BIOLOGICAL AIR QUALITY

Carmen Galán, UCO (Spain) & Mikhail Sofiev, FMI (Finland)

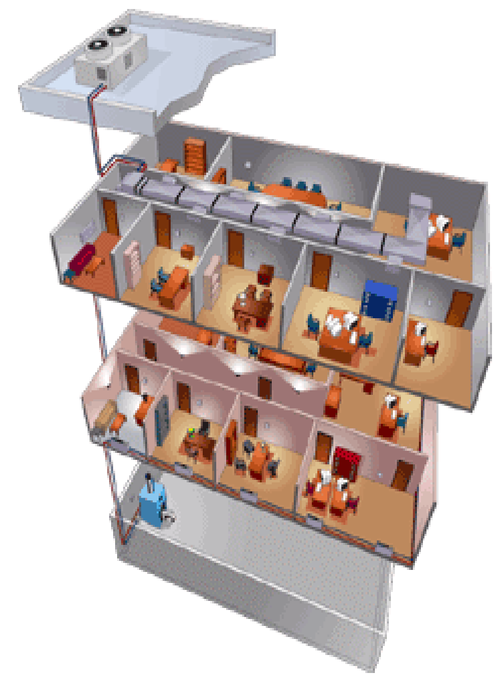
ATMOSPHERIC BIOAEROSOLS

Biological aerosol sources are located where biological activities exist and are exposed to air movements: most of the terrestrial surface can be considered as huge potential source of aerobiological material.

It should be consider natural sources; those generated by human activities: i.e. farming, agricultural and forestry processing; and those generating indoors.

natural sources

outdoor human activities



indoor human activities

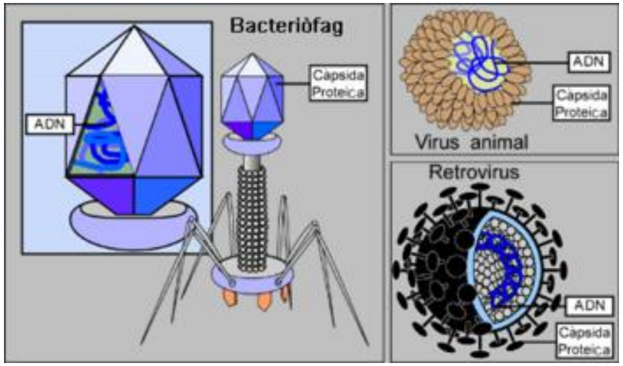
Organisms and biological matter

There are different organisms by using the air for their transport:

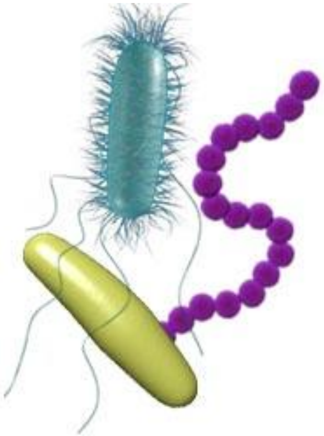
a) ***those by using the wind to transport the complete organisms***;

b) those that transport their propagules through the wind.

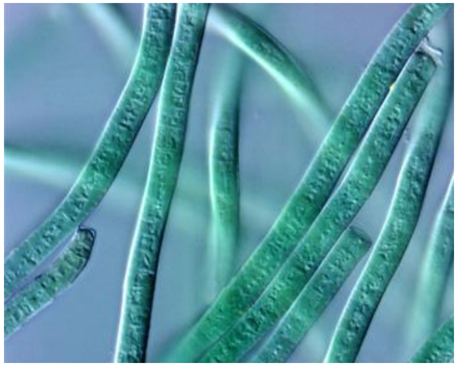
Living Organisms



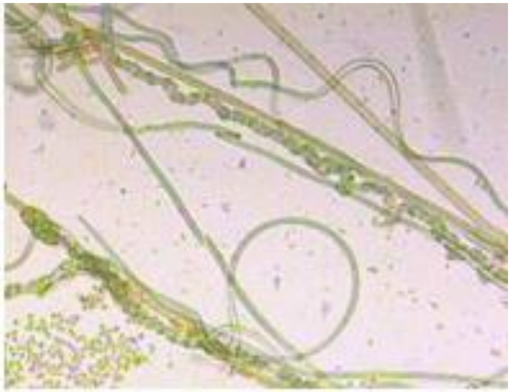
virus



bacteria



cianobacteria



microalgi

fountain, biodeteriory

insects

Organisms and biological matter

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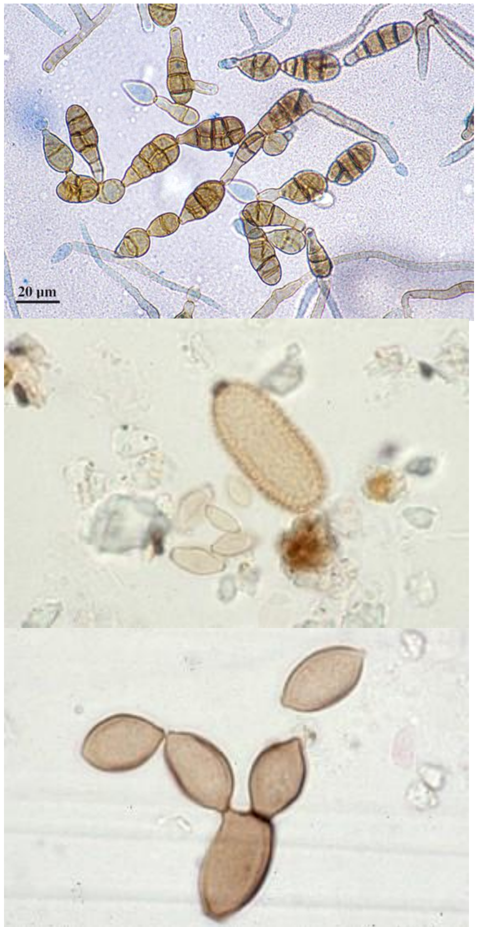
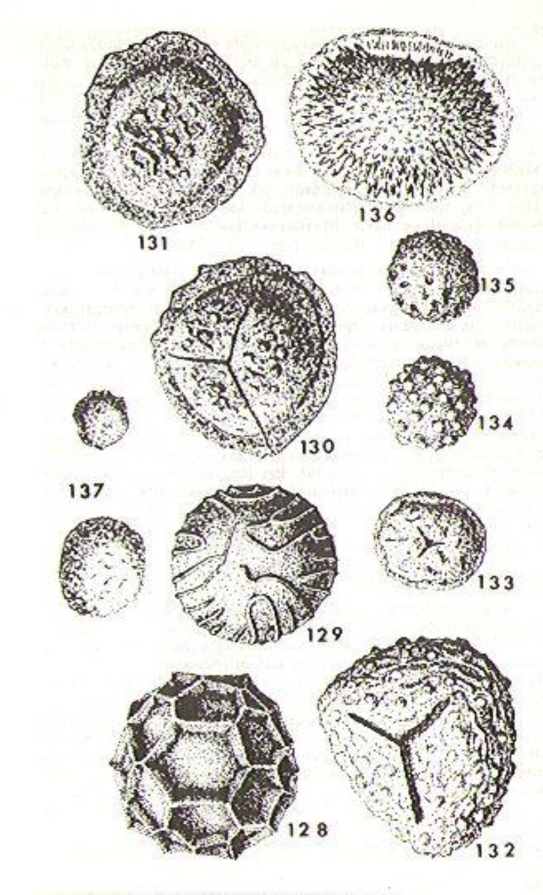
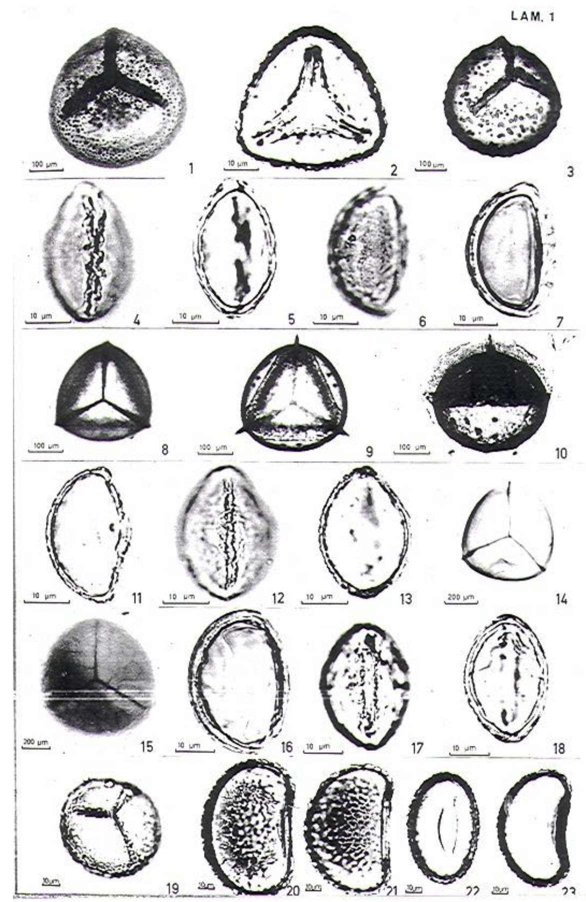
Biological particles



