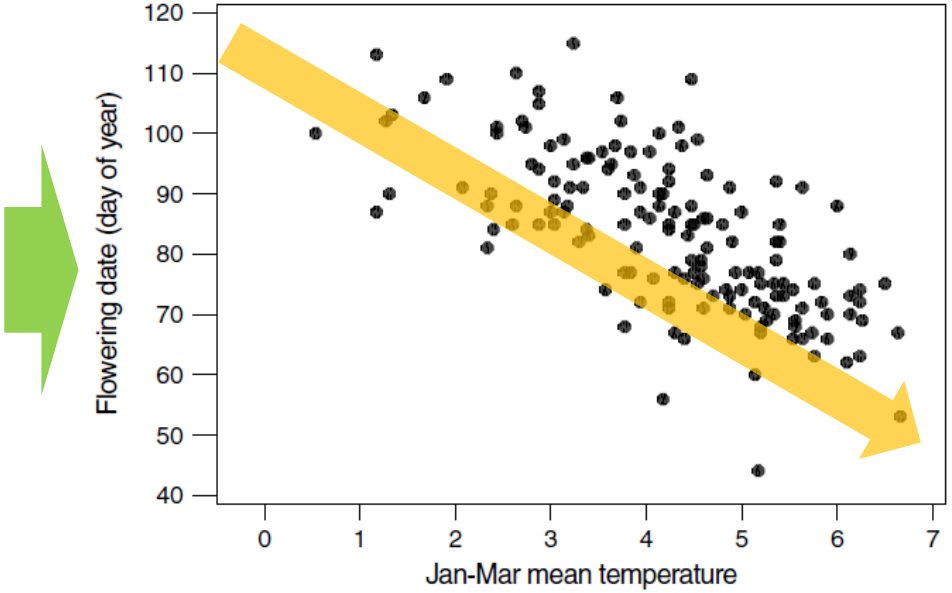
Rising temperatures lead to longer allergy seasons and can make air pollution worse. This can increase the risk and severity of asthma attacks and cause more allergies.

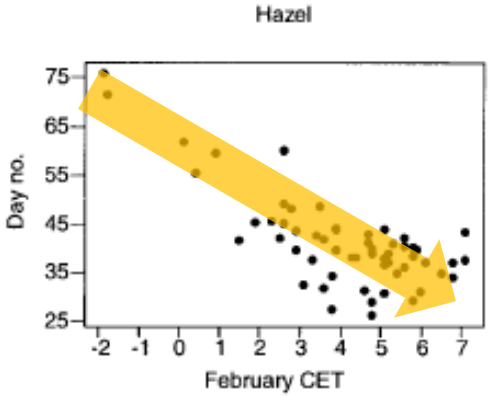
Asthma and Allergy Foundation of America

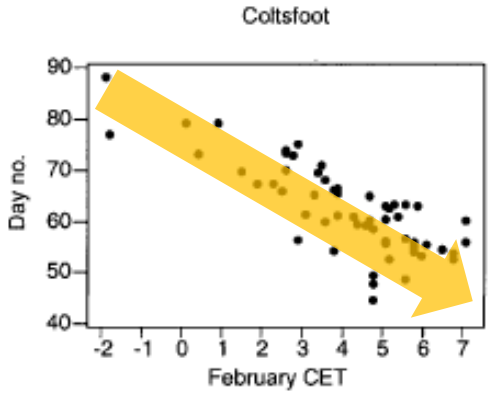
Visit AAFA.org to learn more.

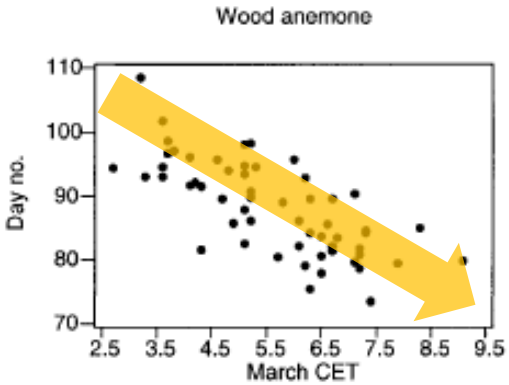
Effect of temperature on flowering

Anemone nemorosa



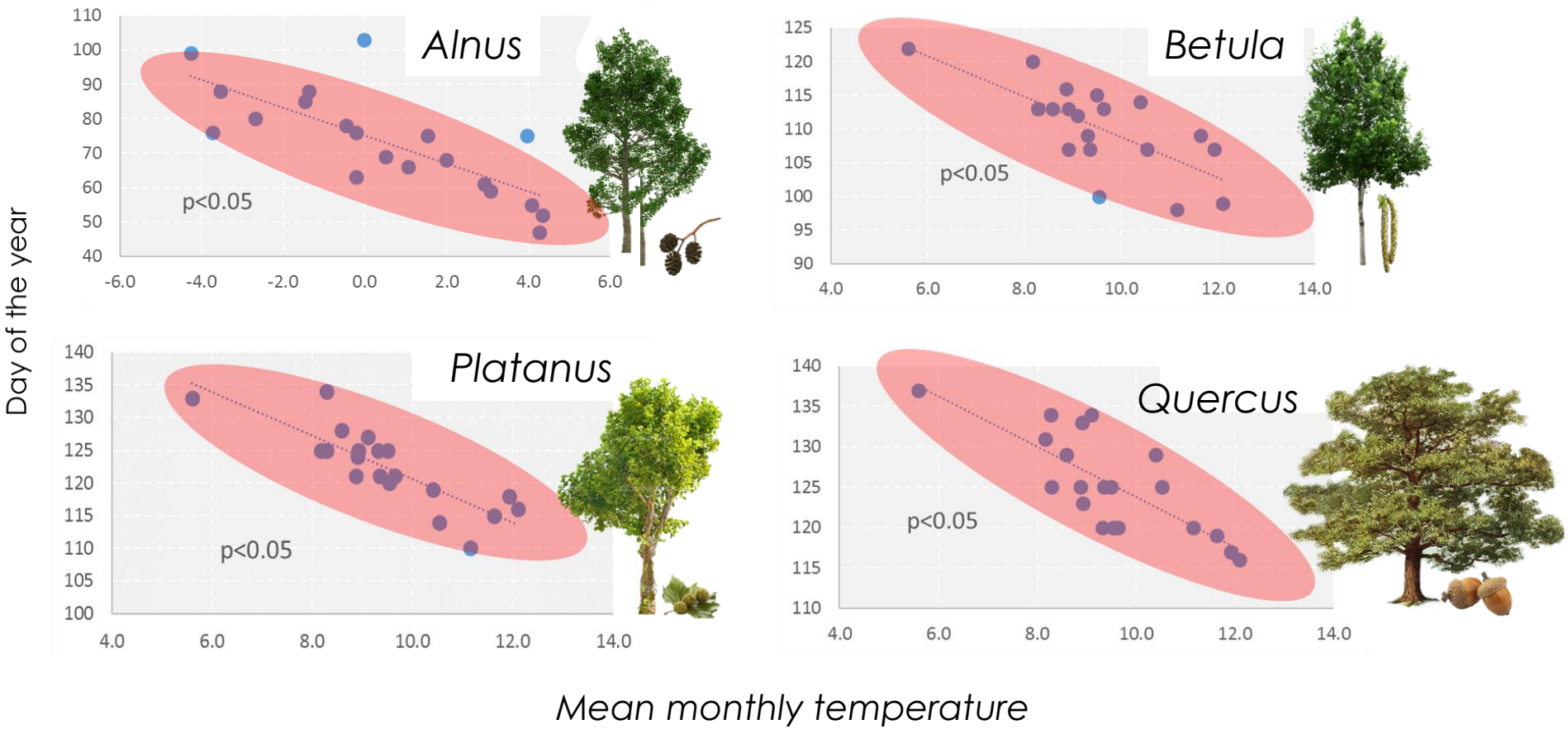






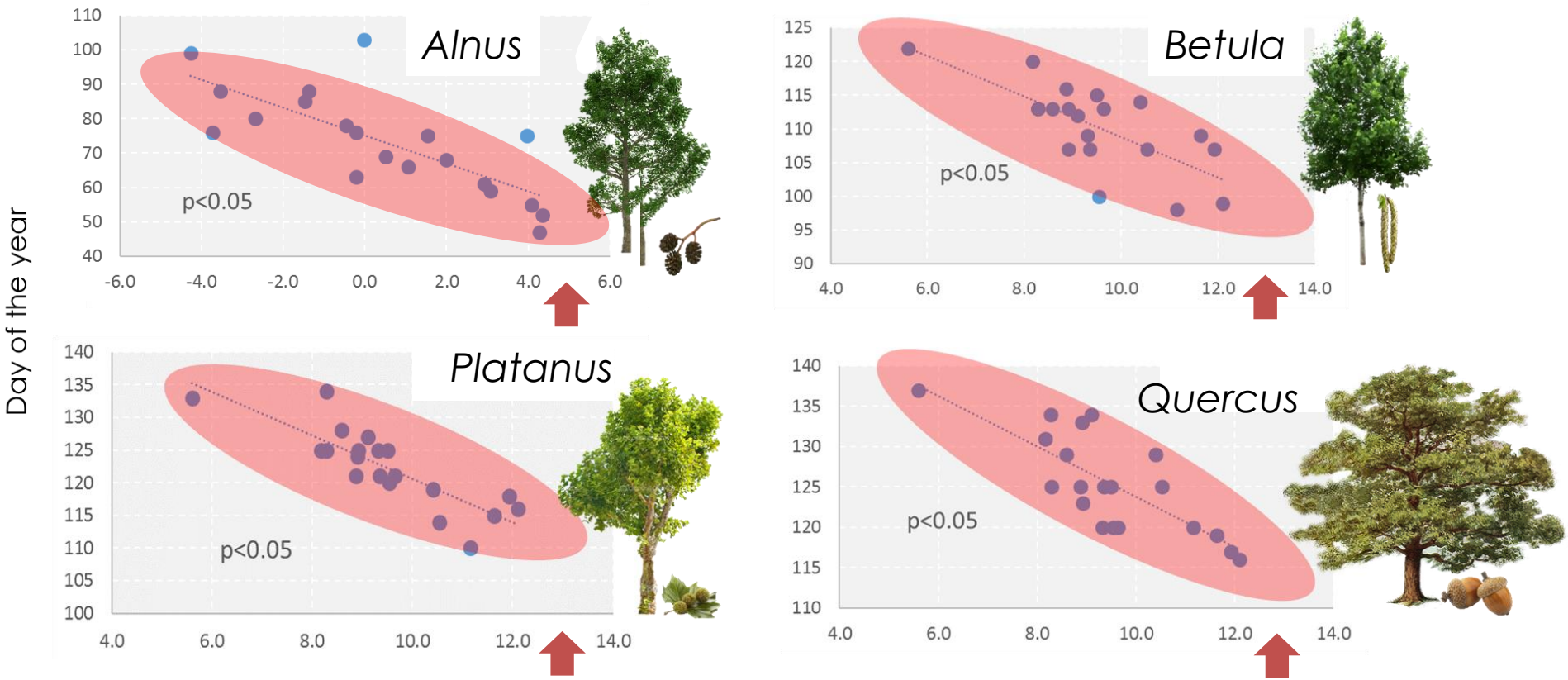
Sparks and Menzel (2002)

Pollination time depends on temperature recorded just before pollen release, i.e. few weeks



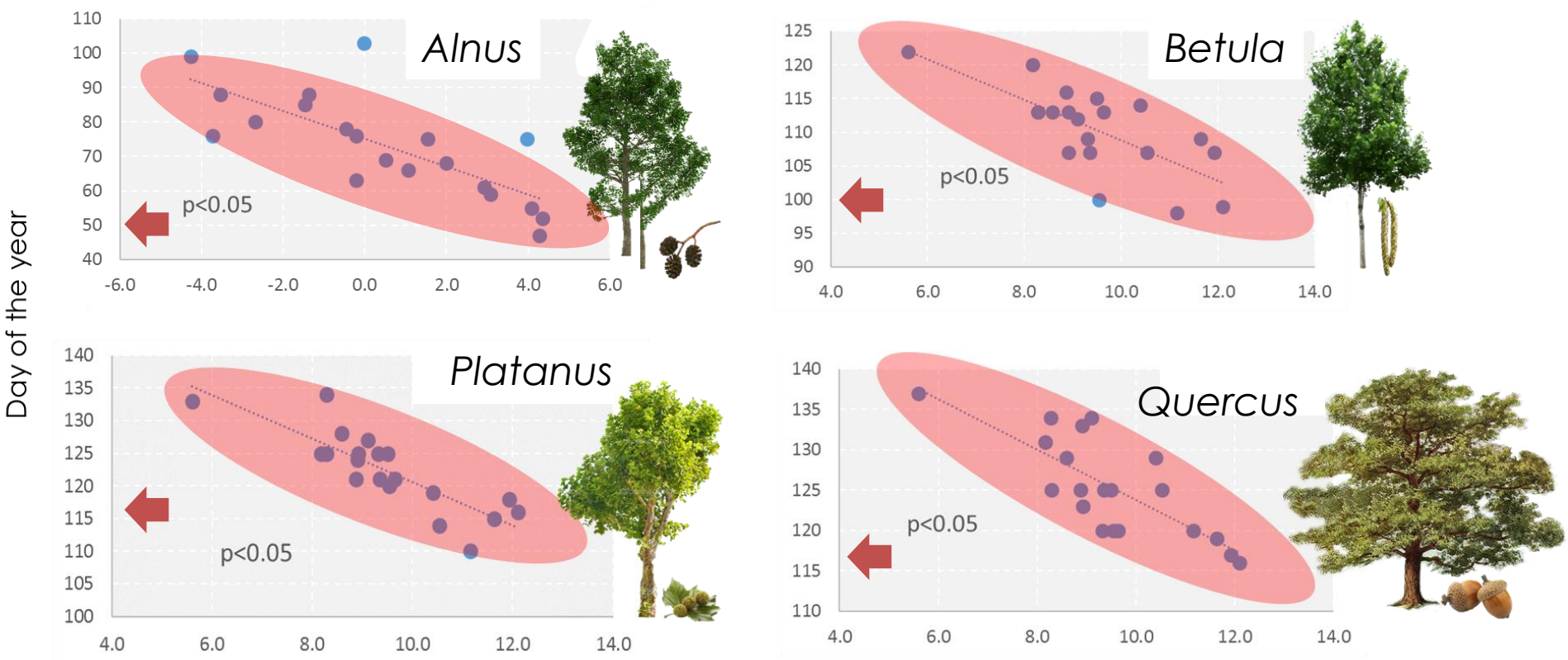
Grewling et al. (2012) Grana

The higher temperature….



Grewling et al. (2012) Grana

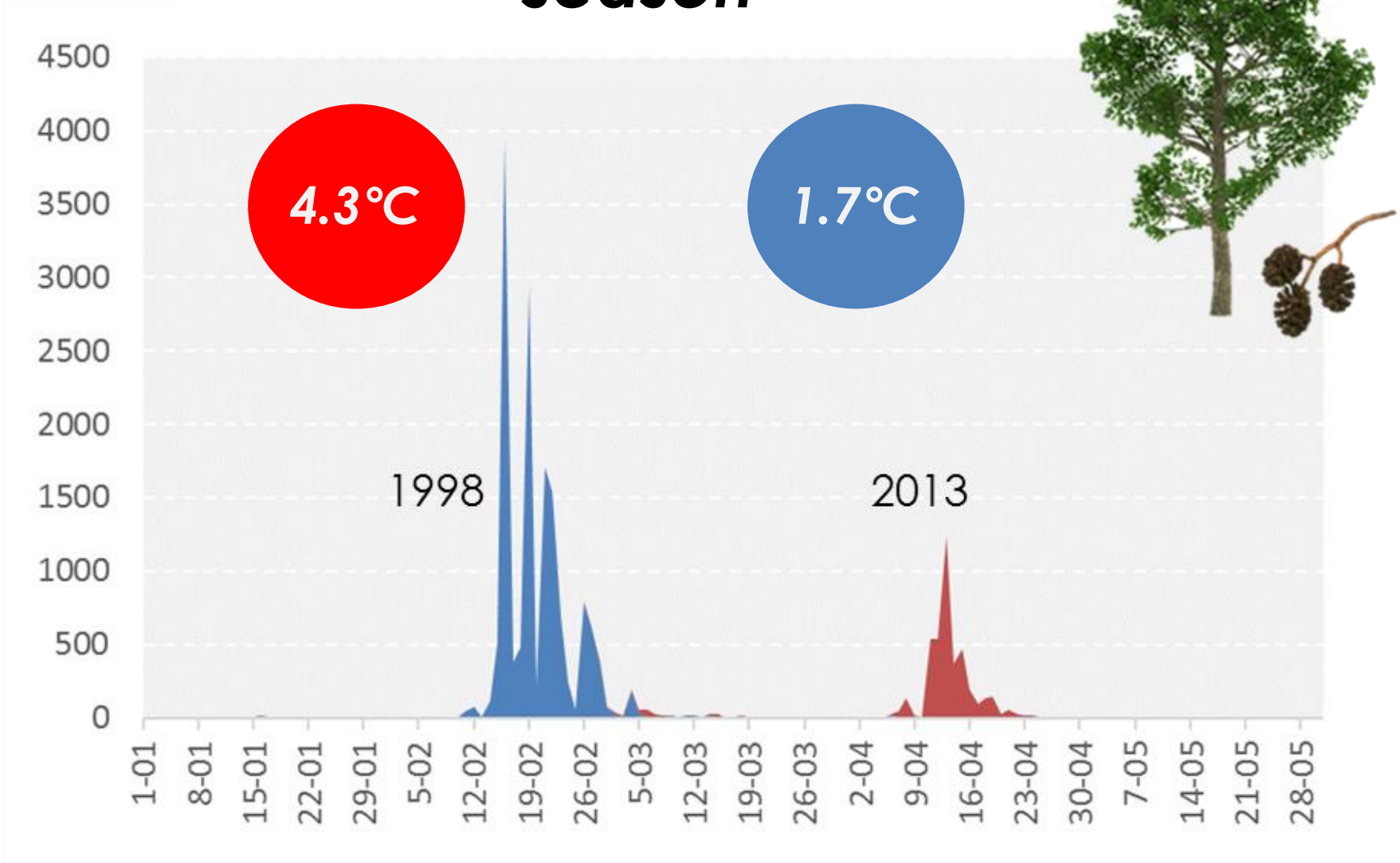
The higher temperature….
The earlier pollination