Fungal spores



Moss spores

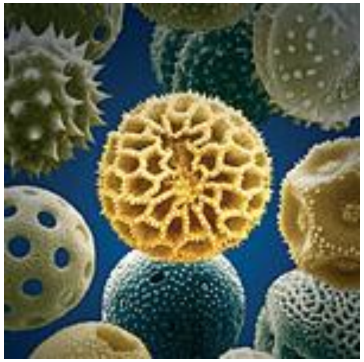


Fern spores

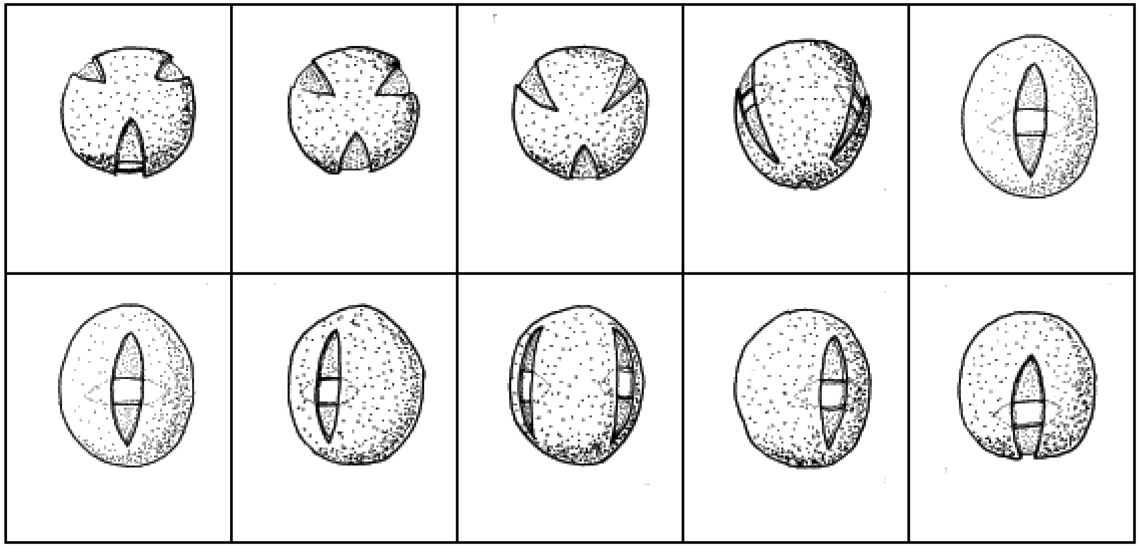
Lower plants

Biological particles

Higher Plants



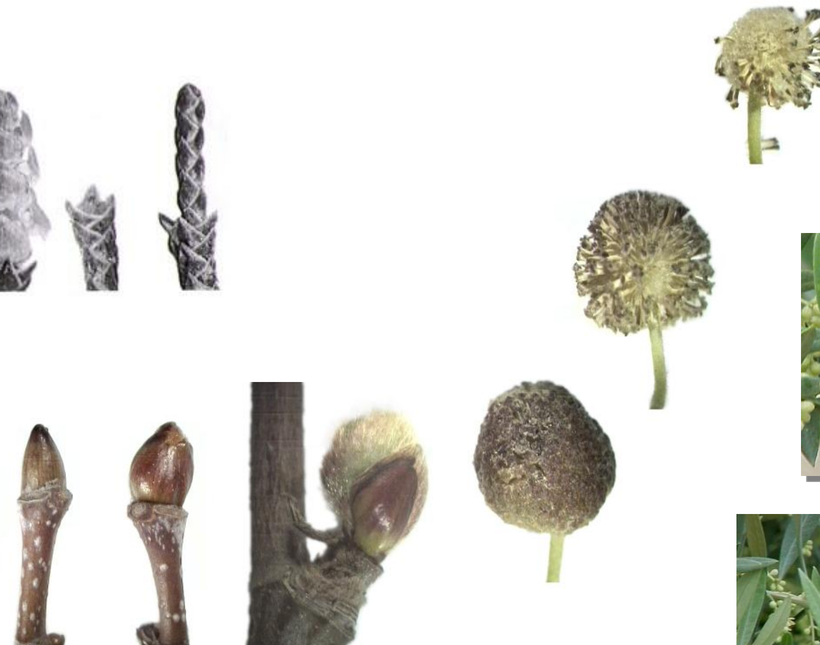
tricolporate pollen grain



Tormo, R. (http://www.unex.es/polen/LHB/)

Phenology is generally described as the art of observing life cycle phases or activities of plants and animals in their temporal occurrence through the year (Lieth, 1974)

Cupressus sempervirens



Platanus hispanica

Dactylis glomerata

Olea europaea

Phenology includes the study of periodic events as influenced by the environment, especially temperature changes driven by weather and climate (Schwartz, 2003)

Cupressus sempervirens

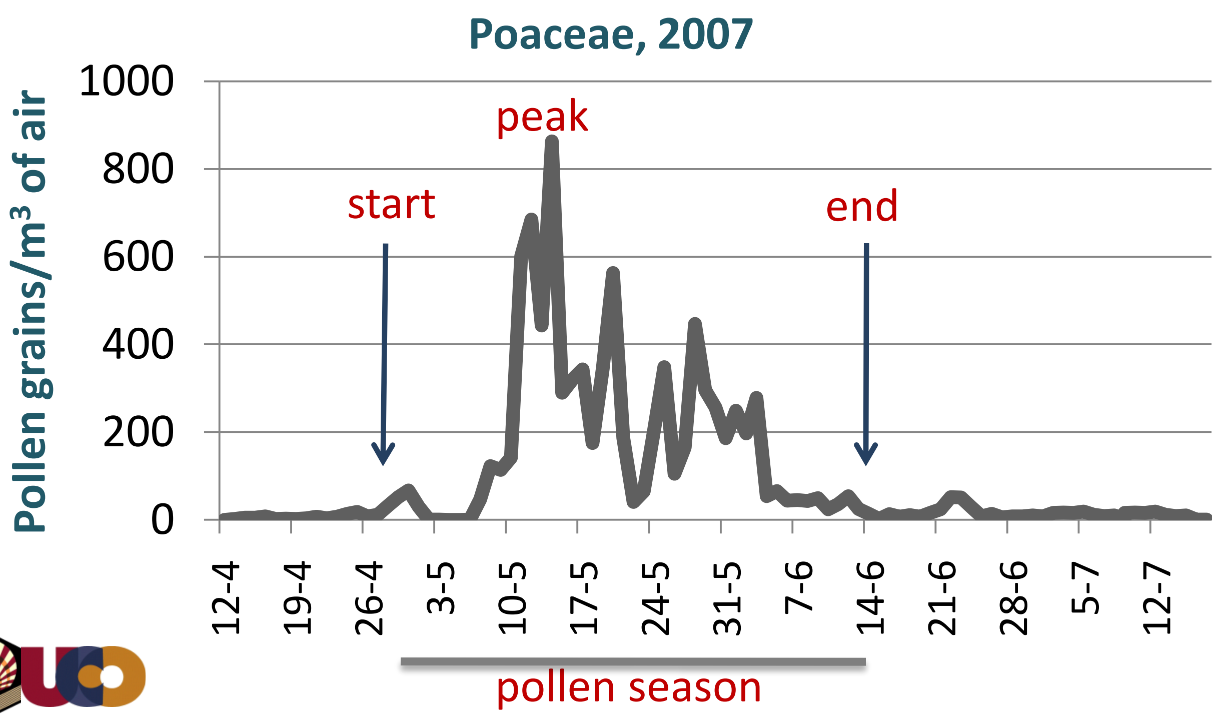
Platanus hispanica

Dactylis glomerata

Olea europaea

AEROBIOLOGY

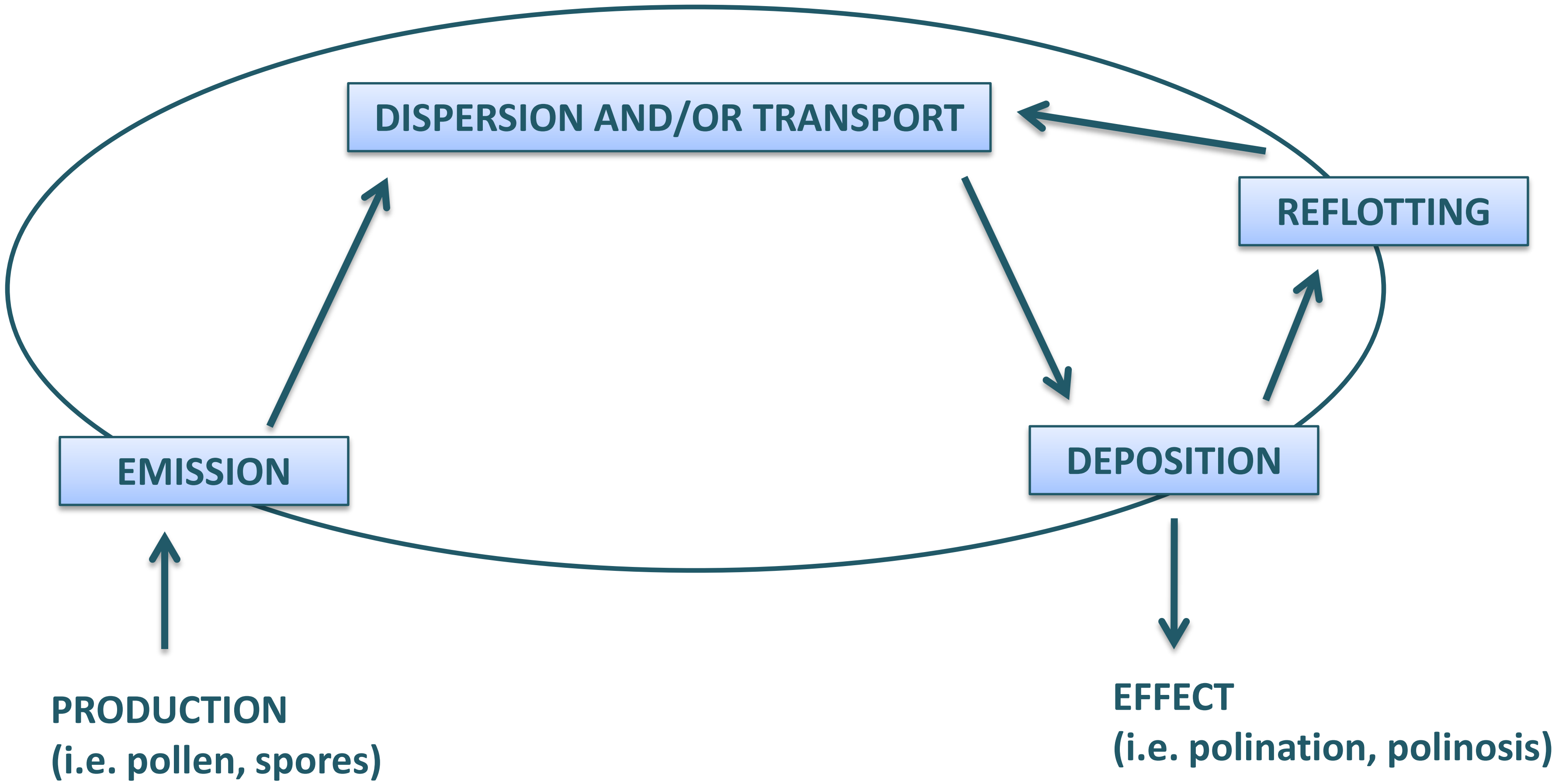
Discipline that study ***passive transport*** of biological matter and living organisms through the air; paying attention to the ***production sources*** of these organisms and material emitted to the atmosphere, their ***emission, transport*** and ***deposition***, and their ***impact*** on fungi, vegetables, animals and humans.



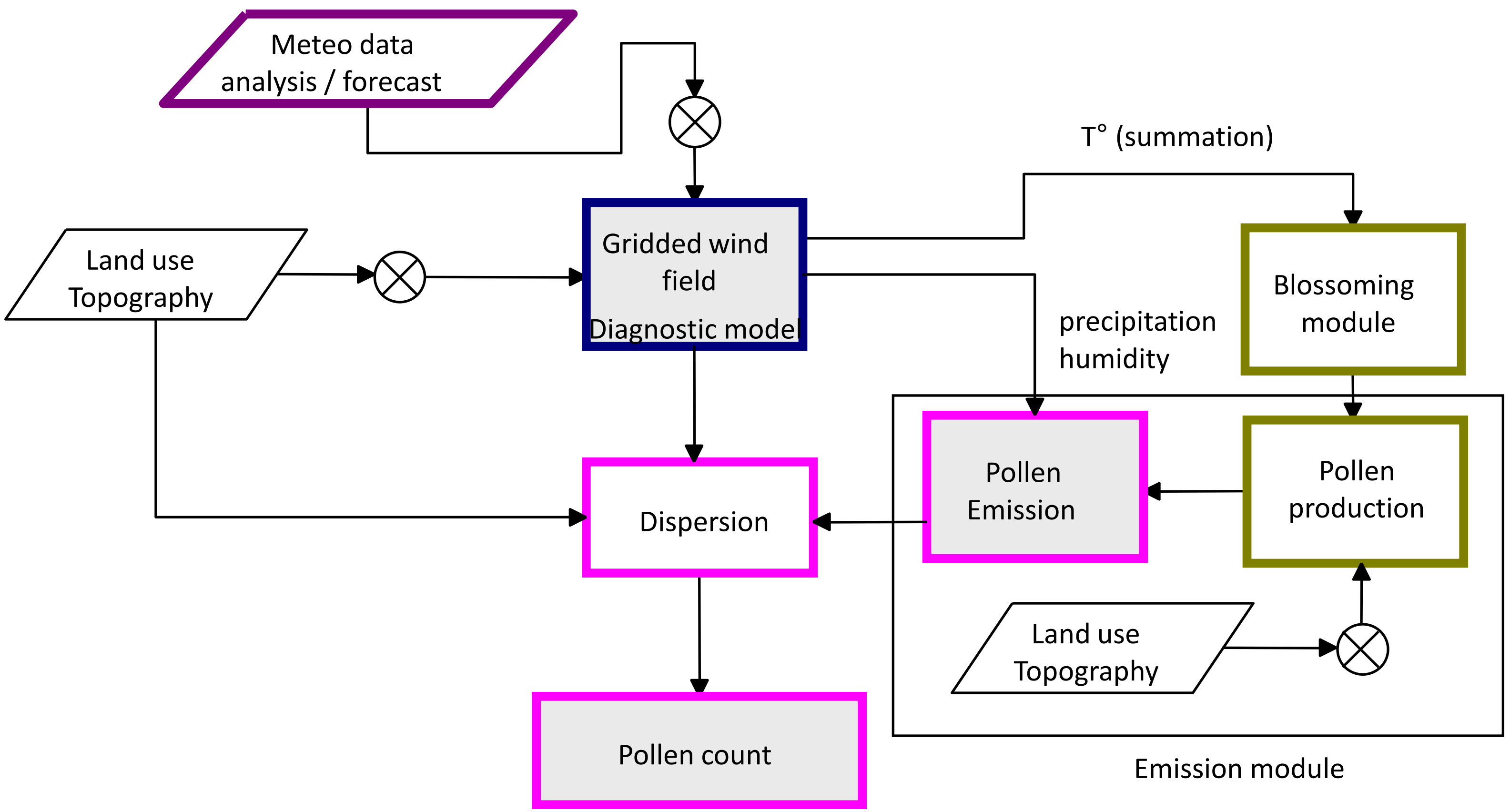
Knowledge about pollen content in the air offers a quantitative value on floral phenology