Mean monthly temperature

Grewling et al. (2012) Grana

Variation in alder pollen season



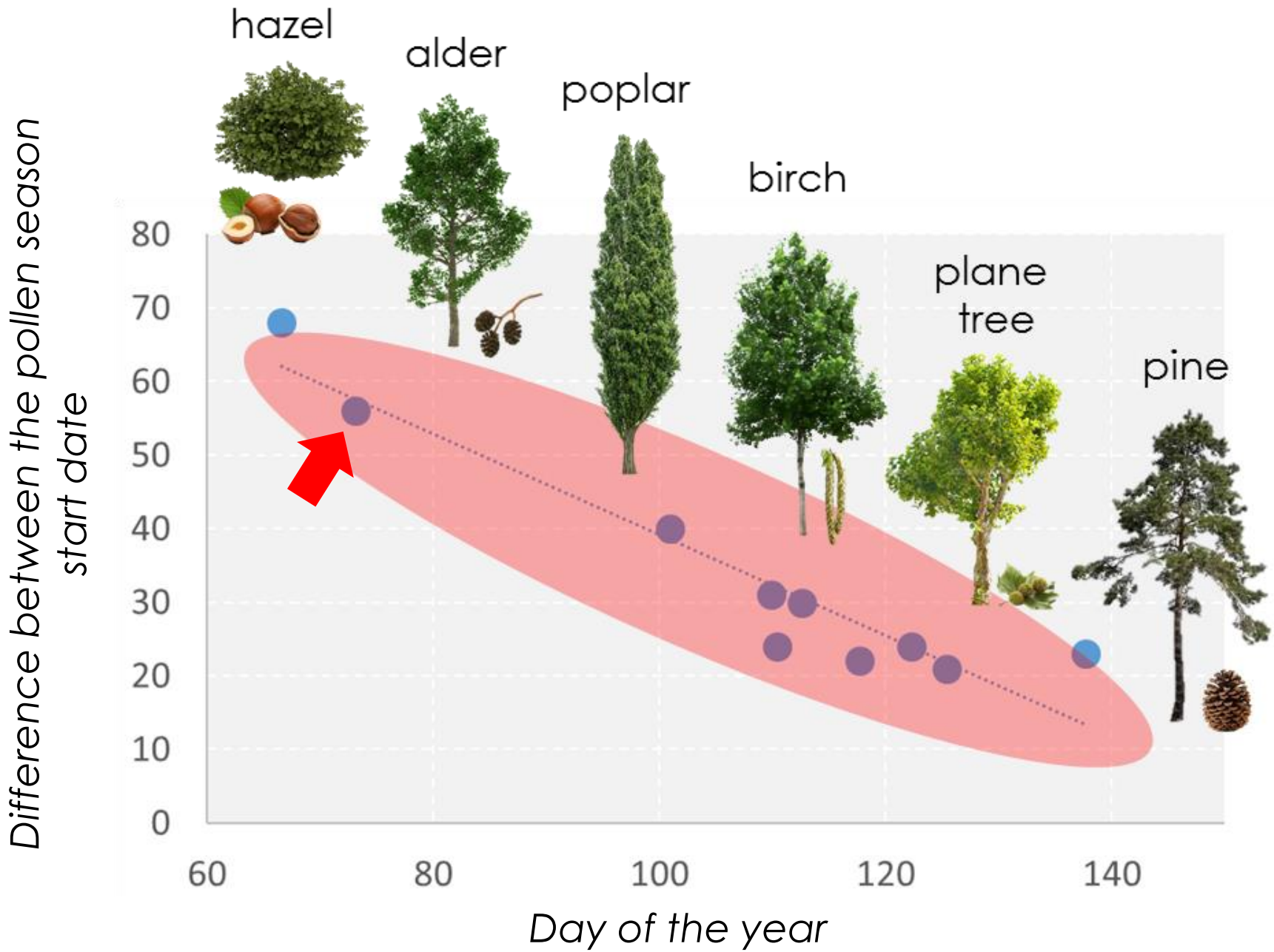

hazel
alder
poplar
birch
plane tree
pine
Difference between the pollen season start date
80
70
60
50
40
30
20
10
0
60
80
100
120
140
Day of the year

Table III. Change of commencement dates during the last 48 years for the eight studied calendars

No.	Site	Flowering of hazel	Flowering of colts-foot	Birch leaf unfolding	Flowering of apple		
1	Trier-Petrisberg	−0.40	−0.12	−0.03	0.01	0.07	−0.04

Europe

Table 2
Summary of full bloom dates and trends for apple and pear cultivars: 1973–2009.

Cultivar	Mean (full bloom date)	SD (days)	Earliest (full bloom)	Latest (full bloom)	Slo			P
Malus domestica								
Golden Delicious	19-October	5.69	9/10/1995	29/10/1974	−1.9**			0.027
Sayaka	19-October	5.21	7/10/2009	31/10/2009	−1.4*			0.075
Granny Smith	18-October	4.35	8/10/1995	26/10/1978	−1.1*	0.096	0.077	0.096

Africa

Table 2 Mean and temporal change of budding and flowering dates

	Budding date				Flowering			
Location	Mean	Trend (day yr^{-1})	r	τ	Mean			τ
A	April 9	−0.23 (0.12)	−0.34^{+}	−0.21	May 9	−0.24 (0.14)	−0.31	−0.23^{+}
								0.26^{+}
								0.33*
								0.36**
								0.26^{+}
								0.19

Asia

ONSET OF NH SPRIN R 345

show

America

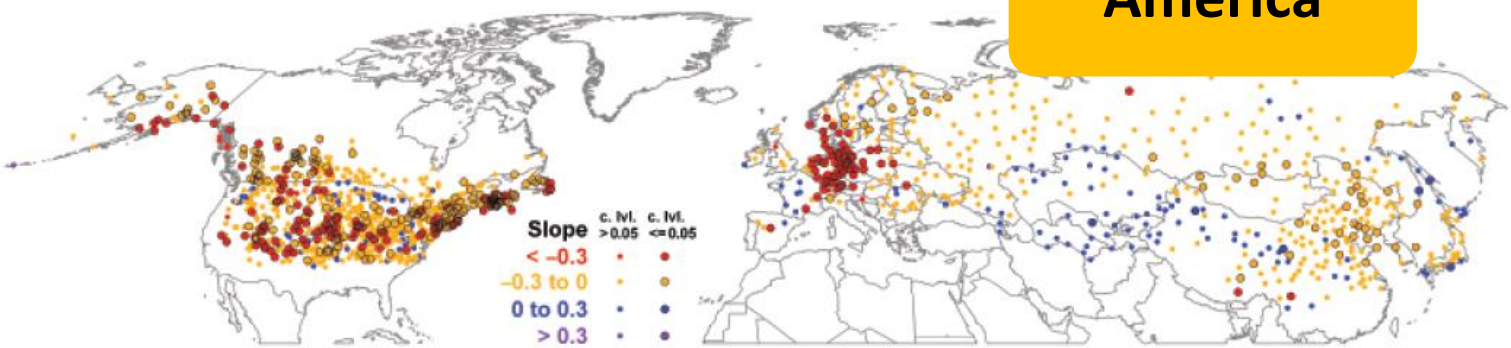


Fig. 1 Spring indices (SI) first leaf date 1961–2000 trend by station. Trend values are in days per year and colors show categories. Stations with trends significant at the 0.05 level or better are shown with larger symbols outlined in black.

Shwartz et al. (2006)

Table III. Change of commencement dates during the last 48 years for the eight studied calendars

No.	Site	Flowering of hazel	Flowering of colts-foot	Birch leaf unfolding	Flowering of apple
1	Trier-Petrisberg	−0.40	−0.12	−0.03	0.01

Europe

Table 2
Summary of full bloom dates and trends for apple and pear cultivars: 1973–2009.

Cultivar	Mean (full bloom date)	SD (days)	Earliest (full bloom)	Latest (full bloom)	Slo	P
Malus domestica						
Golden Delicious	19-October	5.69	9/10/1995	29/10/1974	−1.9**	0.027
Sayaka	19-October	5.21	7/10/2009	31/10/2009	−1.4*	0.075
Granny Smith	18-October	4.35	8/10/1995	26/10/1978	−1.1*	0.096

Africa

Table 2 Mean and temporal change of budding and flowering dates

Location						τ
A					0.31	−0.23+
						0.26+
				R	345	0.33*
						0.36**
						0.26+
						0.19

show

EARLIER

PHENOLOGICAL PHASES

ONSET OF NH SPRIN

North America

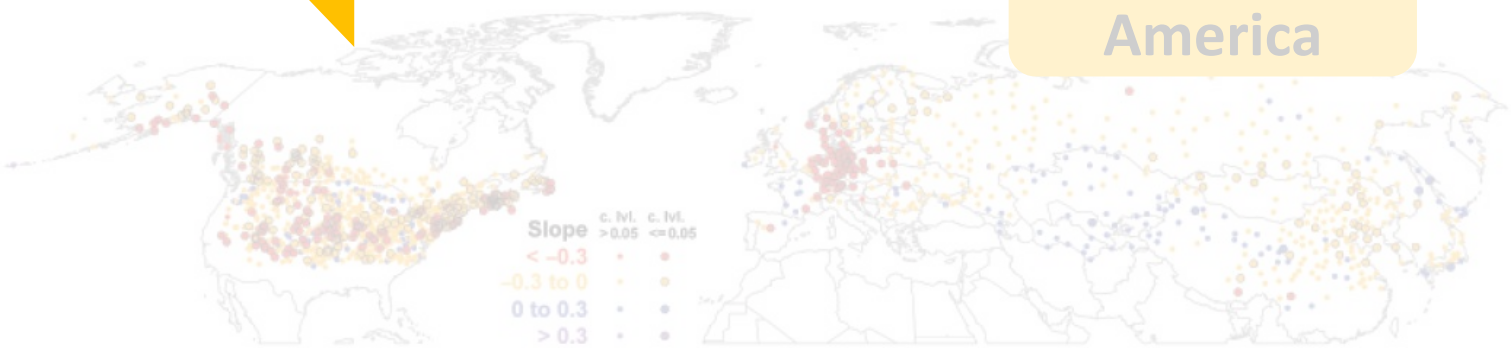


Fig. 1 Spring indices (SI) first leaf date 1961–2000 trend by station. Trend values are in days per year and colors show categories. Stations with trends significant at the 0.05 level or better are shown with larger symbols outlined in black.

Shwartz et al. (2006)

Monaldi Arch Chest Dis
2002; 57: 2, 141–143

PROCEEDINGS

Interactions between climatic changes and allergenic plants

Frenguelli

Available online at www.sciencedirect.com
ScienceDirect
Atmospheric Environment 41 (2007) 7011–7021
ELSEVIER
ATMOSPHERIC ENVIRONMENT
www.elsevier.com/locate/atmosenv

Long-term trends in atmospheric pollen levels in the city of

ina Vokou[a]

). DOI: 10.1002/joc.820

E AND CLIMATE CHANGE ON THE TIMING OF POLLEN RELEASE IN THE NETHERLANDS

ARNOLD J. H. VAN VLIET,[a,*] AART OVEREEM,[a,b] RUDOLF S. DE GROOT,[a] ADRIE F. G. JACOBS[b] and FRITS T. M. SPIEKSMA[c]

tart of the concentration

of the most important allergenic pollens?

UWE KAMINSKI[1*] and TOM GLOD[2]

[1]German Meteorological Service, Centre for Human Biometeorological Research, Freiburg, Germany
[2]University of Trier, FB Physical Geography, Trier, Germany

Contents lists available at ScienceDirect
Agricultural and Forest Meteorology
journal homepage: www.elsevier.com/locate/agrformet
ELSEVIER

Phenological trends in southern Spain: A response to climate change

H. García-Mozo[a,*], A. Mestre[b], C. Galán[a]

Data contributors[1]

and Italy

EMMA TEDESCHINI[1], F. JAVIER RODRÍGUEZ-RAJO[2], ROSANNA CARAMIELLO[3], VICTORIA JATO[2] & GIUSEPPE FRENGUELLI[1]

[1]*Department of Plant Biology and Agroenvironmental Biotechnology and Animal Production, University of Perugia, Perugia, Italy,* [2]*Department of Plant Biology and Soil Sciences, Campus As Lagoas, University of Vigo, Ourense, Spain, and* [3]*Department of Plant Biology, University of Torino, Torino, Italy.*

Vol. 48: 281–291, 2011
doi: 10.3354/cr00966
CLIMATE RESEARCH
Clim Res
Published August 30

Contribution to CR Special 27 'Climate change in the NW Iberian Peninsula'

OPEN ACCESS

Recent trends in airborne pollen for tree species in Galicia, NW Spain

F. J. Rodríguez-Rajo[1,*], M. J. Aira[2], M. Fernández-González[1], C. Seijo[1], V. Jato[1]

General Trends in Airborne Pollen Production and Pollination Periods at a Mediterranean Site (Badajoz, Southwest Spain)

R Tormo-Molina,[1] MA Gonzalo-Garijo,[2] I Silva-Palacios,[3] AF Muñoz-Rodriguez[4]

GRANA

The effects of climate change in Switzerland 1969-1996 on airborne pollen quantities from hazel, birch and grass

Thomas Frei*

* Swiss Meteorological Institute, Zürich, Switzerland

he effect of rec
pollination in tw
in the Iberian Peninsula: Malaga and Vigo

Marta Recio · F. Javier Rodríguez-Rajo · M. Victoria Jato · M. Mar Trigo · Baltasar Cabezudo

ACTA CLIMATOLOGICA ET CHOROLOGICA
Universitatis Szegediensis, Tomus 44-45, 2011, 111-125

TRENDS IN THE CHARACTERISTICS OF ALLERGENIC POLLEN

L MAK

[1]*Department of Climatology and Landsc*

[2]*Department of Meteorology, Eötvös*

Aerobiologia **19:** 227–234, 2003.
© 2003 *Kluwer Academic Publishers. Printed in the Netherlands.*

227

Trends in airborne pollen: A
(Switzerland)

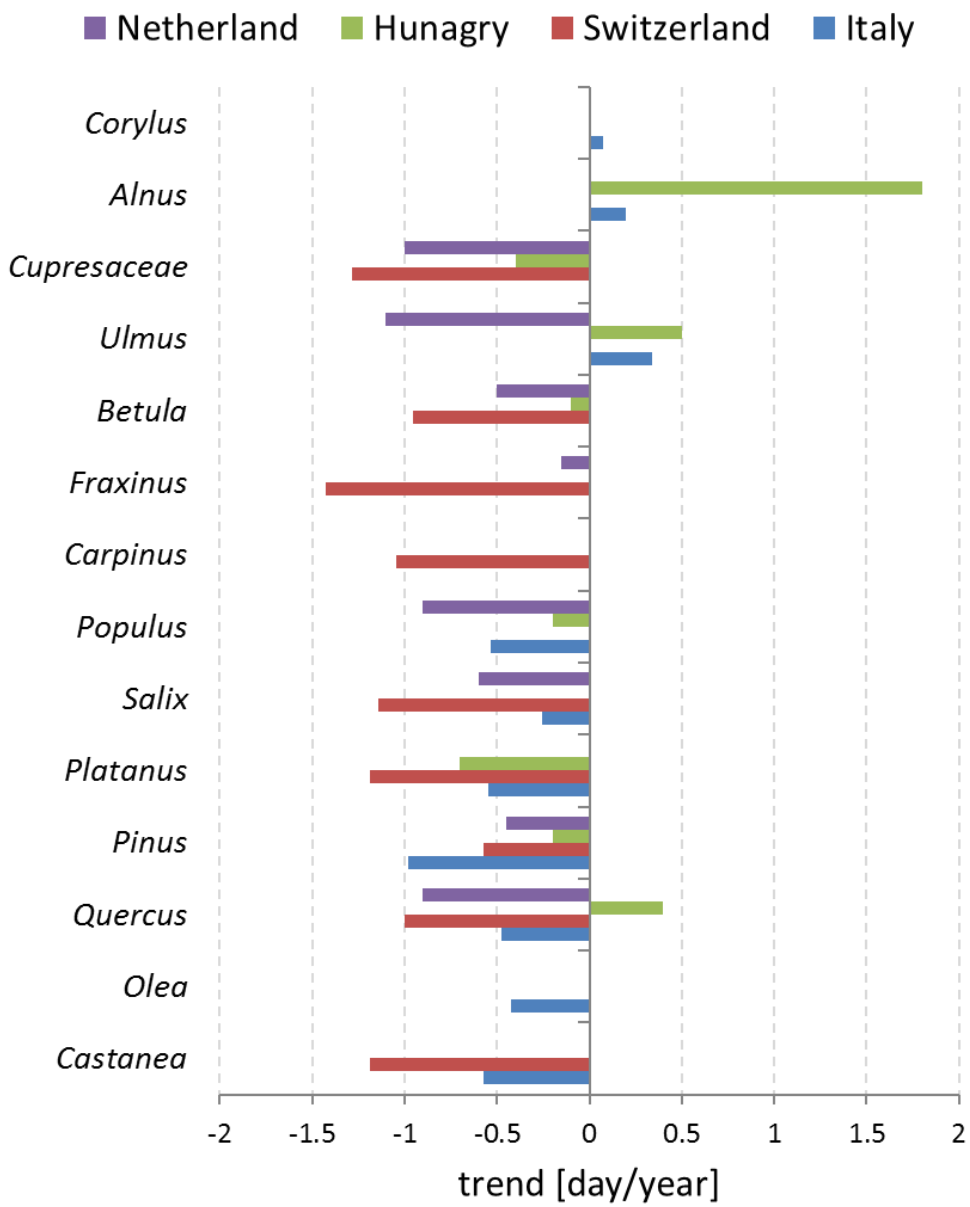
Bernard Clot
Laboratoire de botanique évolutive de l'Un
Switzerland
(Fax: +41 26 662 62 12; E-mail: bernard.cl

Grana

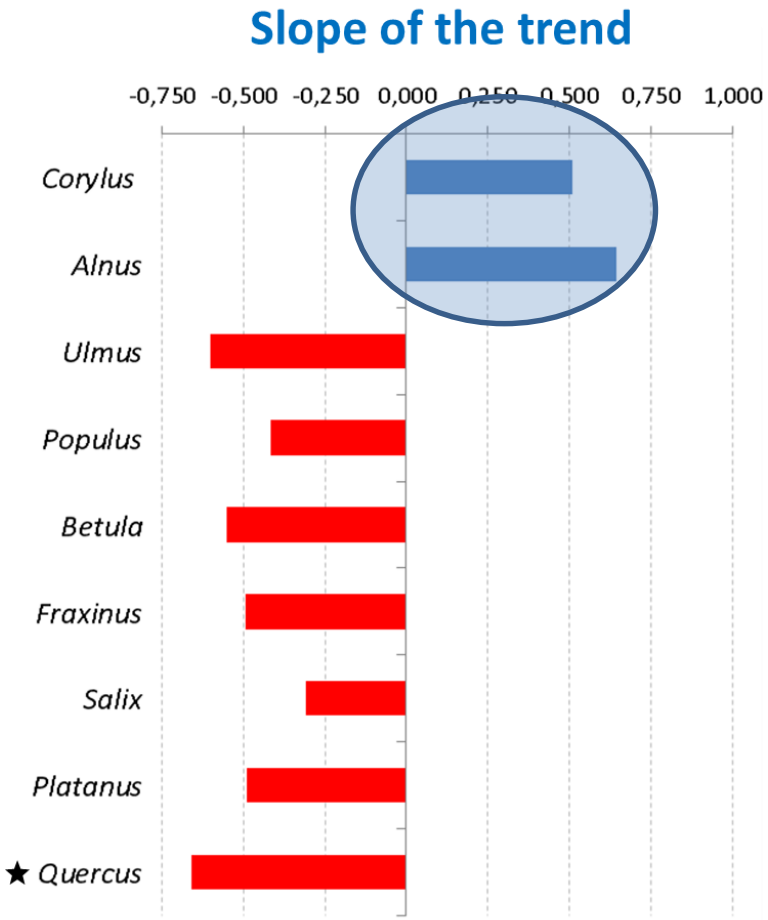
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/sgra20

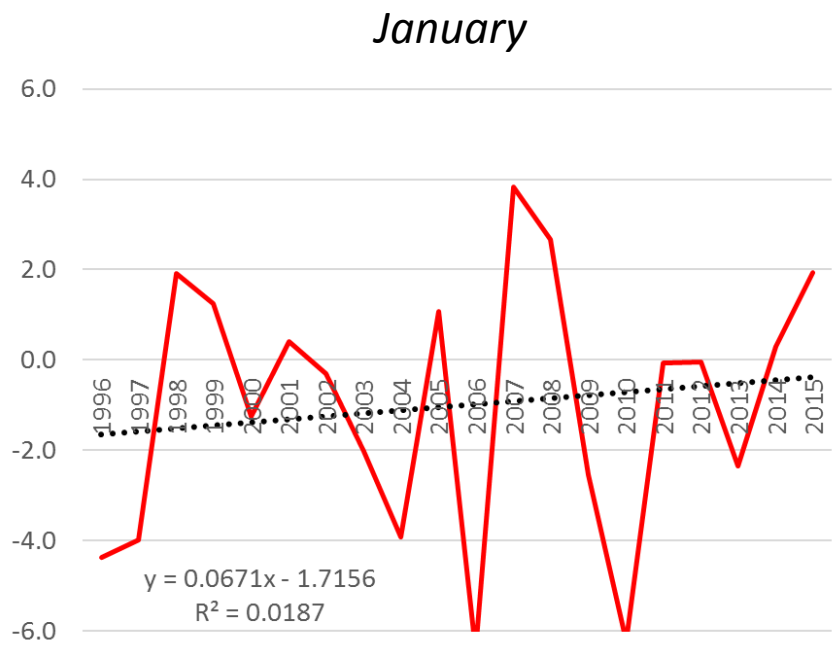
Altering airborne pollen concentrations due to the Global Warming. A comparative analysis of airborne pollen records from Innsbruck and Obergurgl (Austria) for the period 1980-2001

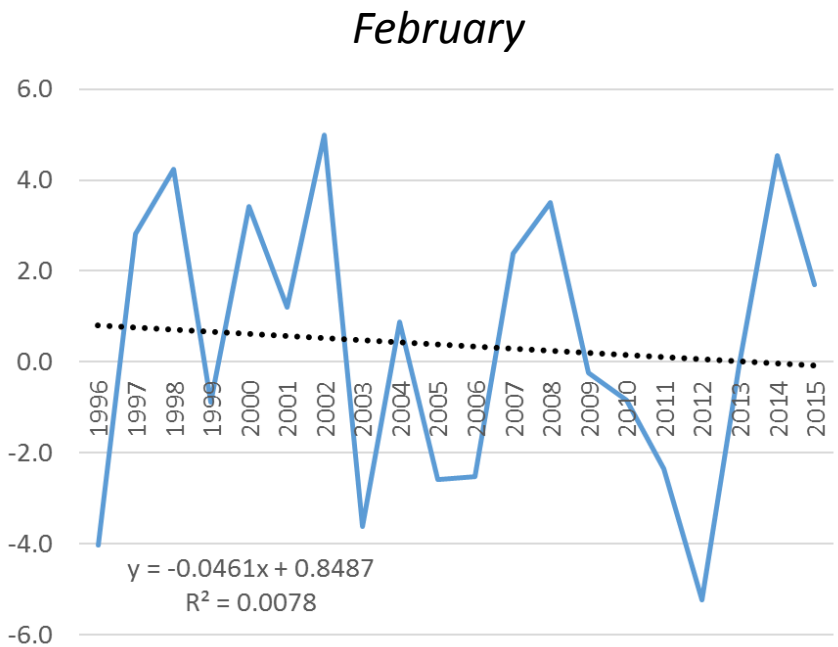
The pollen seasons start earlier

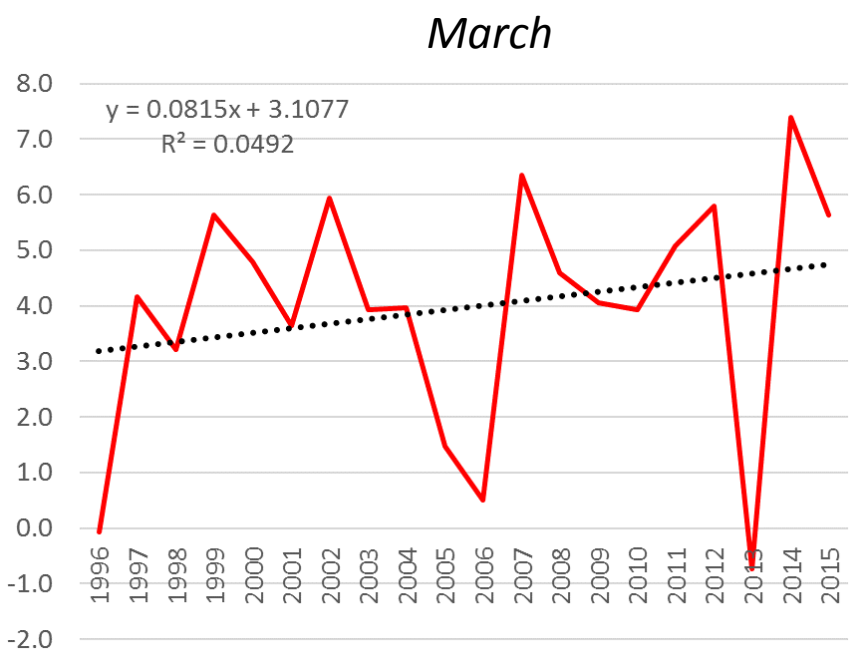


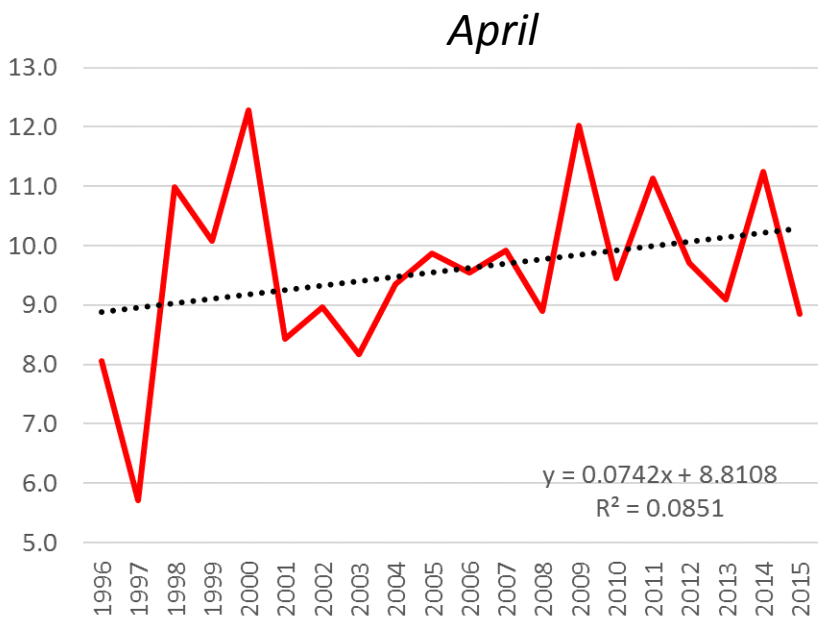
Poznań

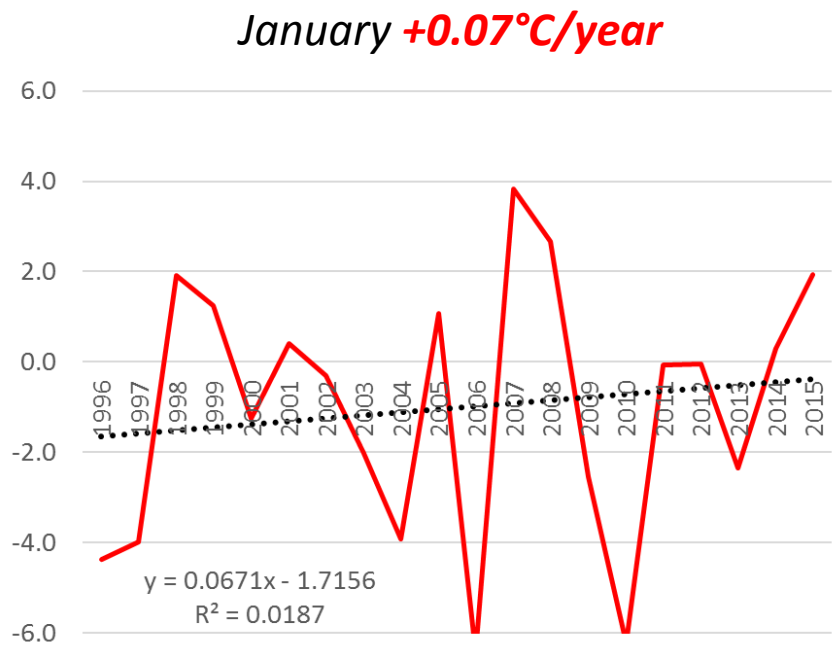


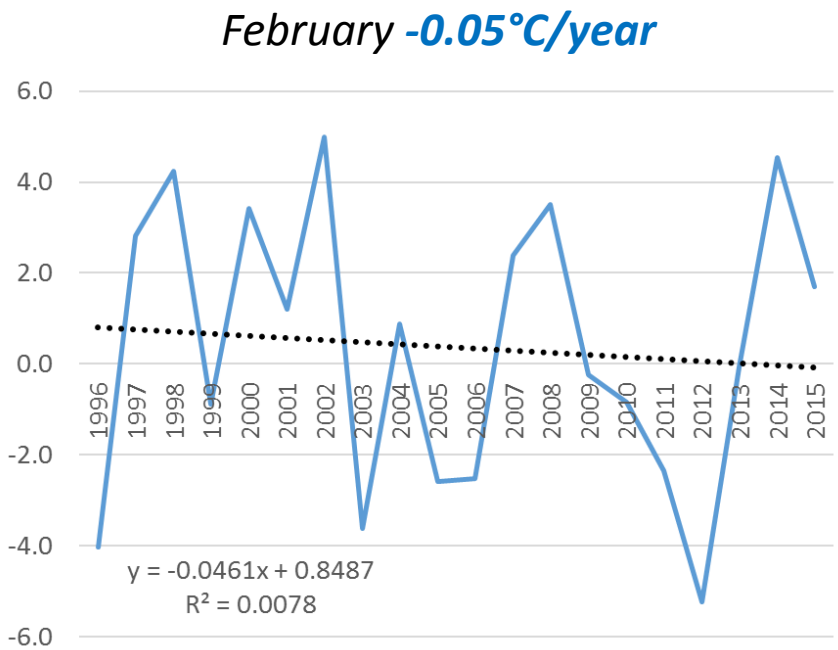

January
6.0
4.0
2.0
0.0
-2.0
-4.0
-6.0
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
y = 0.0671x - 1.7156
R² = 0.0187

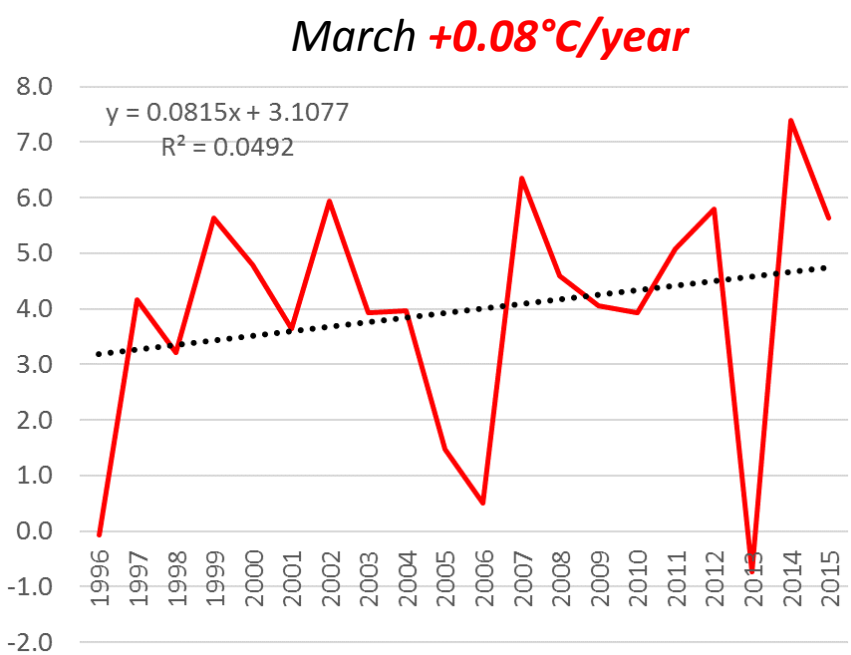

February
6.0
4.0
2.0
0.0
-2.0
-4.0
-6.0
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
y = -0.0461x + 0.8487
R² = 0.0078


March
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
y = 0.0815x + 3.1077
R² = 0.0492
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015


April
13.0
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
y = 0.0742x + 8.8108
R² = 0.0851
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015


January +0.07°C/year
6.0
4.0
2.0
0.0
-2.0
-4.0
-6.0
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
y = 0.0671x - 1.7156
R² = 0.0187


February -0.05°C/year
6.0
4.0
2.0
0.0
-2.0
-4.0
-6.0
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
y = -0.0461x + 0.8487
R² = 0.0078


March +0.08°C/year
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
y = 0.0815x + 3.1077
R² = 0.0492
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015

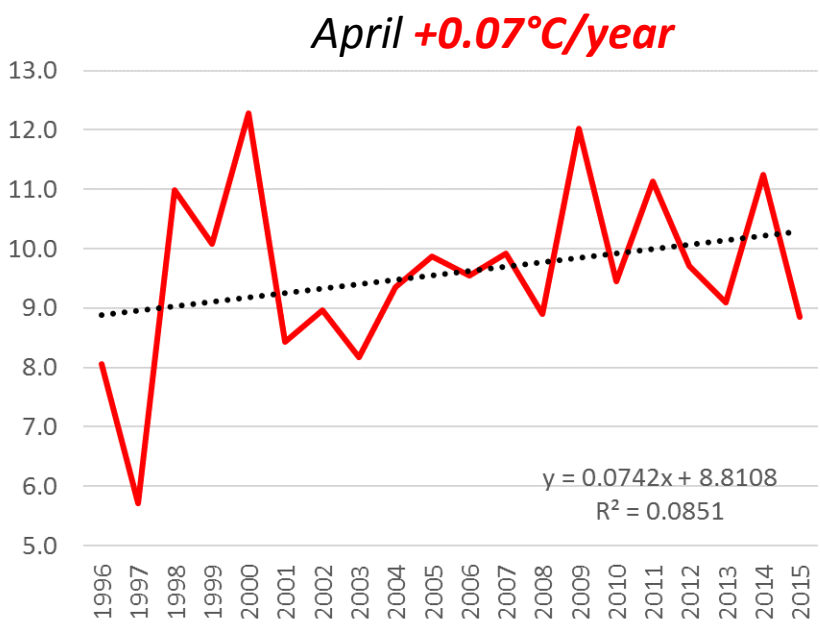

April +0.07°C/year
13.0
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
y = 0.0742x + 8.8108
R² = 0.0851
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015

Table III. Change of commencement dates during the last 48 years for the eight studied calendars

No.	Site	Flowering of hazel	Flowering of colts-foot	Birch leaf unfolding	Flowering of apple
1	Trier-Petrisberg	−0.40	−0.12	−0.03	0.01

Europe

Table 2
Summary of full bloom dates and trends for apple and pear cultivars: 1973–2009.

Cultivar	Mean (full bloom date)	SD (days)	Earliest (full bloom)	Latest (full bloom)	Slo	P
Malus domestica						
Golden Delicious	19-October	5.69	9/10/1995	29/10/1974	−1.9**	0.027
Sayaka	19-October	5.21	7/10/2009	31/10/2009	−1.4*	0.075
Granny Smith	18-October	4.35	8/10/1995	26/10/1978	−1.1*	0.096

Africa

Table 2 Mean and temporal change of budding and flowering dates

Location							τ
A						0.31	−0.23+
							0.26+
					R	345	0.33*
							0.36**
							0.26+
							0.19

EARLIER

START OF POLLEN SEASON OF TREES

North America

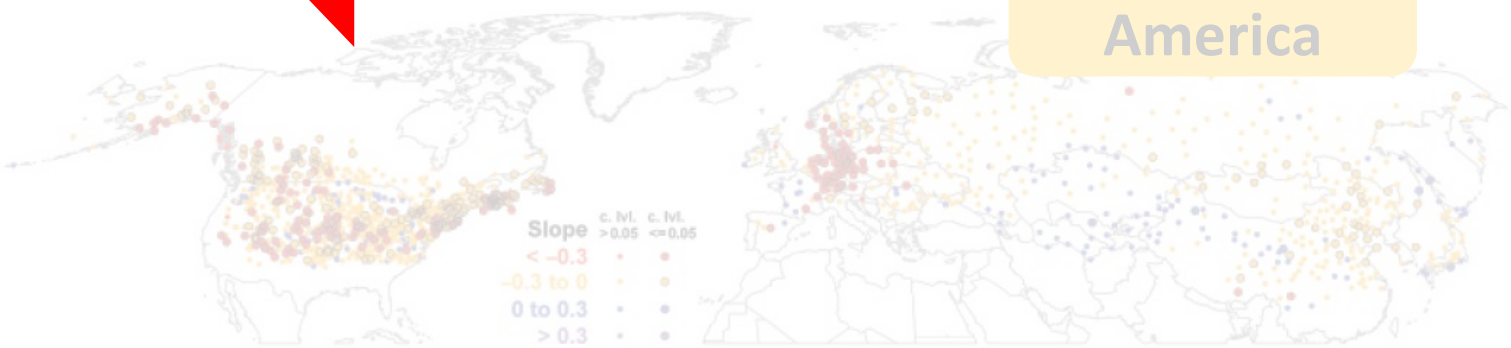
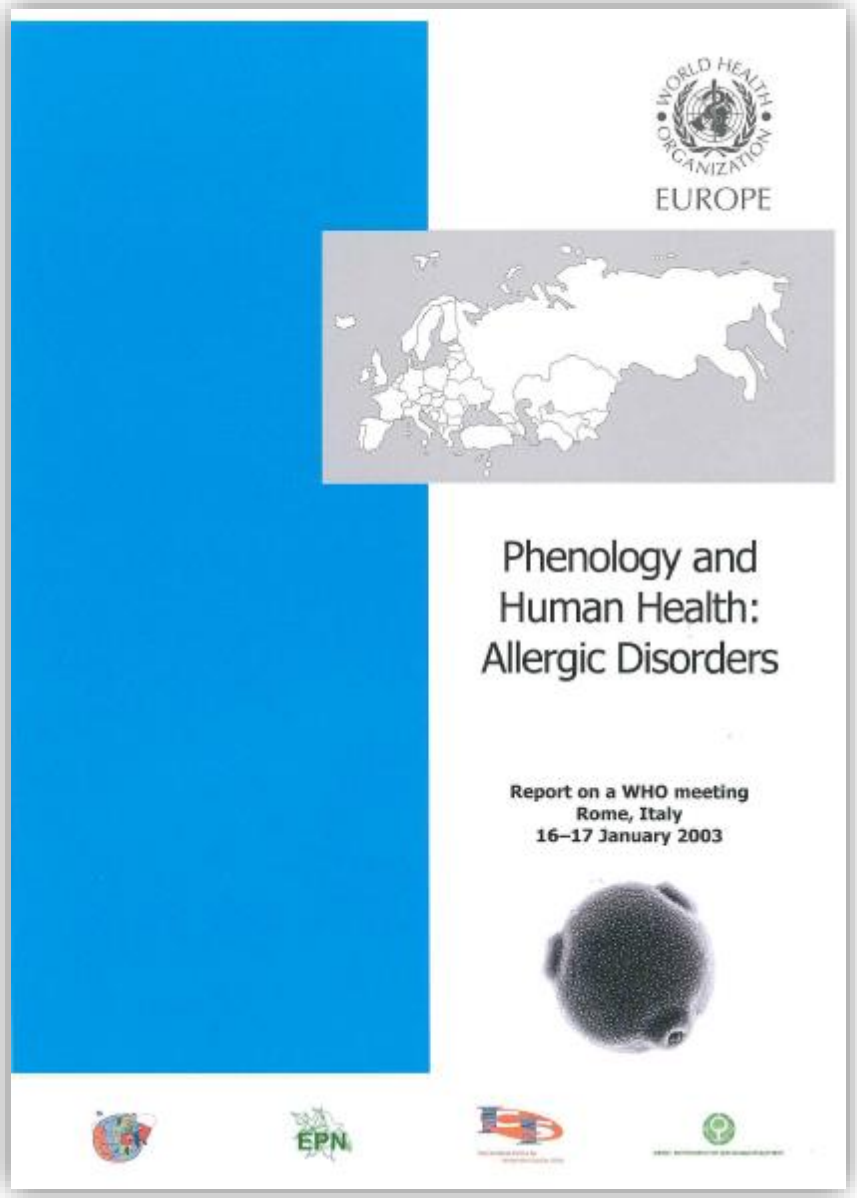