Pollen Grains as Biological Particles Involved in Different Aerobiological Processes

AEROBIOLOGICAL PROCESSES



Forecast system for aeroallergen dispersion overall processing chain



Forecast system for aero-allergen dispersion

The forecast system includes four computational modules:

1. **a meteorological module** to resample the low resolution data provided by the meteorological agencies to a higher resolution needed by the dispersion module;
2. **a blossoming module** to predict the pollen season onset;
3. **an emission module** split into two parts: the potential pollen production to be spread (it depends on land use, topography and phenological behaviour) and the emission rate of pollen (it depends on external factors – e.g. humidity, wind);
4. **a dispersion module** to predict the evolution of pollen counts anywhere in the computational domain.

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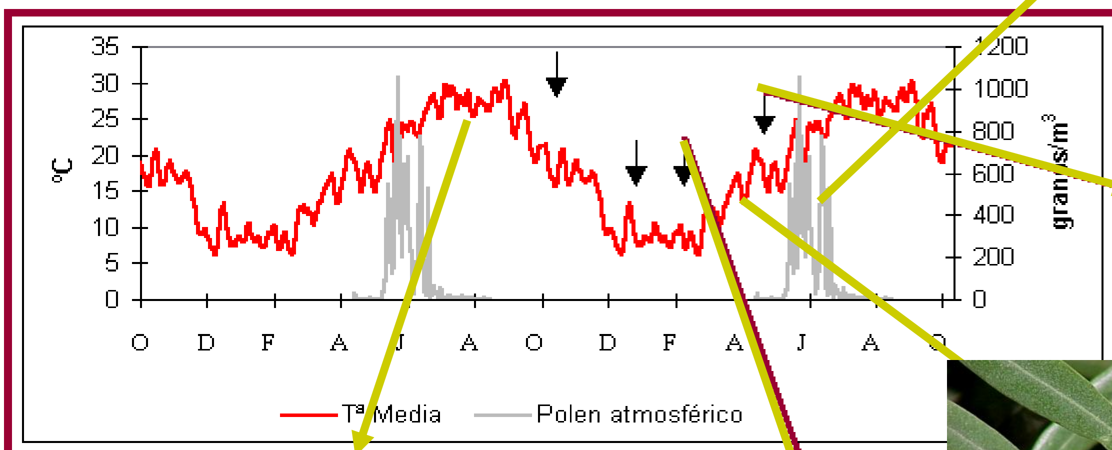
blossoming module

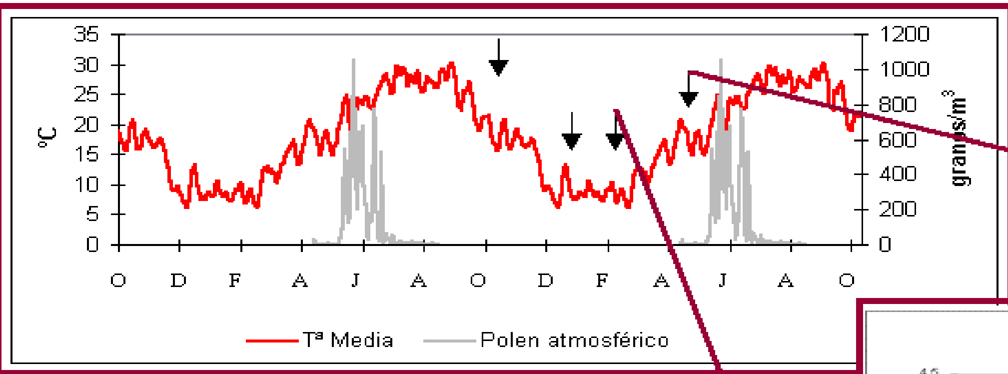
Floral phenology / Aerobiology: pheno-climatic parameters

I.e.: Winter duration and severity & spring warming control the start and intensity of temperate tree pollination