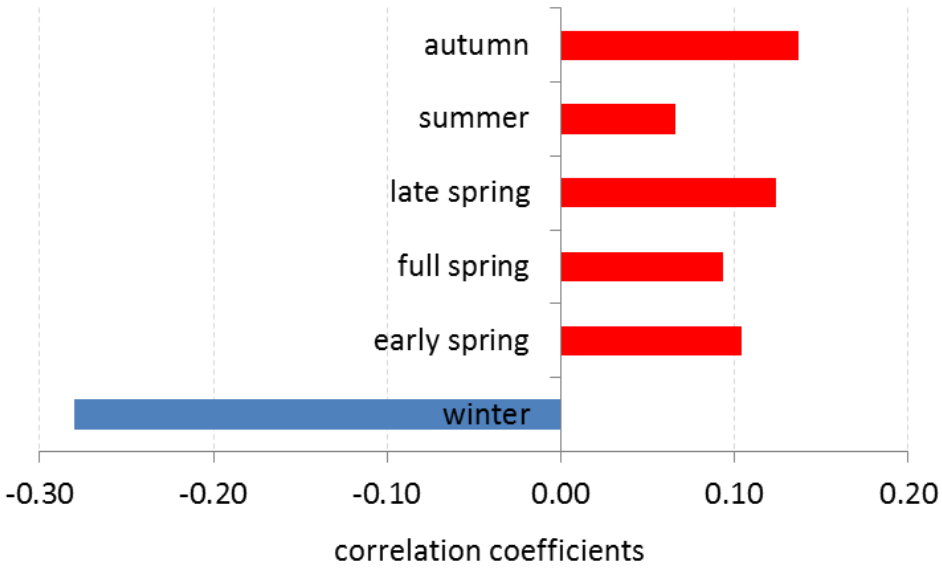
Fig. 1 Spring indices (SI) first leaf date 1961–2000 trend by station. Trend values are in days per year and colors show categories. Stations with trends significant at the 0.05 level or better are shown with larger symbols outlined in black.

Shwartz et al. (2006)

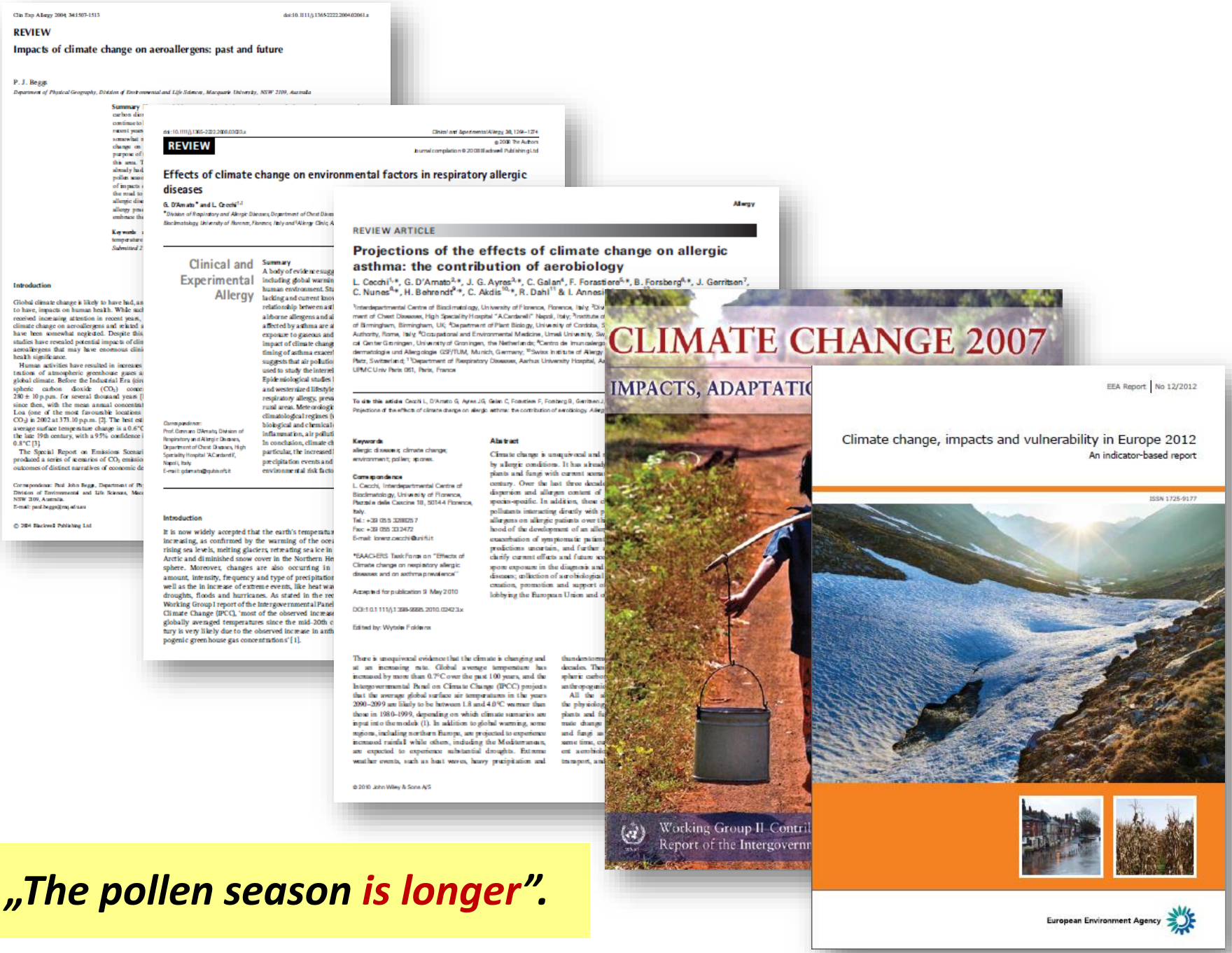
What about the duration of pollen season?



Changes in start and duration of pollen season in Europe, 1974-2002 (Jäger 2001).



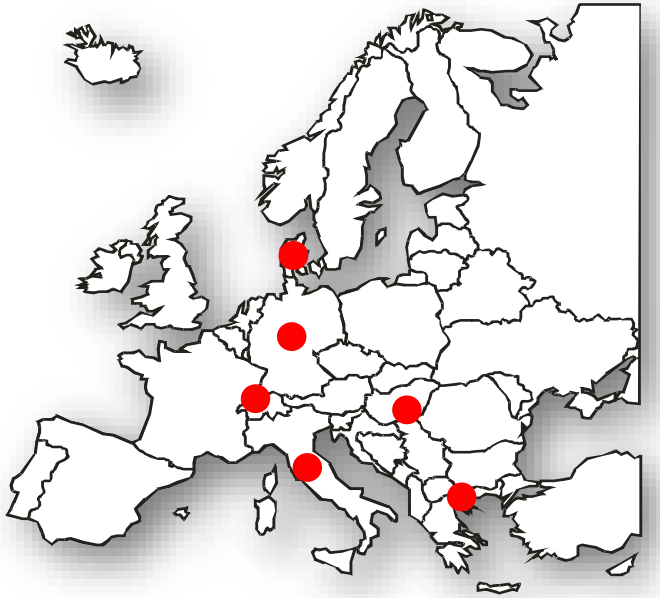
„Warming is likely to further cause an earlier onset and may **extend the duration of flowering and pollen season**, for some species (e.g. grasses, weeds)."

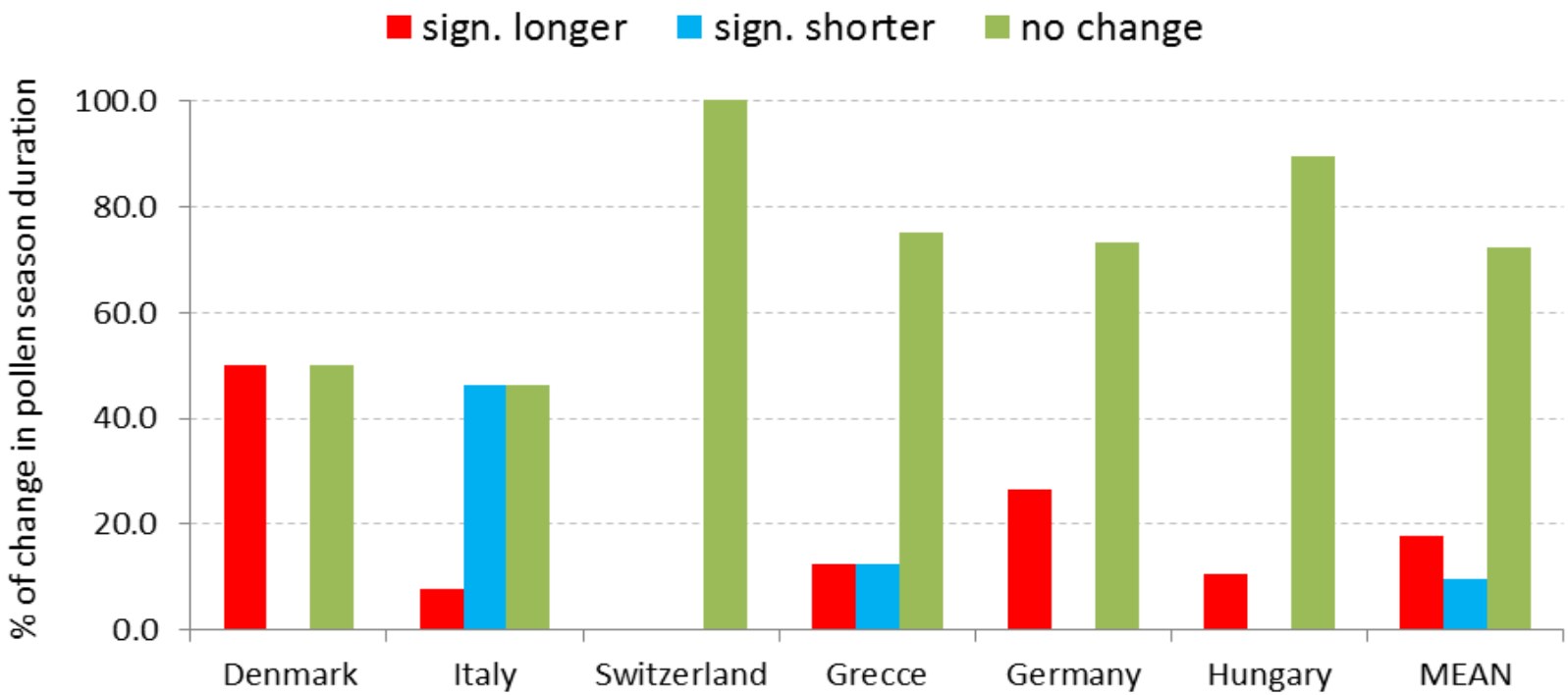


„The pollen season is longer".

Duration of pollen season

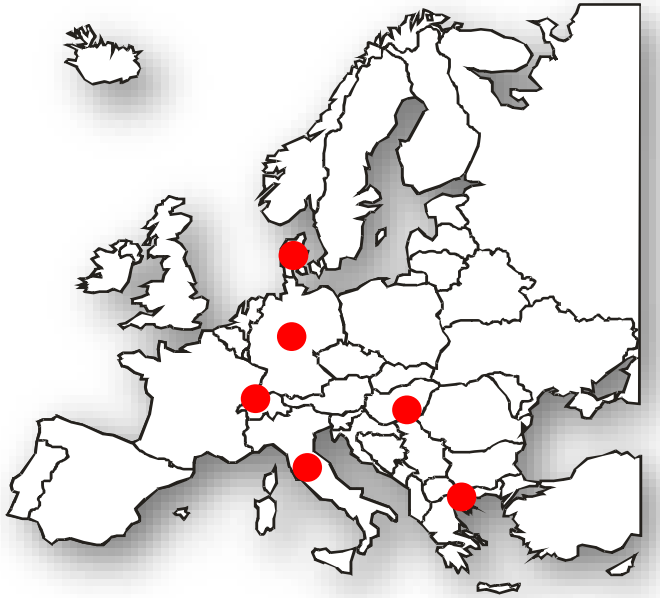
Country	Number of data series	Length of data series	References
Denmark	2	1979-1998	Rasmussen (2002)
Italy	13	1982-2001	Frenguelli (2002)
Switzerland	19	1979-1999	Clot (2003)
Grecce	16	1987-2005	Damialis et al. (2007)
Germany	15	1994-2009	Kaminski (2011)
Hungary	19	1997-2007	Marka et al. (2011)