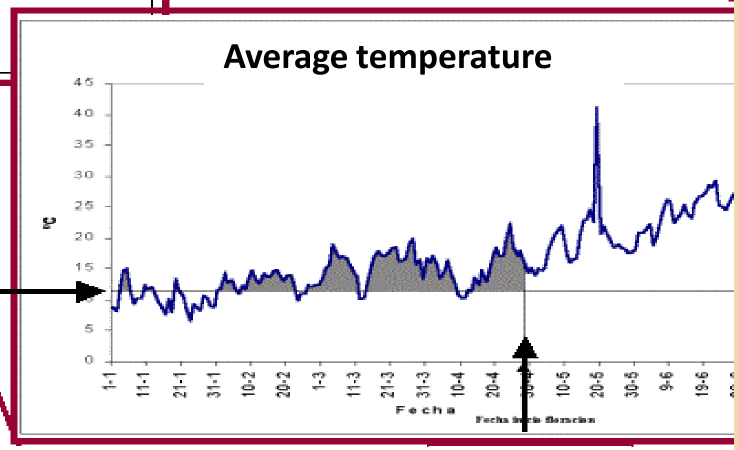


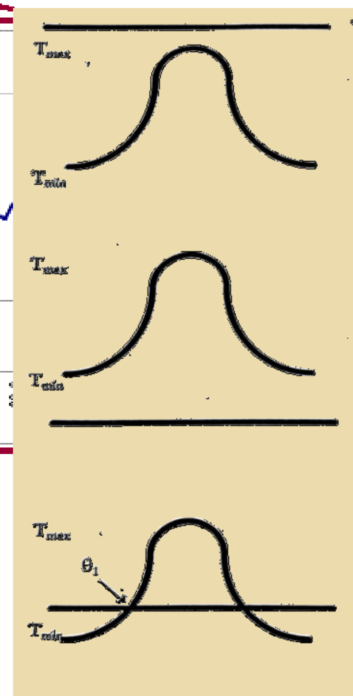
blossoming module

Floral phenology / Aerobiology: pheno-climatic parameters



Threshold temperature

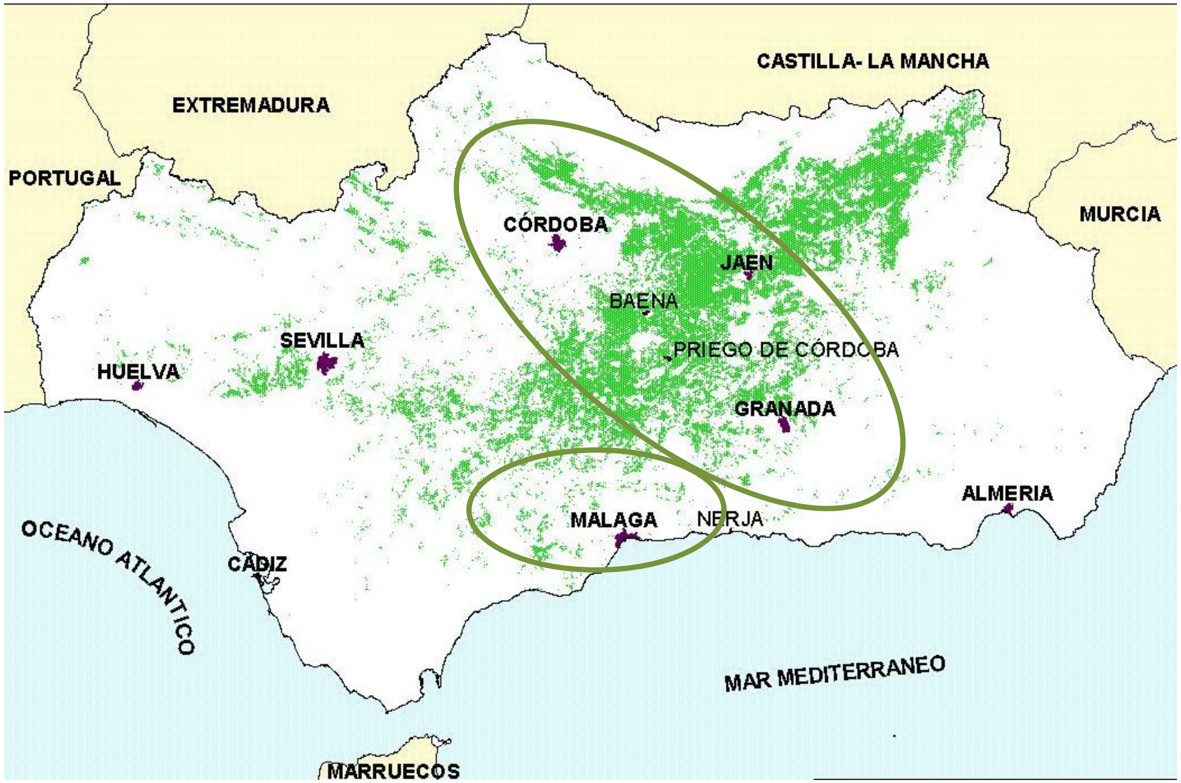




Pollen season start

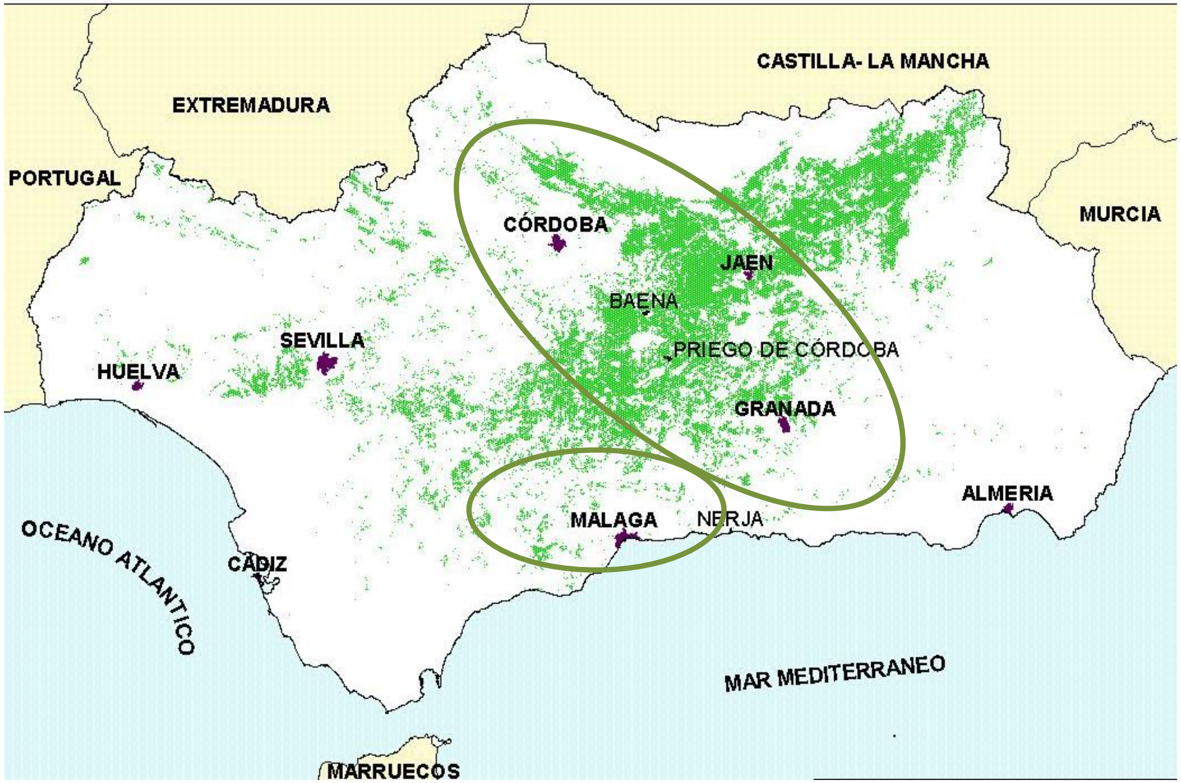
Heat units accumulation

Senoidal extrapolation
(Snyder, 1995)



	Altitud	Average Tª	Threshold Tª	Heat Unit	Bio-climatology
Málaga	5	18.0º	10	179.6º	Termomediterran
Córdoba	123	18.0º	12.5	210.6º	Termomediterran
Jaén	550	17.0º	7	345.9º	Mesomediterran
Granada	685	15.5º	6	421.7º	Mesomediterran
Priego	650	14.4º	5	379.4º	Mesomediterran

Galán et al. (2001)



	Real Date	Forecast	Forecast -Real date
Málaga	70	67	-3
Granada	108	105	-3
Jaén	113	106	-7
Priego	106	109	+3
Córdoba	97	105	+8
Mean value			**4.8**

Dactylis glomerata

blossoming module, i.e. grasses

The models assumes that flowering (t_f) occurs when the state of development of flowers, described by forcing function (S_f), reaches a critical value ($F*$).
The state of forcing function is described by a daily sum of rate of forcing, starting at day t_0 such as

$$S_f(t_f) = \sum_{t_1}^{t_f} R_f(t) = F^*$$

Where $R_f(t) = \frac{1}{1+e^{d\ (x(t)+e)}}$ with $x(t)$, the daily temperature

García-Mozo et al. (2008)

Dactylis glomerata

blossoming module, i.e. grasses

Day t_1 is defined by the day when a critical amount of rainfall (R^*) has occurred within the last 7 days such as

$$\sum_{t_1-7}^{t_{1f}} R(t) = R^*$$ with $R(t)$ the daily rainfall

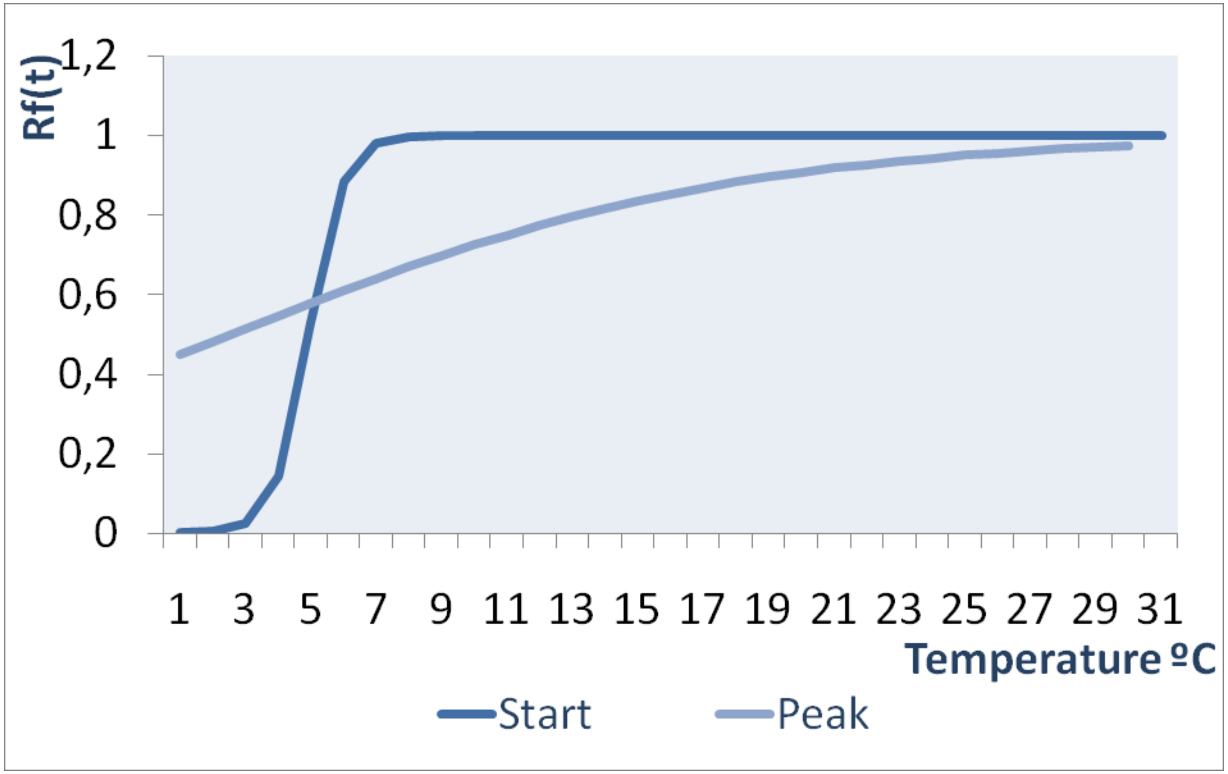
Accumulation of rainfall takes place when a critical photoperiod (P^*) has been reached such as $P(t_0)=P^*$ with P(t) the daily photoperiod, calculated as a function of latitude, and $t_0<t_1-7$.

The model has thus 5 parameters (F^*, P^*, R^*, d and e).

García-Mozo et al. (2008)

Dactylis glomerata

blossoming module, i.e. grasses



Graphic representation of the relationship between temperature and heat accumulation calculated with the process-based models for the start and peak

García-Mozo et al. (2008)

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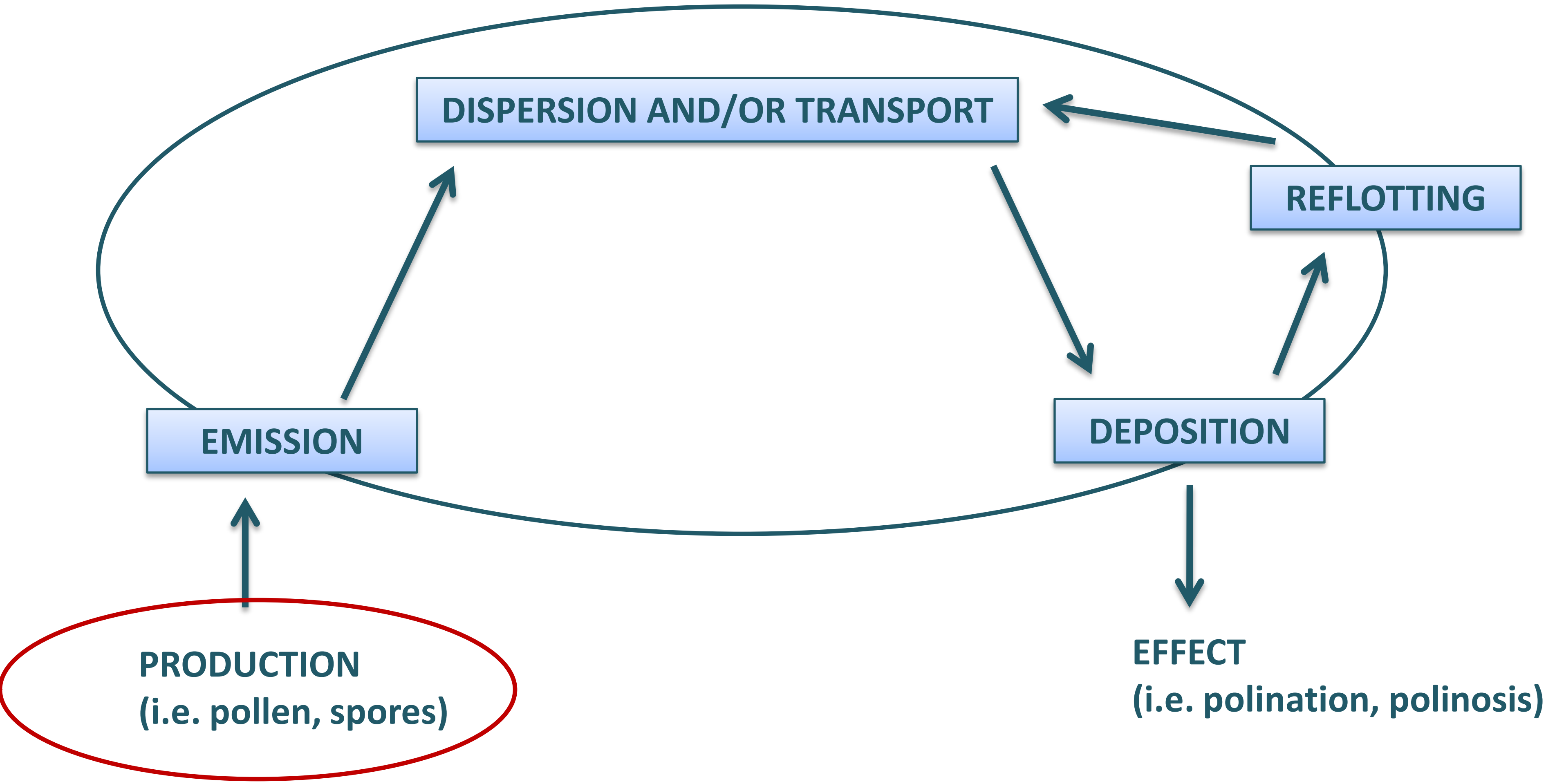
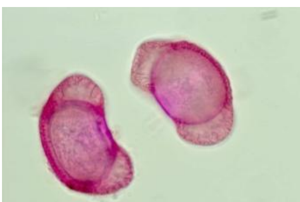
AEROBIOLOGICAL PROCESSES



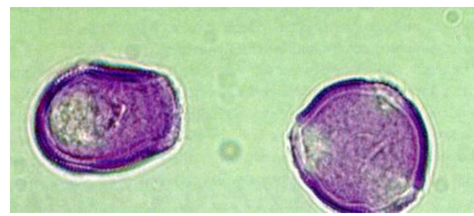
Pollen types

In aerobiological studies sometimes pollen can not be distinguishing between different genera or species as they share the same characteristics under light microscopy, they are stenopalynous.