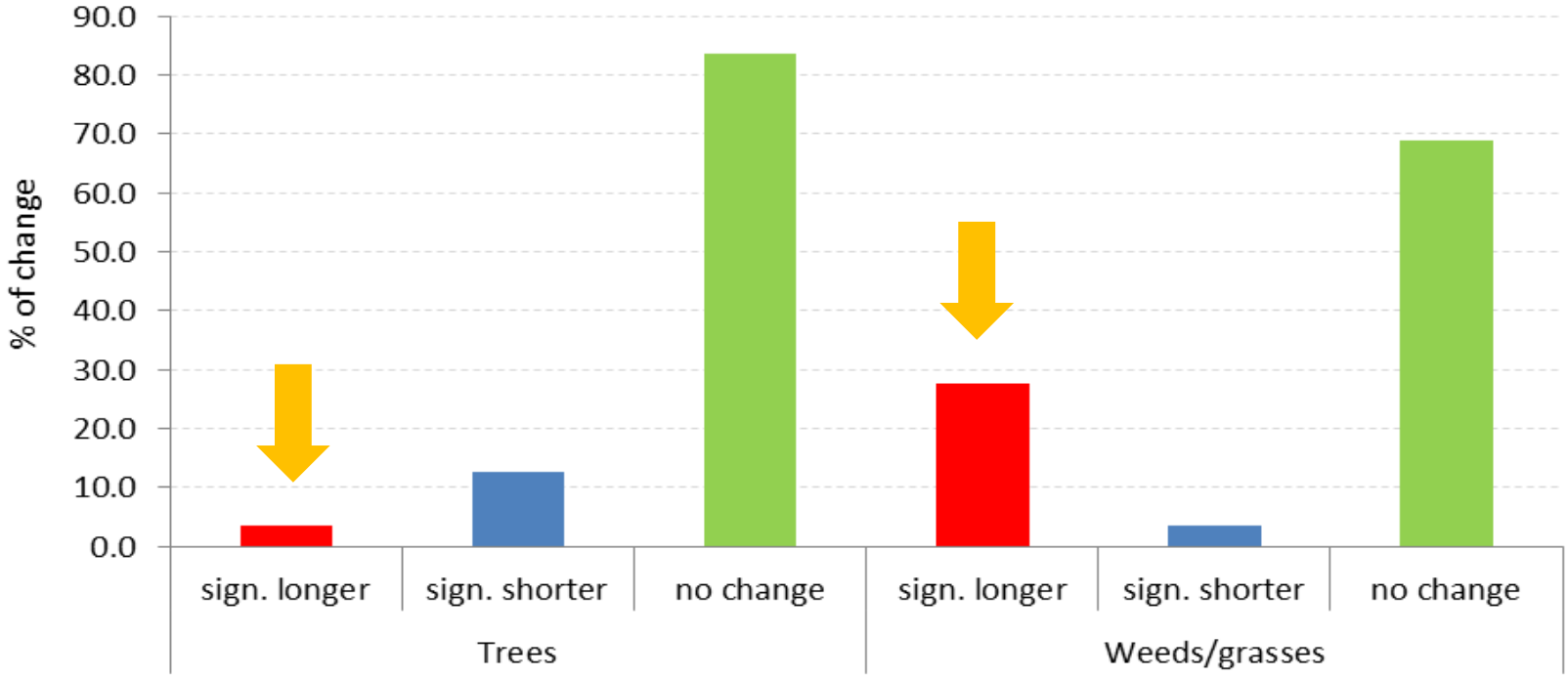




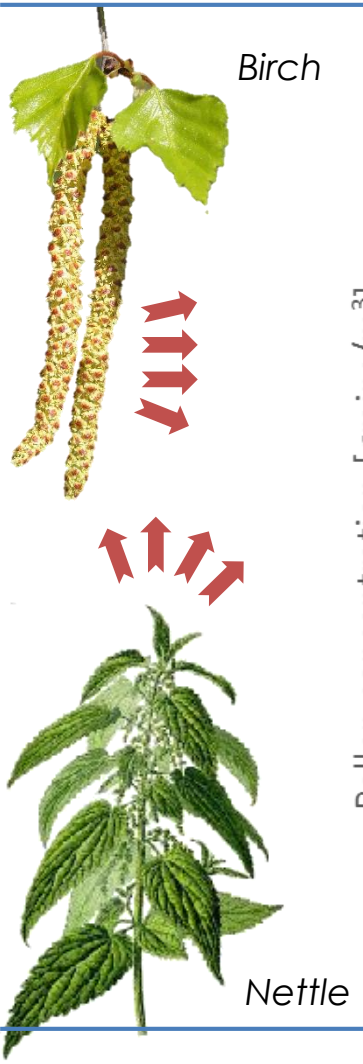
Duration of pollen season

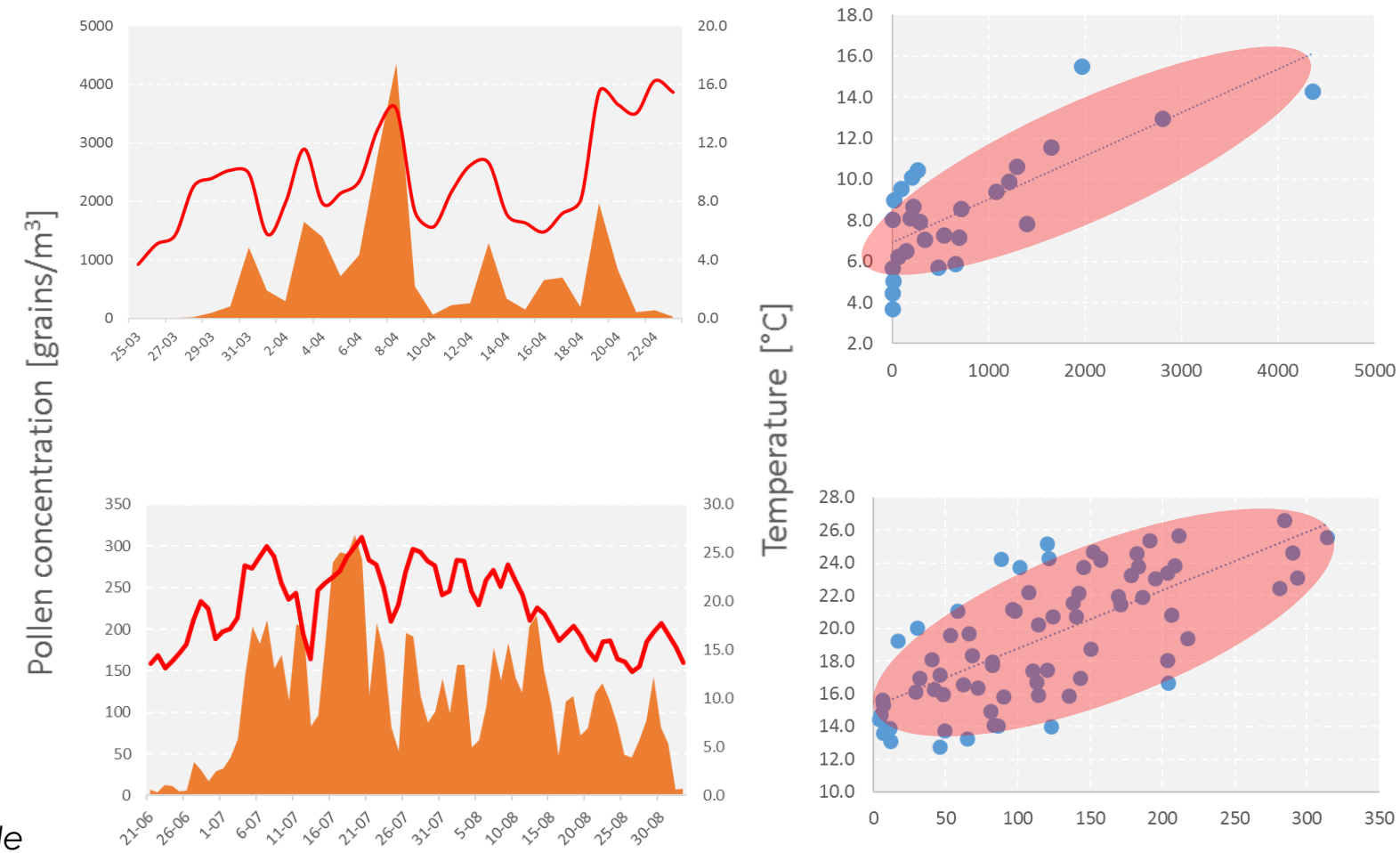
Country	Number of data series	Length of data series	References
Denmark	2	1979-1998	Rasmussen (2002)
Italy	13	1982-2001	Frenguelli (2002)
Switzerland	19	1979-1999	Clot (2003)
Grecce	16	1987-2005	Damialis et al. (2007)
Germany	15	1994-2009	Kaminski (2011)
Hungary	19	1997-2007	Marka et al. (2011)



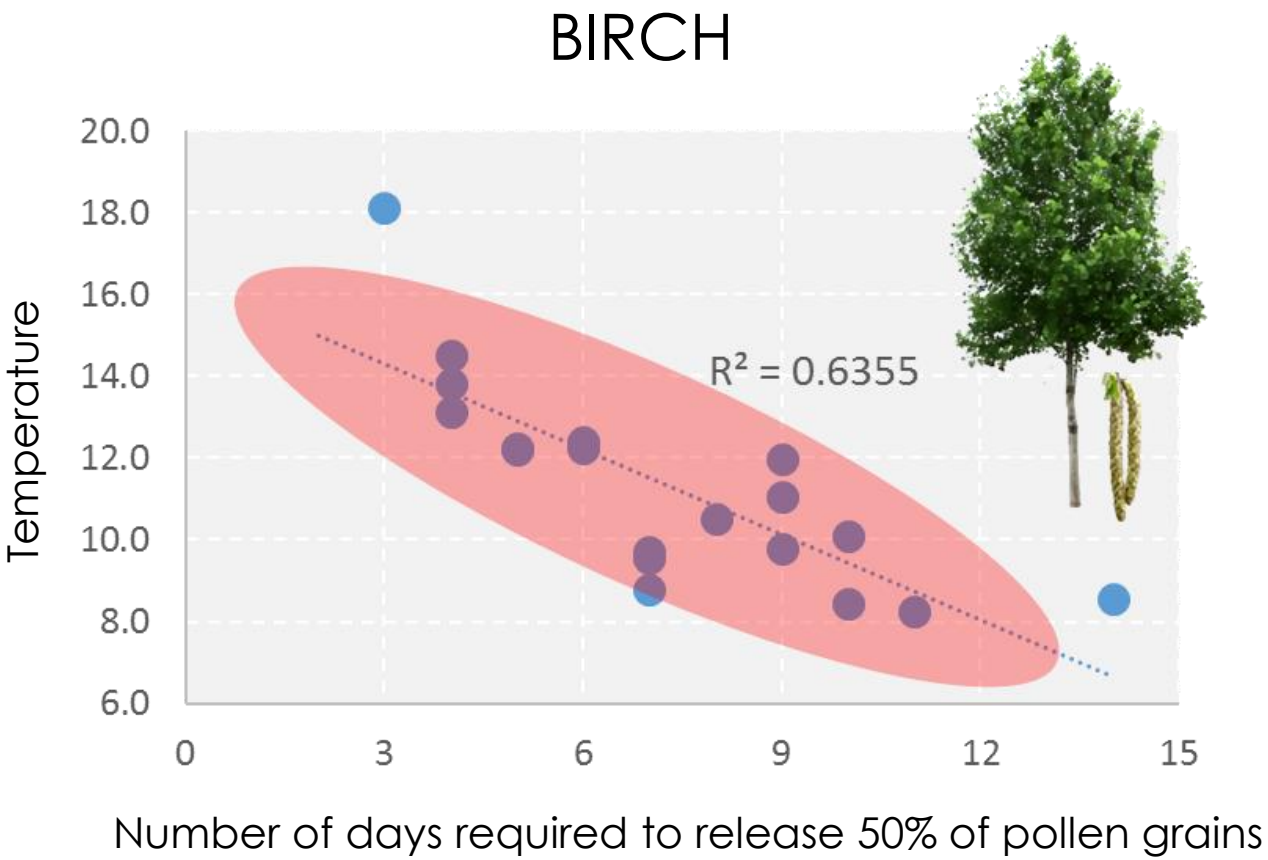


Temperature regulates the pace of pollen realease from anthers

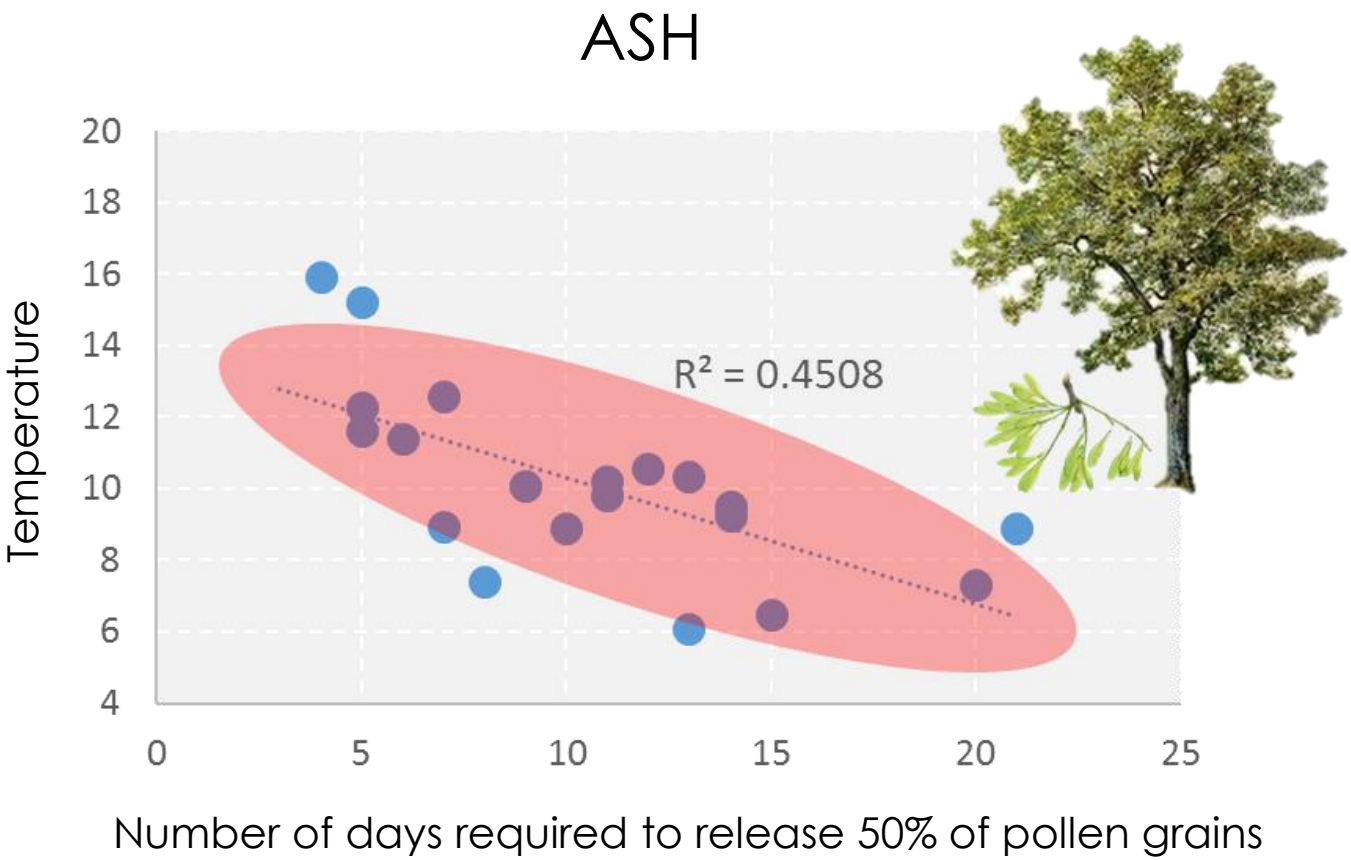




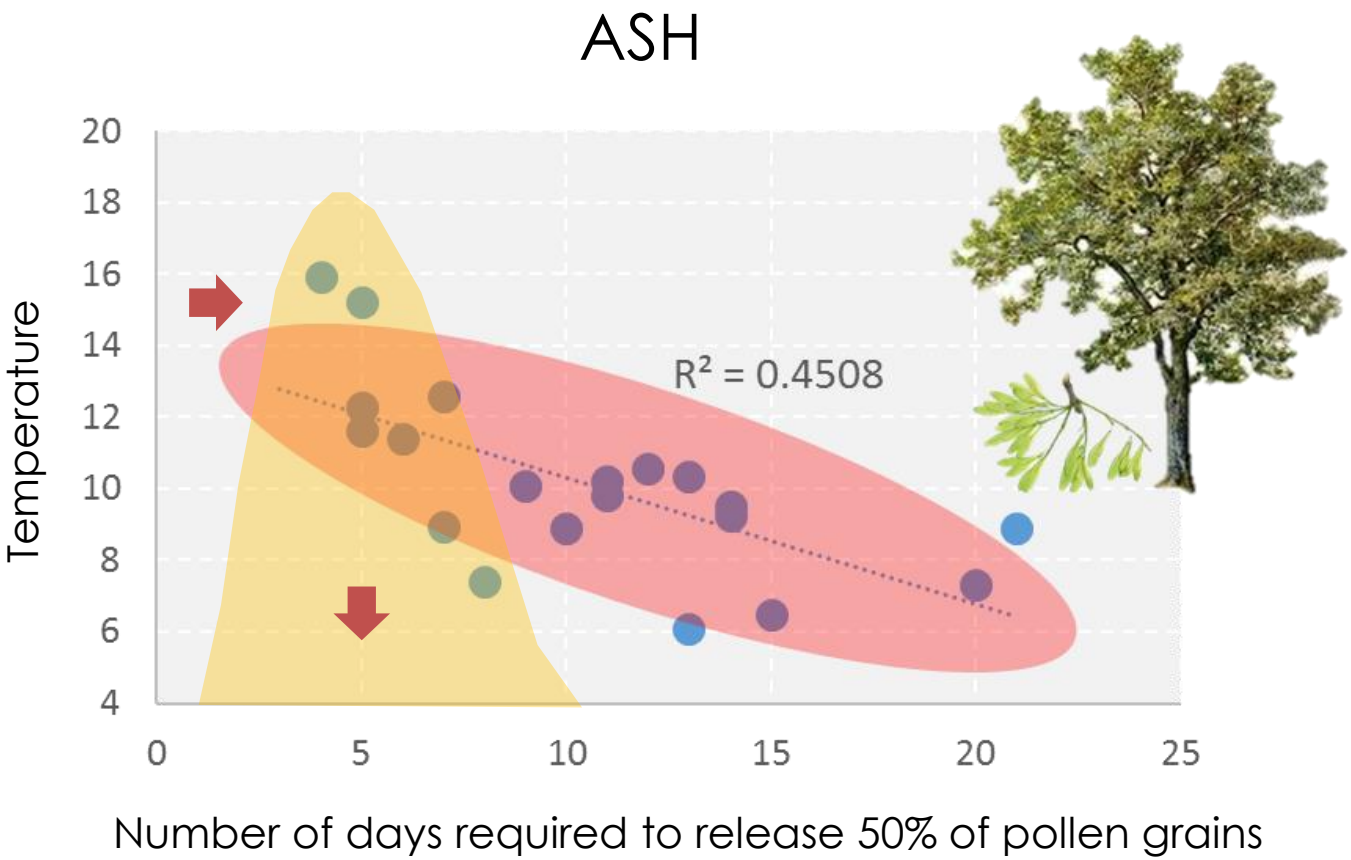
Temperature regulates the pace of pollen realease from anthers



Temperature regulates the pace of pollen realease from anthers



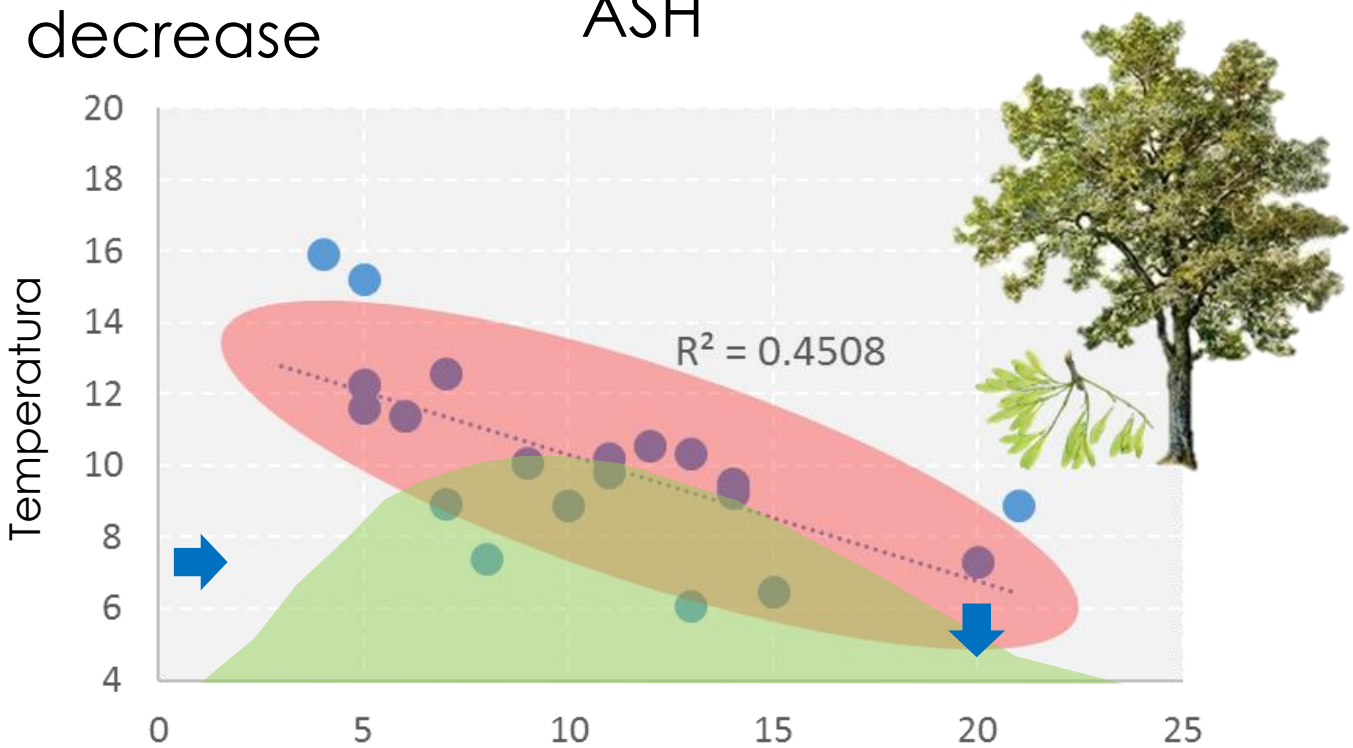
Temperature regulates the pace of pollen realease from anthers



Temperature regulates the pace of pollen realease from anthers

2x temperature decrease

ASH



Number of days required to release 50% of pollen grains

Duration of pollen seasons of weeds in Poznań

Table 4 Mann–Kendall trend test (test *Z* column) and Sen's slope estimate (*Q* column) of pollen season parameters of weed taxa

Pollen season parameter	Poaceae		*Rumex* spp.		Urticaceae		*Artemisia* spp.	
	Test *Z*	*Q*	Test *Z*	*Q*	Test *Z*	*Q*	Test *Z*	*Q*
Start date (DOY)	−2.12*	−1.03	−0.59	−0.31	−1.04	−0.39	−2.86**	−0.75
End date (DOY)	2.7**	1.86	2.66**	2.81	2.60**	1.41	2.26*	1.27
Peak date (DOY)	−0.27	−0.22	1.40	1.56	−1.22	−0.79	0.46	0.10
Duration (days)	3.52**	3.00	2.75**	3.76	2.12*	2.00	2.75**	2.49
Peak value (P/m³)	−0.81	−6.56	−1.67	−1.50	0.41	7.96	−1.76	−7.32
SPI (pollen)	−0.41	−58.5	−1.22	−11.75	1.49	517.17	−2.12*	−81.33

*$p<0.05$; **$p<0.01$

+2-4 day/year

grasses sorrel nettle mugwort

Bogawski et al. (2014)