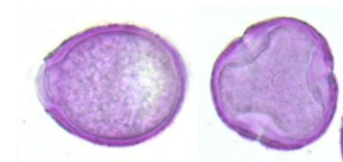


Pinaceae

Cupressaceae



Platanus hispanica



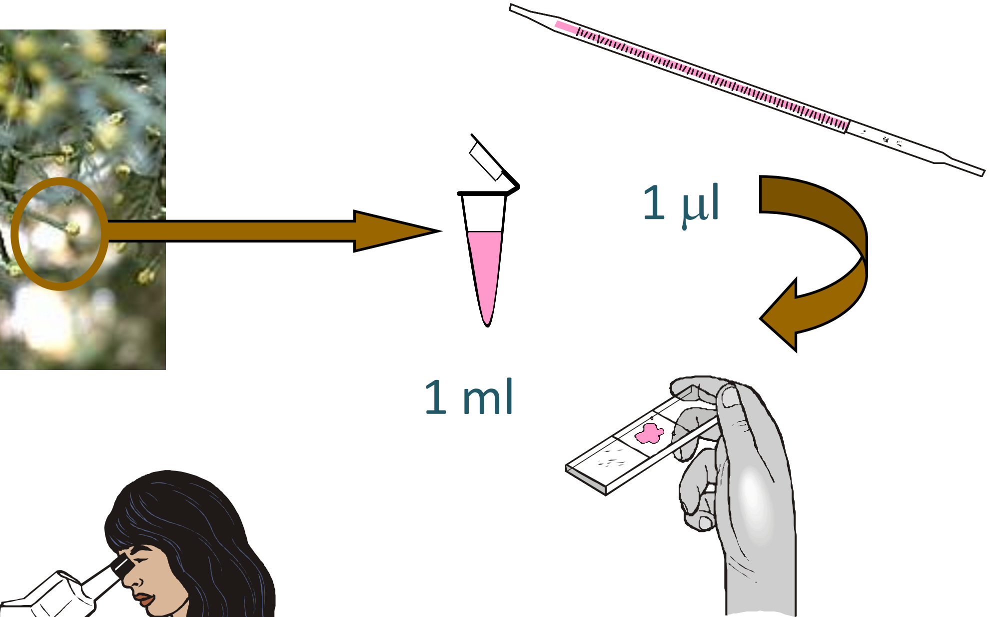
Quercus

Studies about pollen production per plant provide information on the relative contribution of each species to the total amount of pollen enabling to estimate the average potential pollen emission.

Poaceae

Potential pollen production

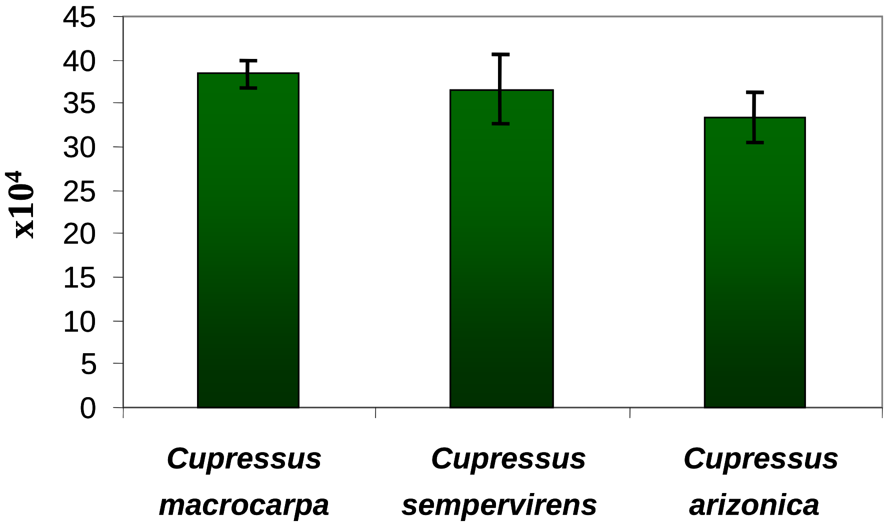
Cupressus arizonica



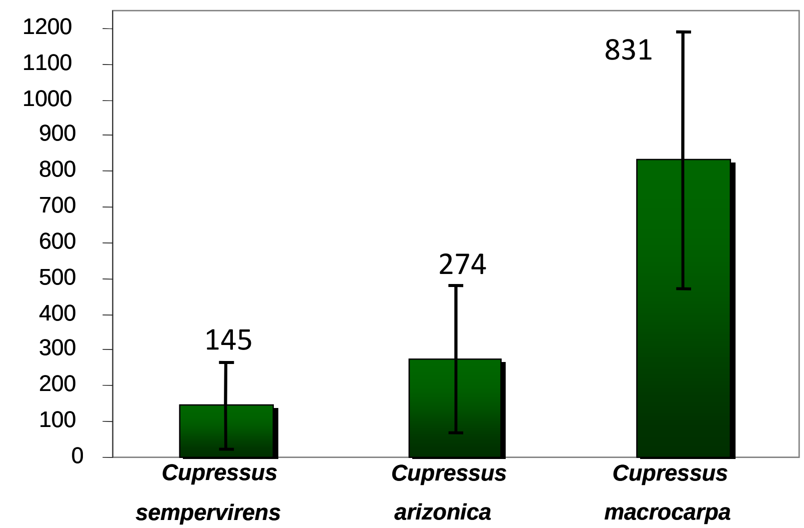
CRUDEN (1977)

Producción de polen, *Cupressus* (Hidalgo et al., 1999)

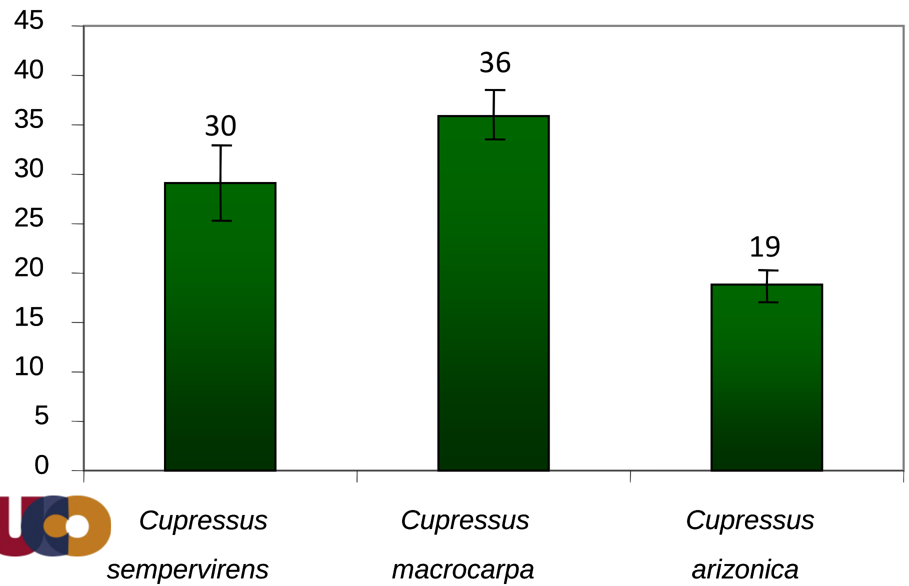
Number of pollen grains/flower



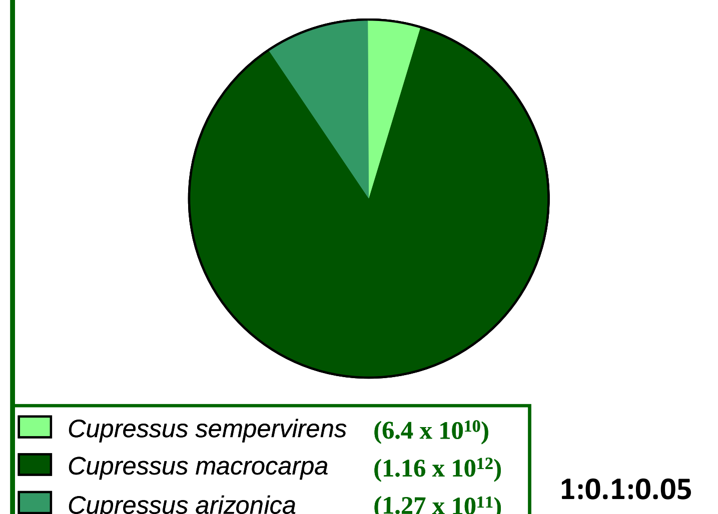
Number of flowers/branch (20-30 cm)