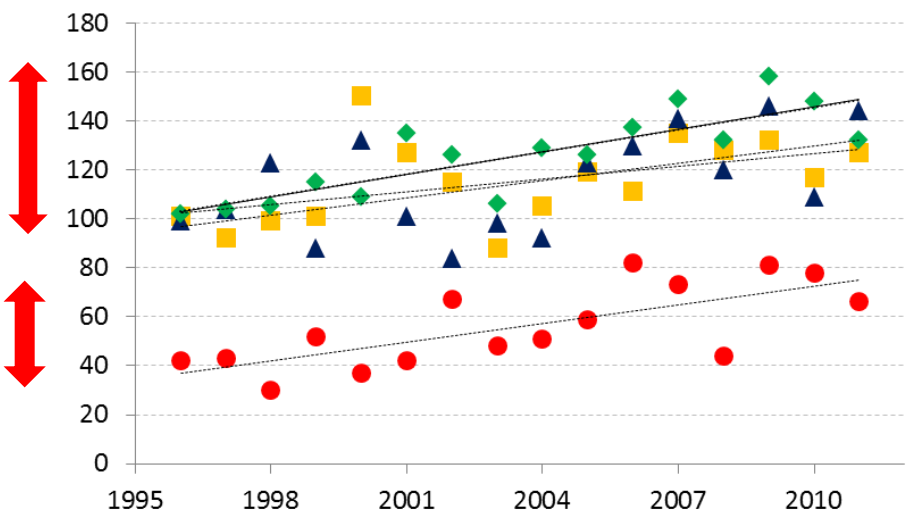
Duration of pollen seasons of weeds in Poznań

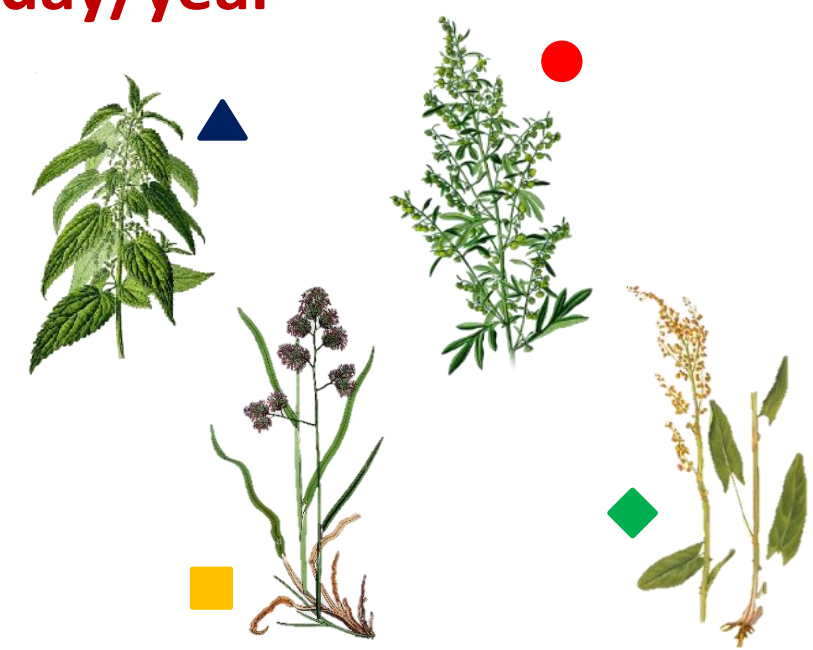
Table 4 Mann–Kendall trend test (test *Z* column) and Sen's slope estimate (*Q* column) of pollen season parameters of weed taxa

Pollen season parameter	Poaceae		*Rumex* spp.		Urticaceae		*Artemisia* spp.	
	Test *Z*	*Q*	Test *Z*	*Q*	Test *Z*	*Q*	Test *Z*	*Q*
Start date (DOY)	−2.12*	−1.03	−0.59	−0.31	−1.04	−0.39	−2.86**	−0.75
End date (DOY)	2.7**	1.86	2.66**	2.81	2.60**	1.41	2.26*	1.27
Peak date (DOY)	−0.27	−0.22	1.40	1.56	−1.22	−0.79	0.46	0.10
Duration (days)	3.52**	3.00	2.75**	3.76	2.12*	2.00	2.75**	2.49
Peak value (P/m^3)	−0.81	−6.56	−1.67	−1.50	0.41	7.96	−1.76	−7.32
SPI (pollen)	−0.41	−58.5	−1.22	−11.75	1.49	517.17	−2.12*	−81.33

*$p<0.05$; **$p<0.01$

+2-4 day/year





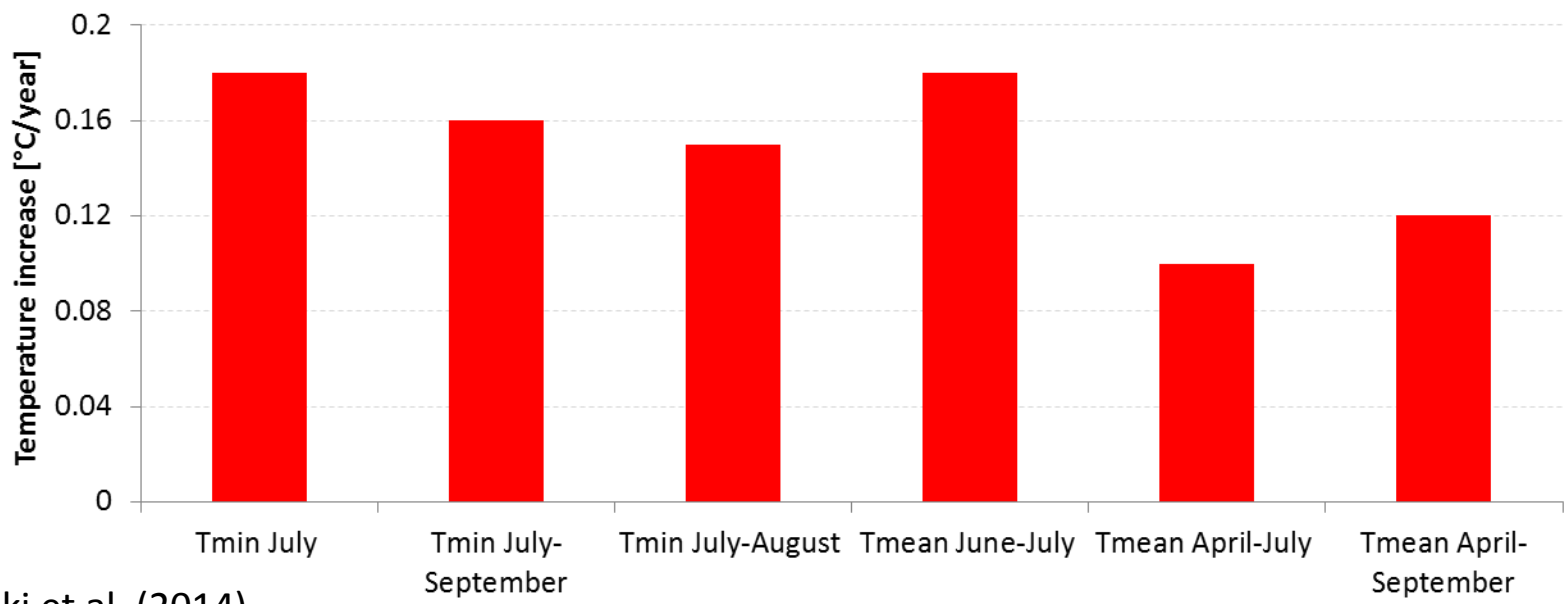
Bogawski et al. (2014)

Duration of pollen seasons of weeds in Poznań

Table 4 Mann–Kendall trend test (test *Z* column) and Sen's slope estimate (*Q* column) of pollen season parameters of weed taxa

Pollen season parameter	Poaceae		*Rumex* spp.		Urticaceae		*Artemisia* spp.	
	Test *Z*	*Q*	Test *Z*	*Q*	Test *Z*	*Q*	Test *Z*	*Q*
Start date (DOY)	−2.12*	−1.03	−0.59	−0.31	−1.04	−0.39	−2.86**	−0.75
End date (DOY)	2.7**	1.86	2.66**	2.81	2.60**	1.41	2.26*	1.27
Peak date (DOY)	−0.27	−0.22	1.40	1.56	−1.22	−0.79	0.46	0.10
Duration (days)	3.52**	3.00	2.75**	3.76	2.12*	2.00	2.75**	2.49
Peak value (P/m^3)	−0.81	−6.56	−1.67	−1.50	0.41	7.96	−1.76	−7.32
SPI (pollen)	−0.41	−58.5	−1.22	−11.75	1.49	517.17	−2.12*	−81.33

*$p<0.05$; **$p<0.01$



Bogawski et al. (2014)

Duration of pollen seasons of weeds in Poznań

Table 4 Mann–Kendall trend test (test *Z* column) and Sen's slope estimate (*Q* column) of pollen season parameters of weed taxa

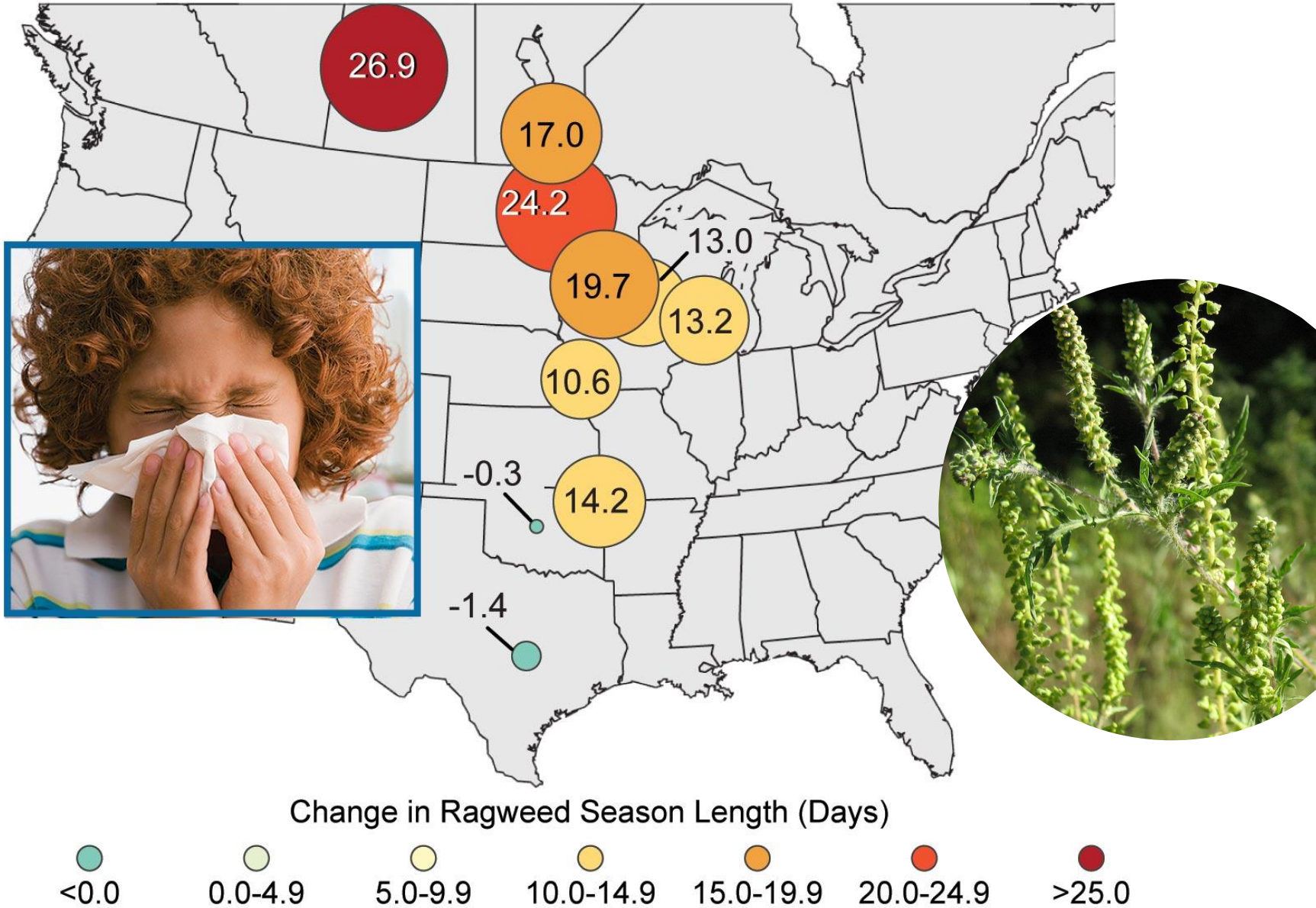
Pollen season parameter	Poaceae		*Rumex* spp.		Urticaceae		*Artemisia* spp.	
	Test *Z*	*Q*	Test *Z*	*Q*	Test *Z*	*Q*	Test *Z*	*Q*
Start date (DOY)	−2.12*	−1.03	−0.59	−0.31	−1.04	−0.39	−2.86**	−0.75
End date (DOY)	2.7**	1.86	2.66**	2.81	2.60**	1.41	2.26*	1.27
Peak date (DOY)	−0.27	−0.22	1.40	1.56	−1.22	−0.79	0.46	0.10
Duration (days)	3.52**	3.00	2.75**	3.76	2.12*	2.00	2.75**	2.49
Peak value (P/m^3)	−0.81	−6.56	−1.67	−1.50	0.41	7.96	−1.76	−7.32
SPI (pollen)	−0.41	−58.5	−1.22	−11.75	1.49	517.17	−2.12*	−81.33

*$p<0.05$; **$p<0.01$

Taxon	T_{mean} April-July	T_{mean} April-September	T_{mean} June-July	T_{min} July	T_{min} July-August	T_{min} July-September
Poaceae	ns	ns	0.536*	0.649**	0.780**	0.830**
Rumex sp.	ns	ns	ns	ns	ns	ns
Urticaceae	ns	ns	ns	ns	ns	ns
Artemisia sp.	0.532*	0.691**	0.686**	0.732**	0.670**	0.750**

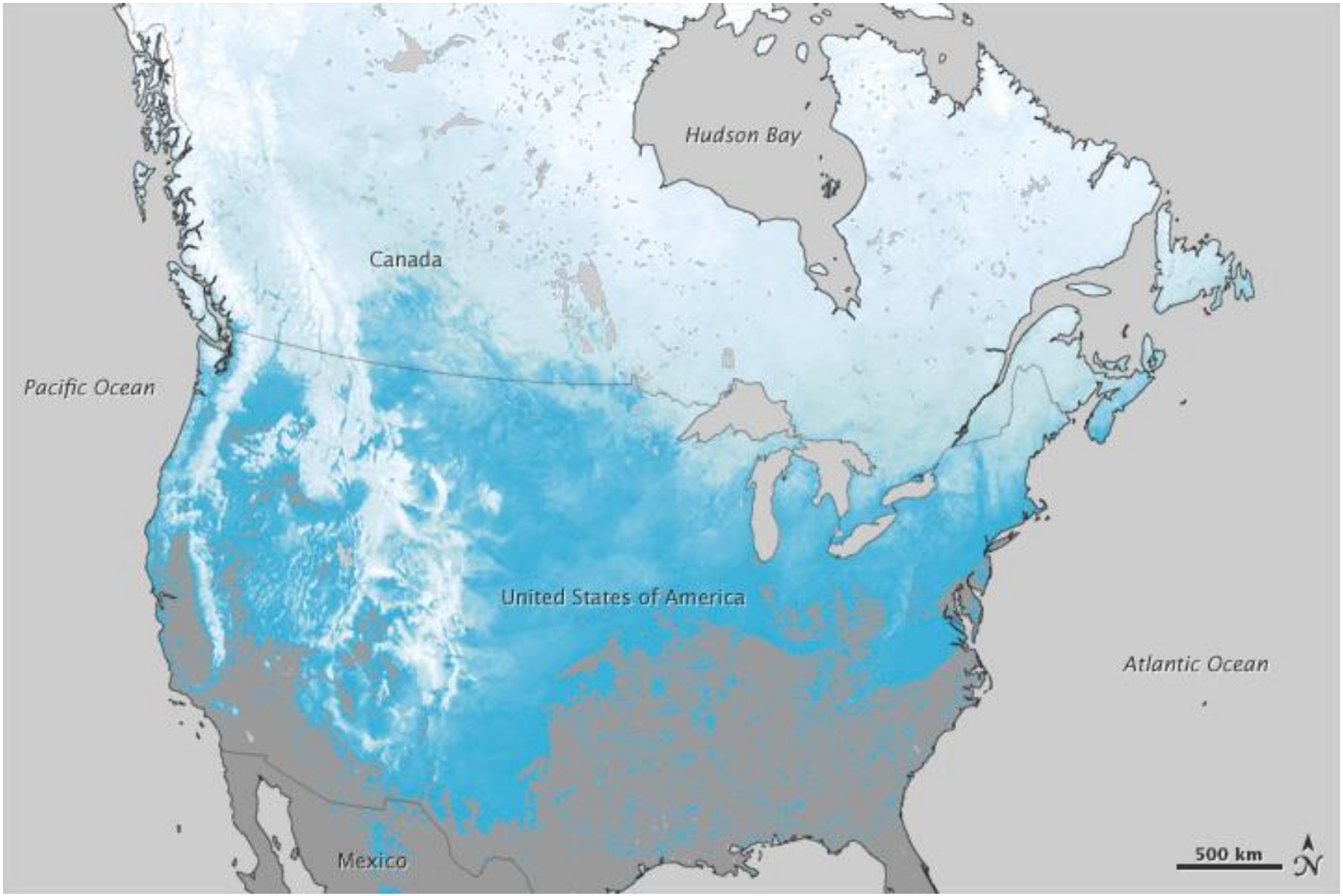
Bogawski et al. (2014)

RAGWEED pollen seasons in North America

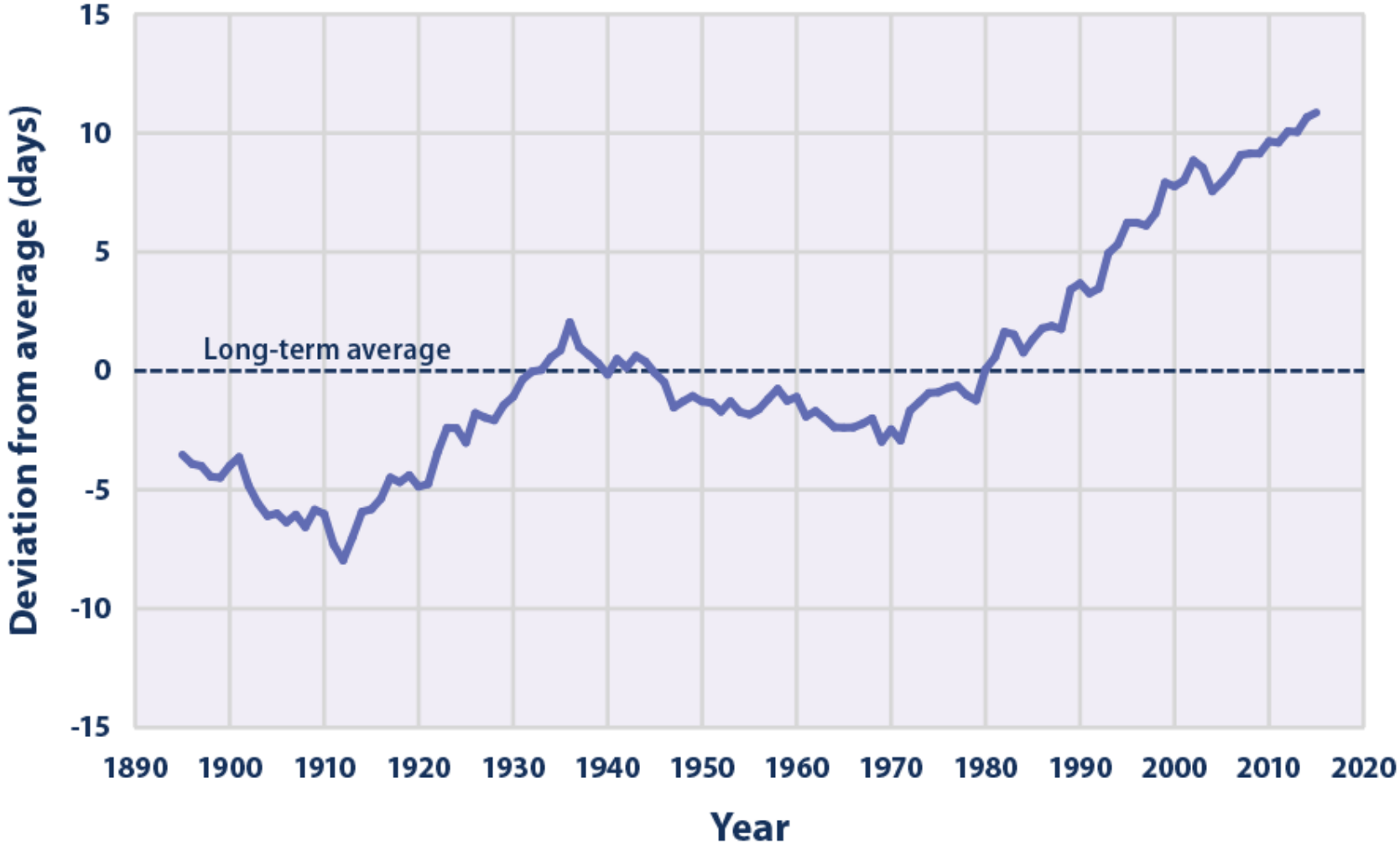


Ziska et al. 2011

Number of days before the first frost

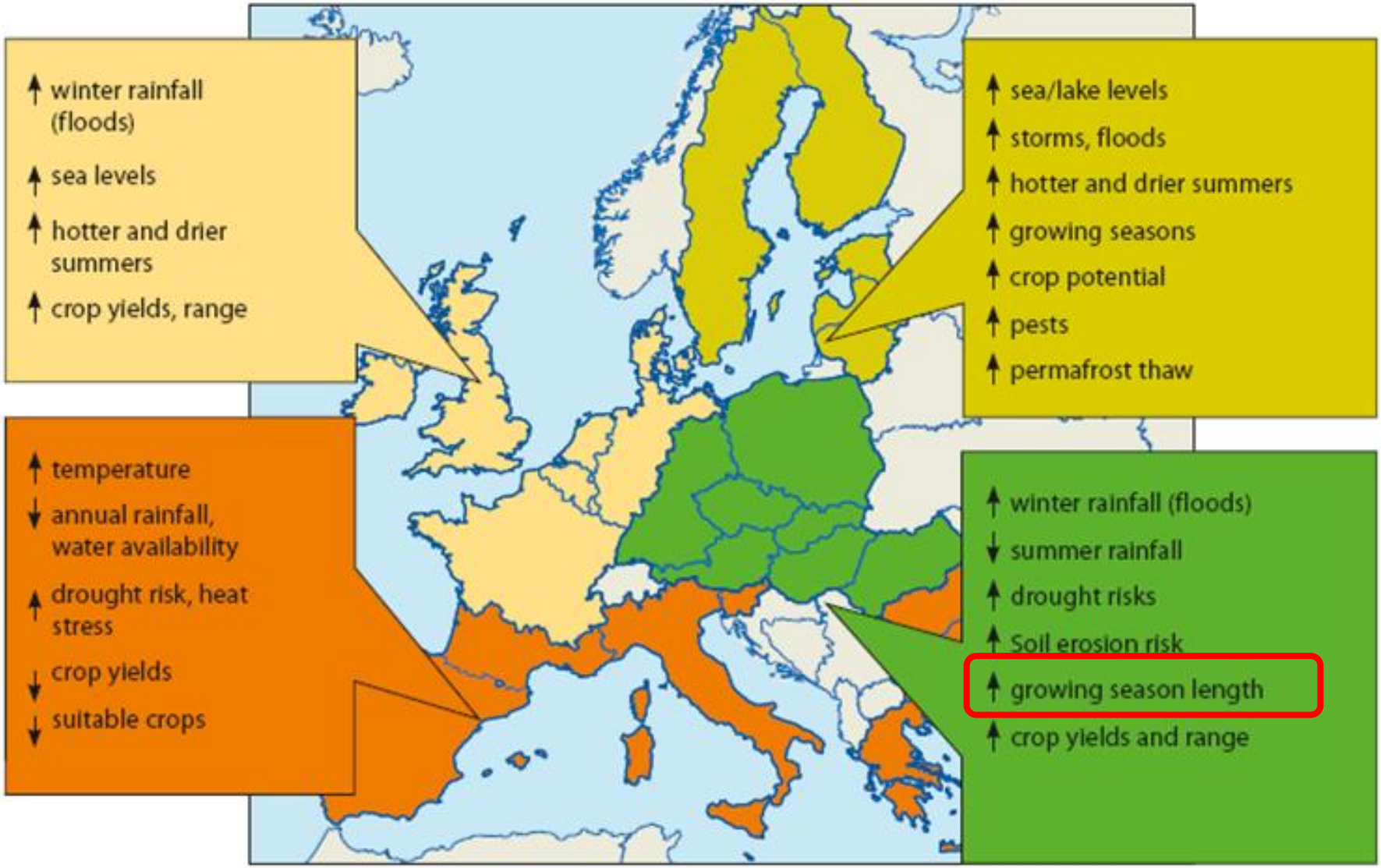


Length of Growing Season in the Contiguous 48 States, 1895–2015



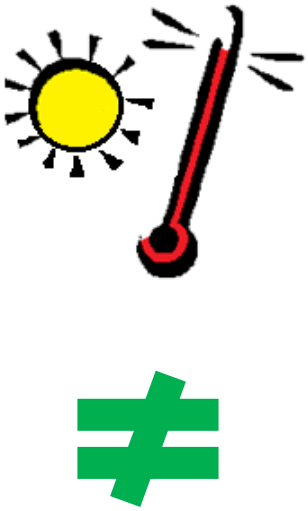
Data source: Kunkel, K.E. 2016 update to data originally published in: Kunkel, K.E., D.R. Easterling, K. Hubbard, and K. Redmond. 2004. Temporal variations in frost-free season in the United States: 1895–2000. Geophys. Res. Lett. 31:L03201.

For more information, visit U.S. EPA's "Climate Change Indicators in the United States" at www.epa.gov/climate-indicators.



http://adapt2clima.eu/en/climate-change-agriculture

The effect of temperature on pollen season duration in not the same and varies depending on plant type, i.e. trees and weeds



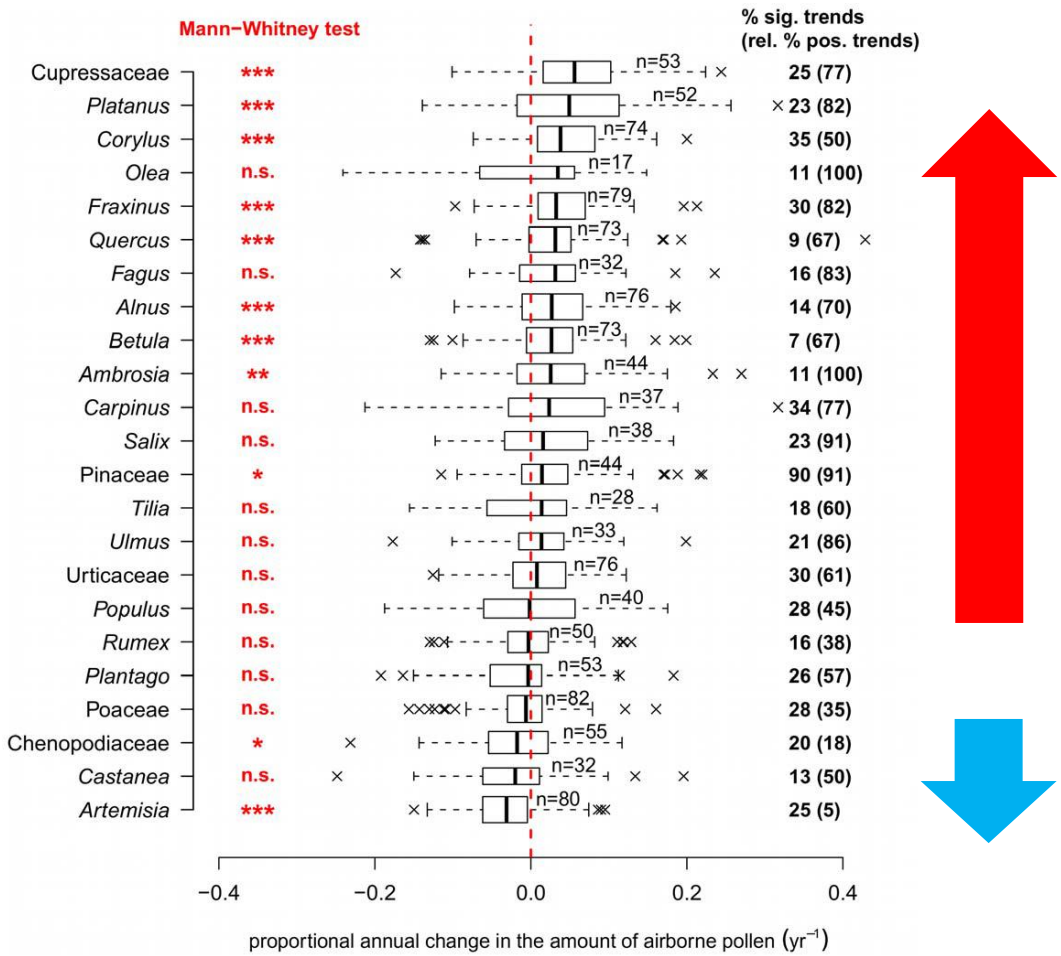
TREES

WEEDS

Shorter seasons

Longer seasons

Intensity of pollen seasons

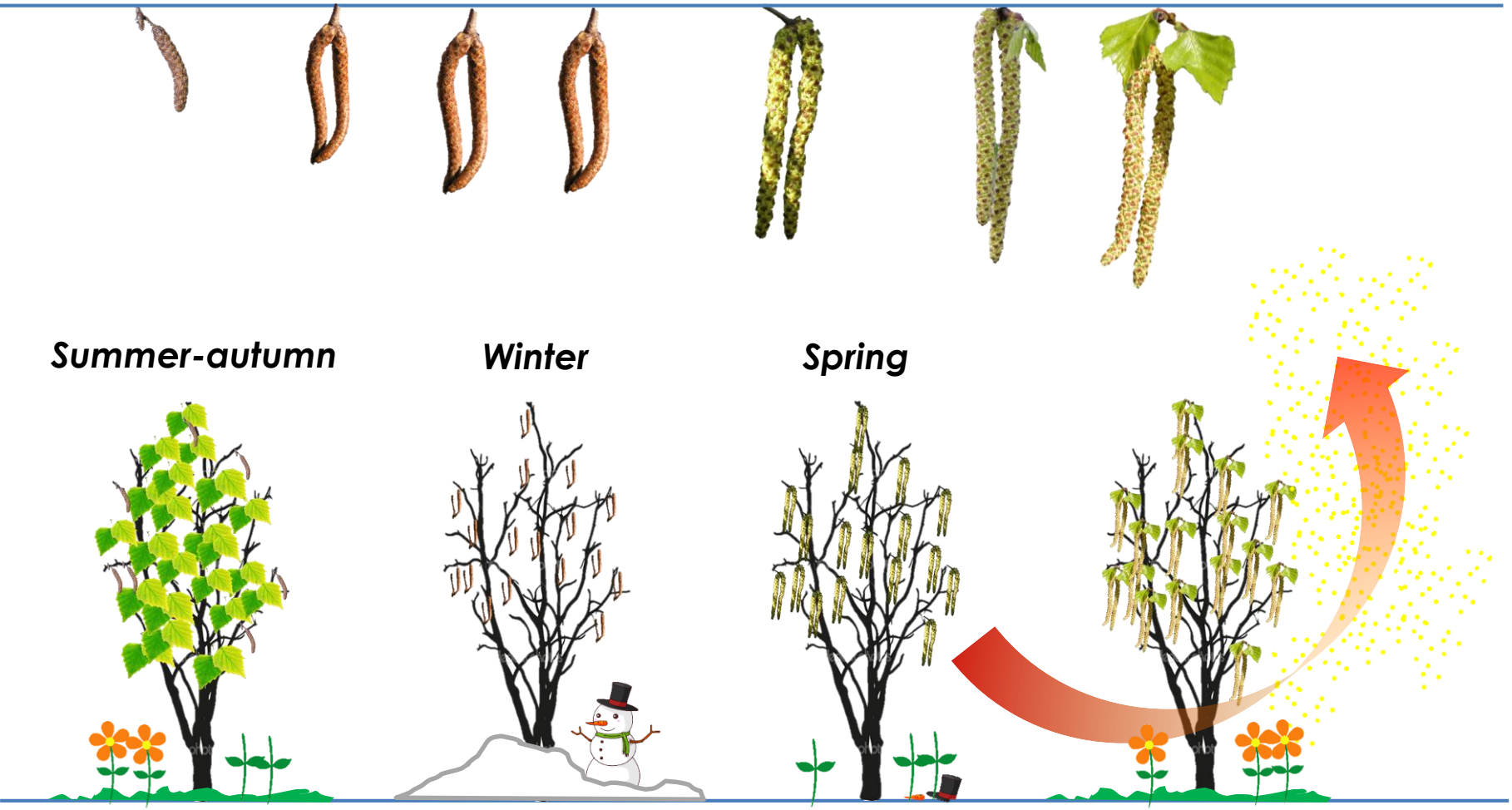


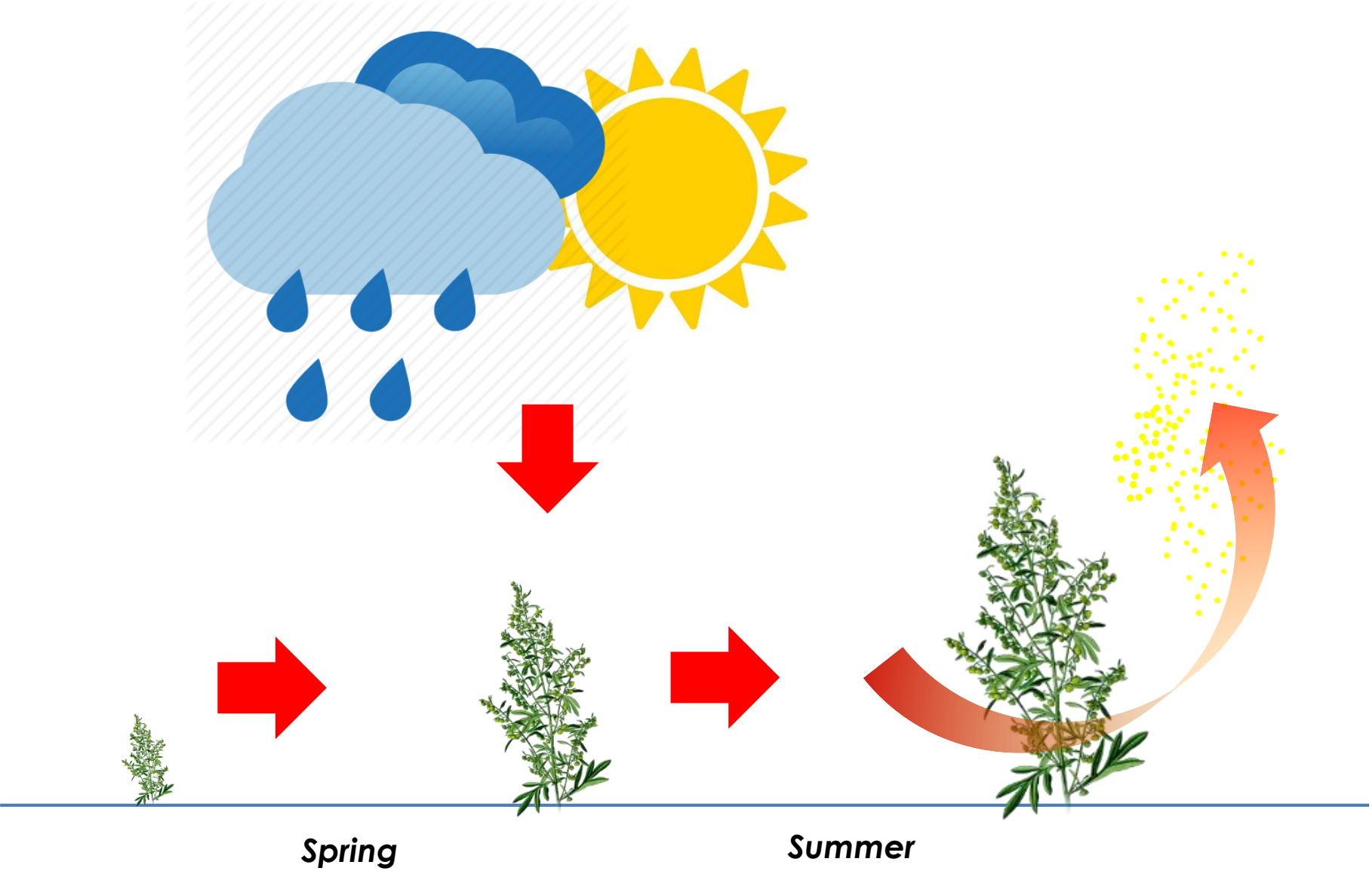
Intensity of pollen seasons of most of the plants is **increasing**

Ziello et al. (2012) PLoS One

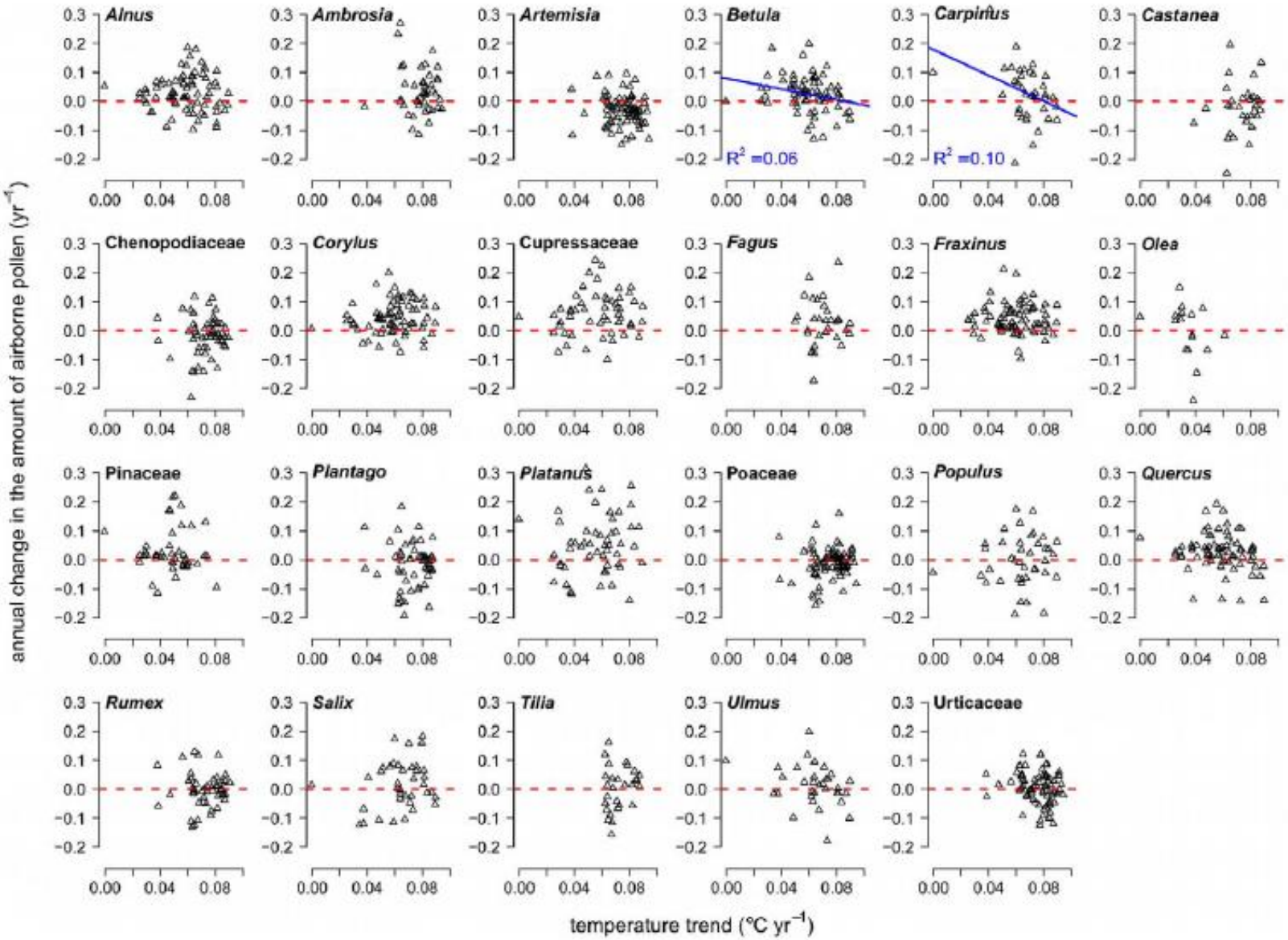
Development of plants and pollen production depends on weather conditions

Male catkins of birch




Spring
Summer

Temperature does not influence markedly on pollen season intensity



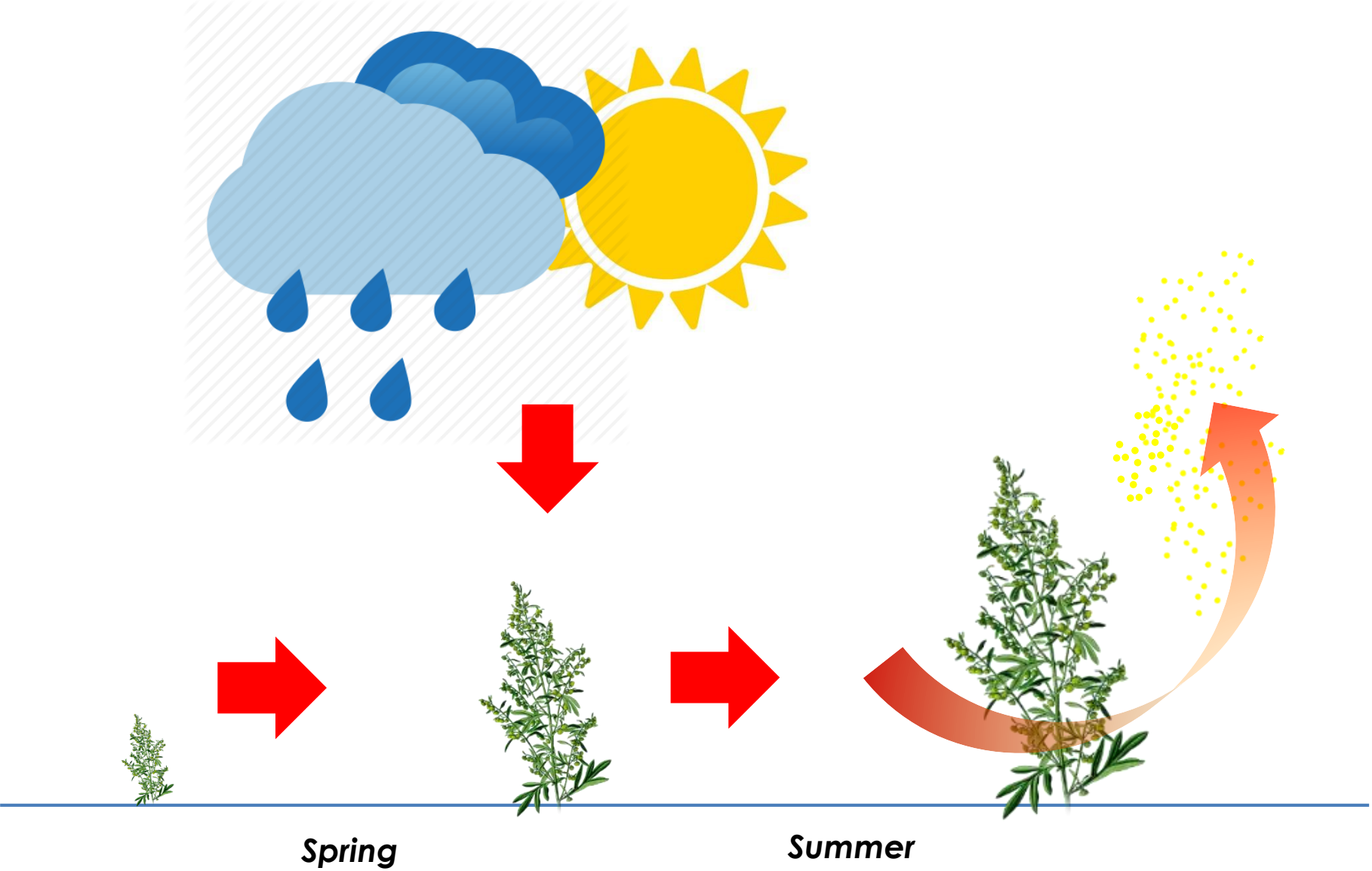
Ziello et al. (2012) PLoS One

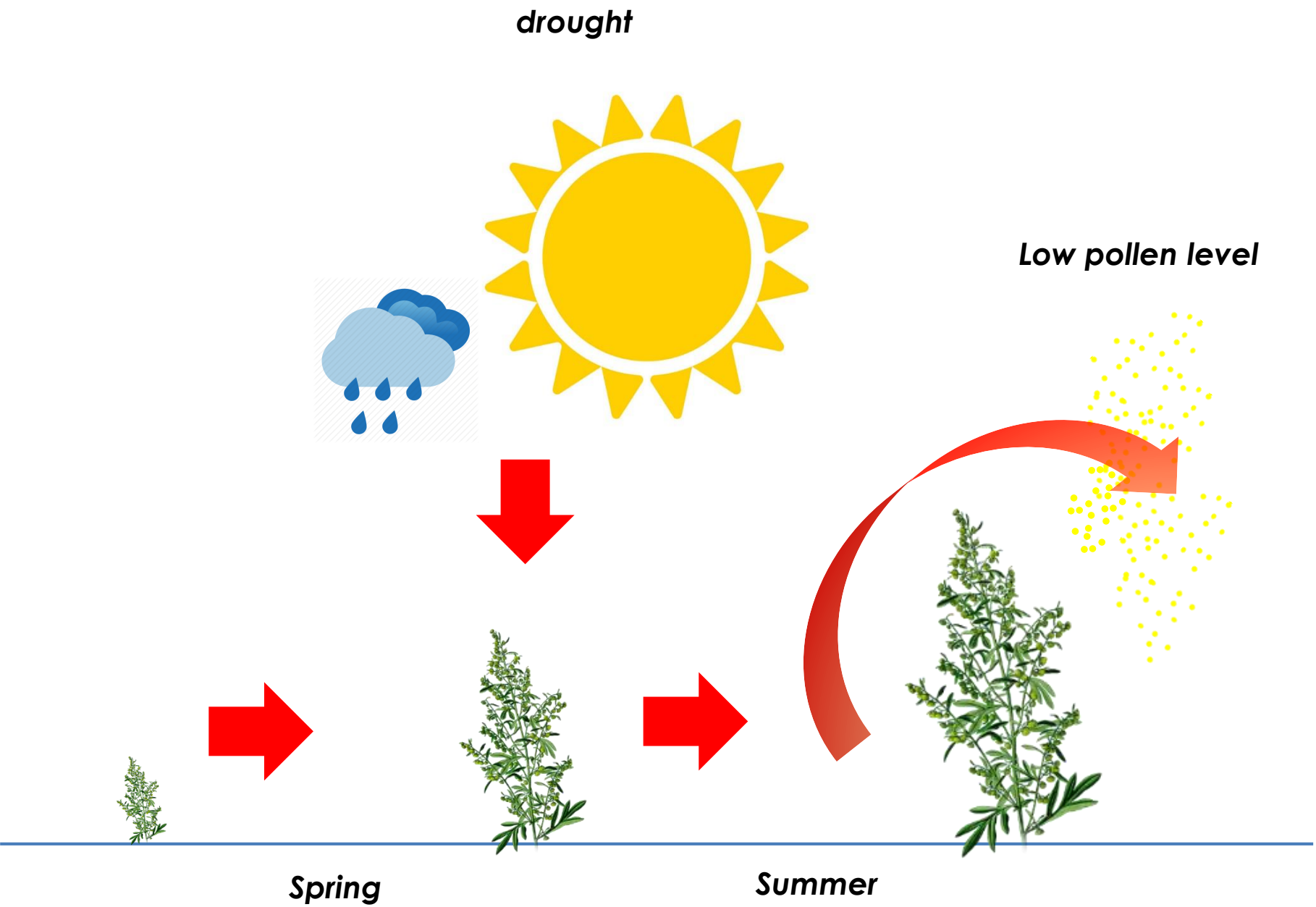
Table 4 Mann–Kendall trend test (test *Z* column) and Sen's slope estimate (*Q* column) of pollen season parameters of weed taxa

Pollen season parameter	Poaceae		*Rumex* spp.		Urticaceae		*Artemisia* spp.	
	Test *Z*	*Q*	Test *Z*	*Q*	Test *Z*	*Q*	Test *Z*	*Q*
Start date (DOY)	−2.12*	−1.03	−0.59	−0.31	−1.04	−0.39	−2.86**	−0.75
End date (DOY)	2.7**	1.86	2.66**	2.81	2.60**	1.41	2.26*	1.27
Peak date (DOY)	−0.27	−0.22	1.40	1.56	−1.22	−0.79	0.46	0.10
Duration (days)	3.52**	3.00	2.75**	3.76	2.12*	2.00	2.75**	2.49
Peak value (P/m^3)	−0.81	−6.56	−1.67	−1.50	0.41	7.96	−1.76	−7.32
SPI (pollen)	−0.41	−58.5	−1.22	−11.75	1.49	517.17	−2.12*	−81.33

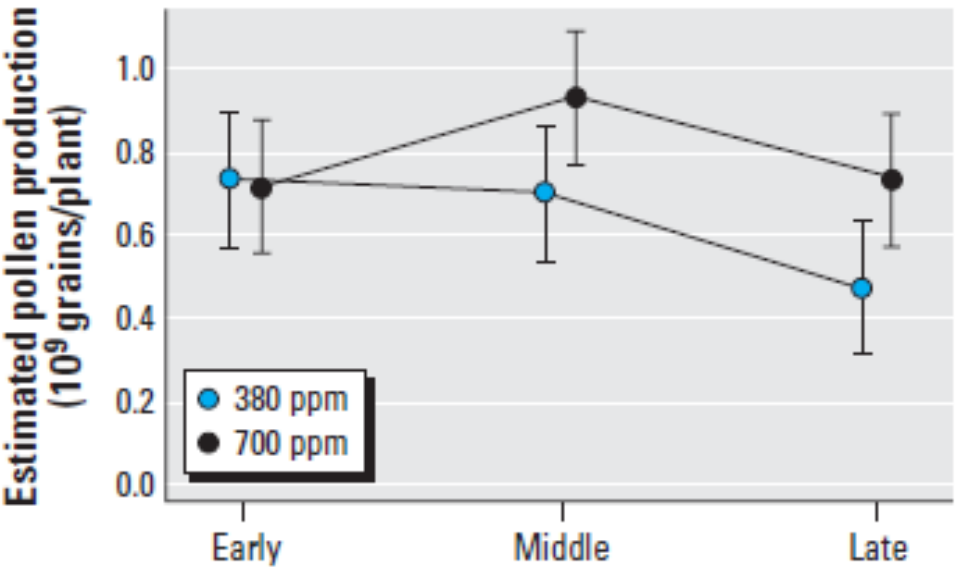
*$p<0.05$; **$p<0.01$

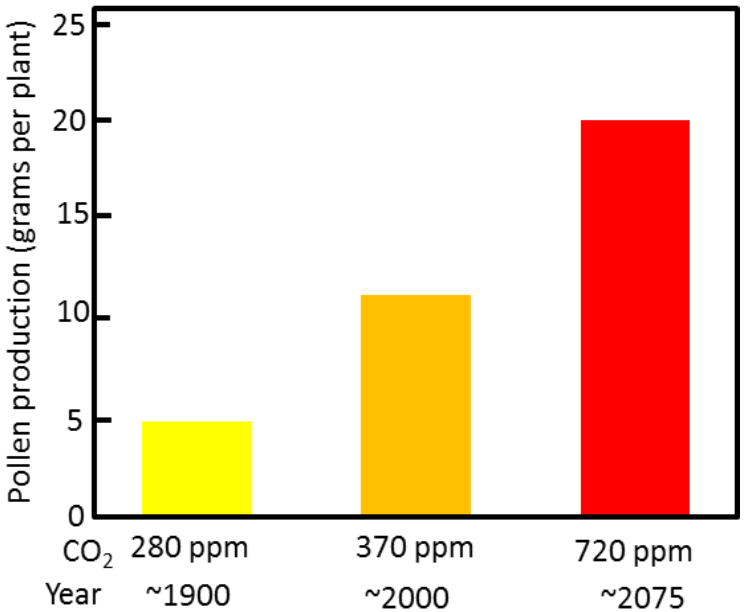
T_{mean} June–July	T_{min} July	T_{min} July–August	T_{min} July–September
ns	ns	–	–
ns	0.515*	0.627*	0.670**
0.536*	0.649**	0.780**	0.830**
ns	ns	ns	ns
ns	ns	ns	ns
–	–	–	–
ns	ns	–	–
ns	ns	ns	ns
ns	ns	ns	ns
ns	ns	ns	ns
ns	ns	ns	ns
–	–	–	–
ns	ns	ns	–
ns	ns	ns	ns
ns	ns	ns	ns
ns	ns	ns	ns
ns	ns	ns	ns
−0.728**	−0.805**	–	–
ns	ns	ns	
ns	0.552*	0.565*	0.626*
0.686**	0.732**	0.670**	0.750**
−0.629*	−0.547*	ns	−0.635**
−0.571*	−0.521*	−0.615*	−0.644**


Spring
Summer


drought
Low pollen level
Spring
Summer

CO_2 and the production of pollen grains

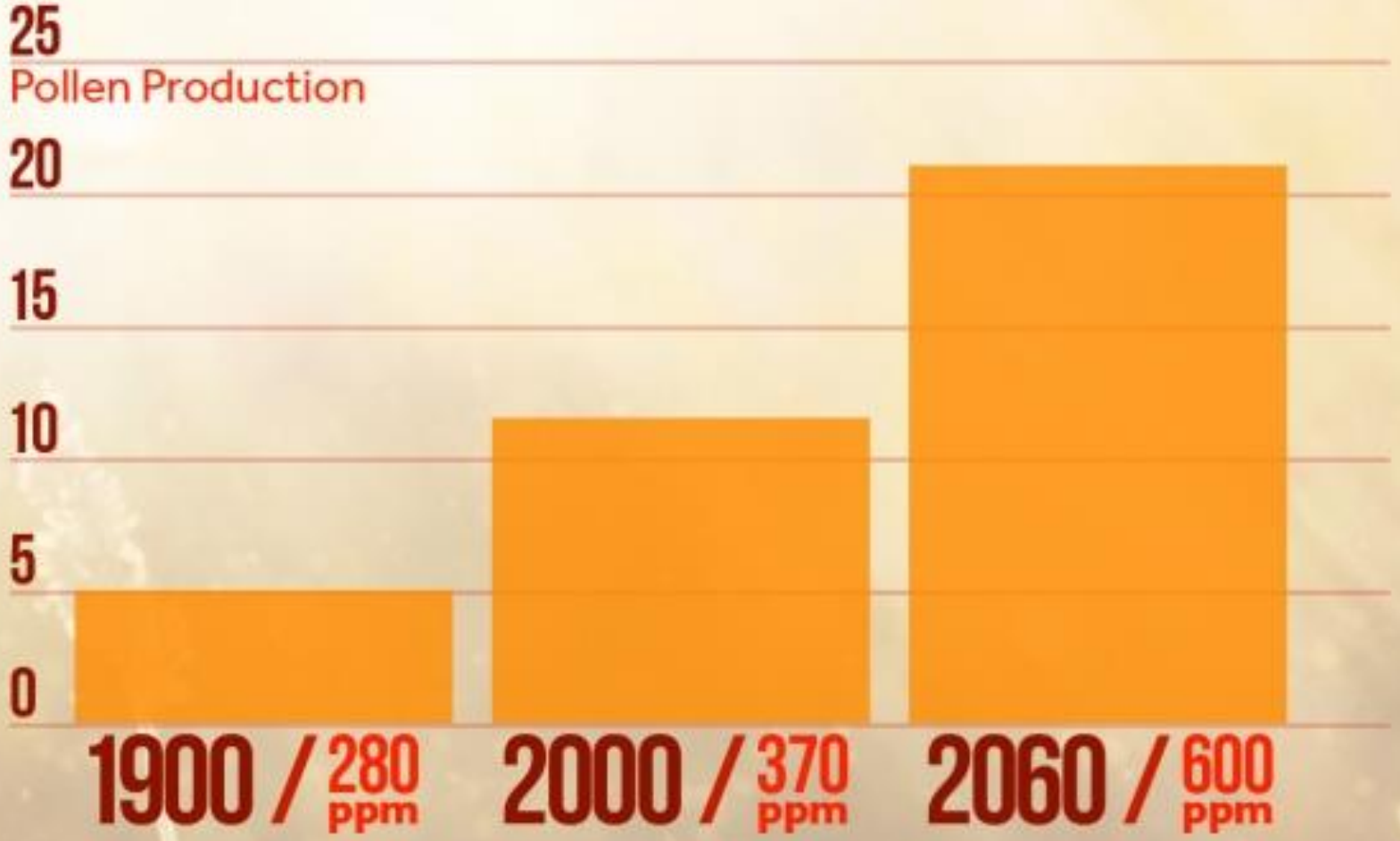




*„At **high CO_2 levels**, plants showed greater biomass and reproductive effort compared with those in ambient CO_2. Overall, ragweed **pollen production can be expected to increase** significantly under predicted future climate conditions" (Rogers et al. 2006).*

*„Under future predicted greenhouse gas emissions and associated climate conditions (…), there will be an overall **increase in ragweed pollen production**." (Ziska and Caulfield, 2000)*

MORE CO_2 = MORE POLLEN



Pollen Production: Grams Per Ragweed Plant
Source: Ziska et al. 2000

CLIMATE CENTRAL

In summary…

Pollen seasons start earlier
Pollen season are shorter
Pollen season more intense?

Pollen season start earlier
Pollen season are longer
Pollen season more intense