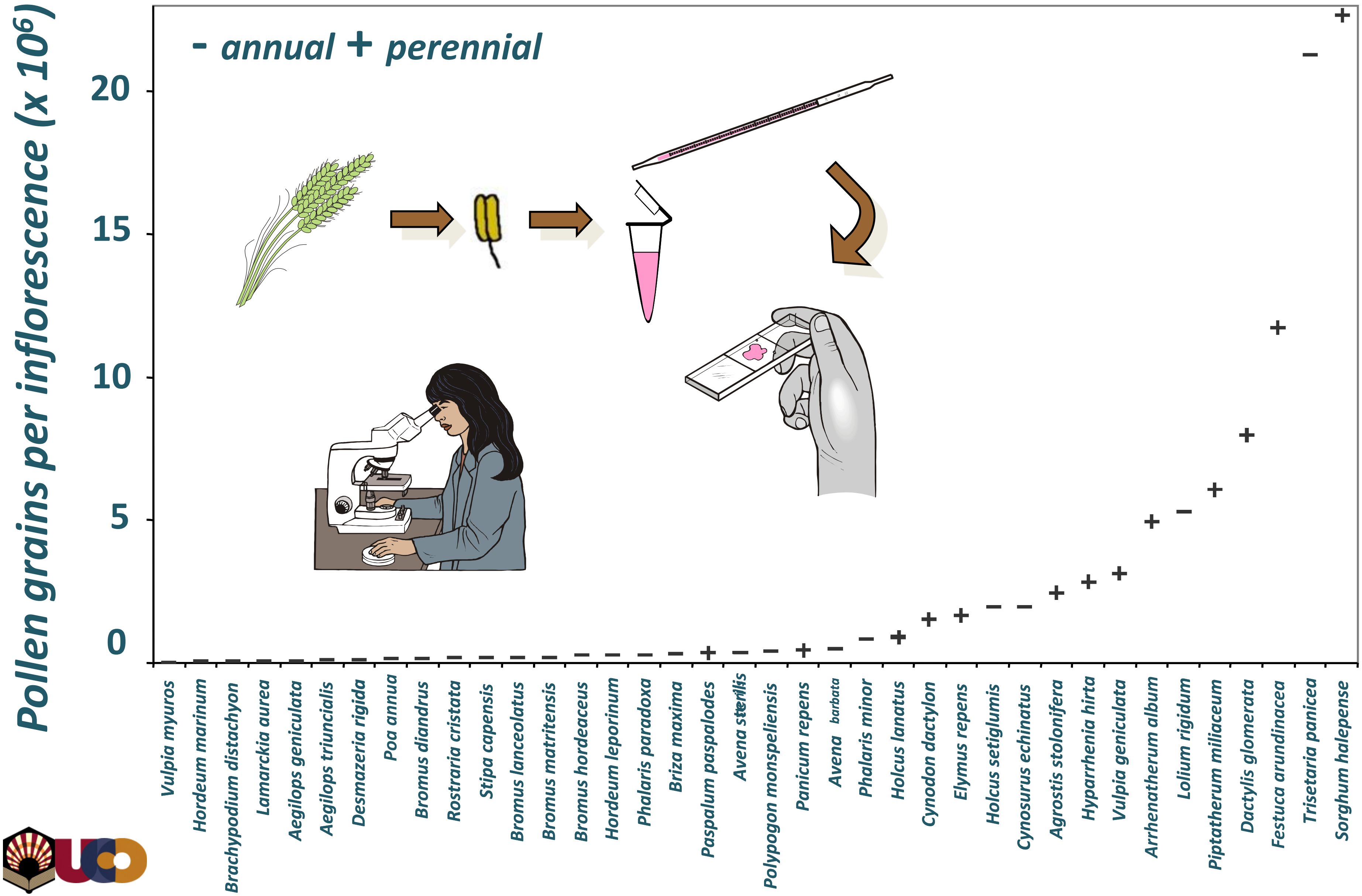
Number of branch/m²

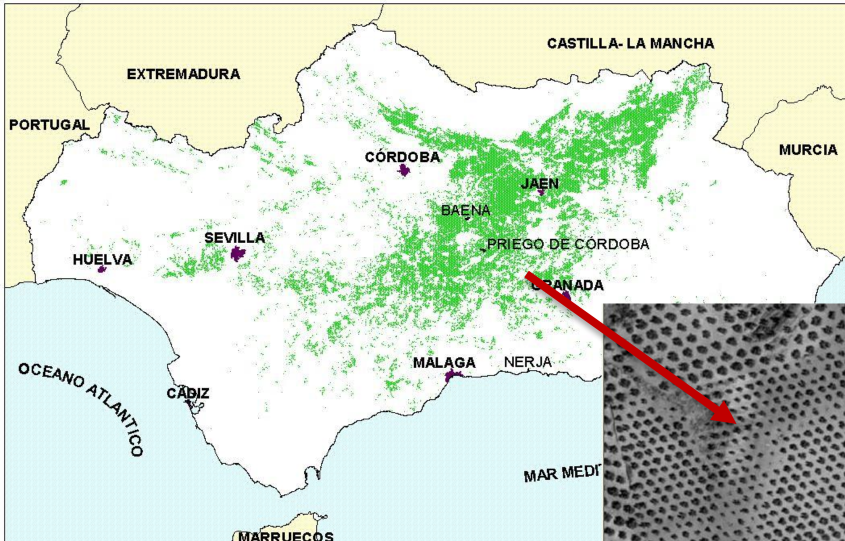


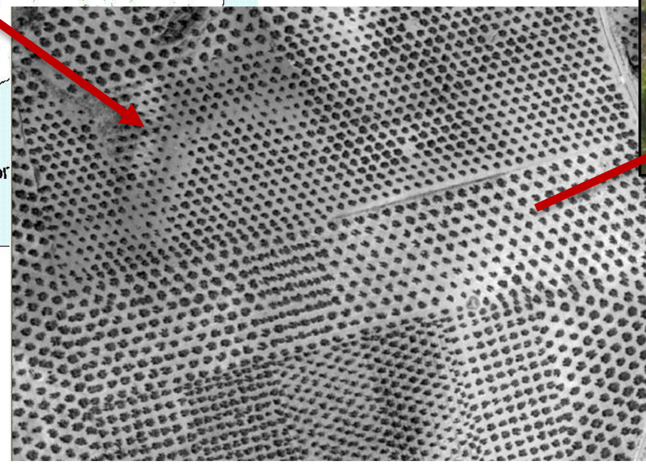
Total pollen production



Grass pollen production per inflorescence (Prieto-Baena et al., 2003)





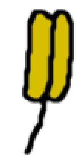


Olive crop

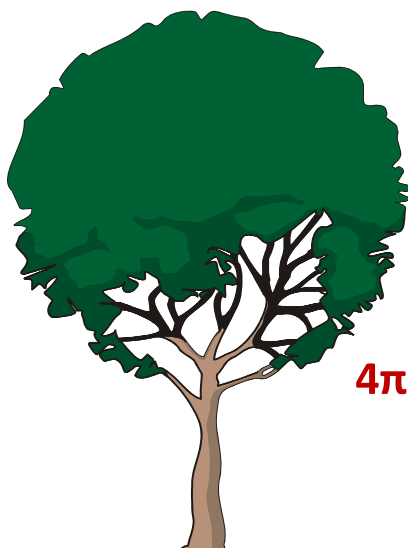
Orthophoto

20 ha

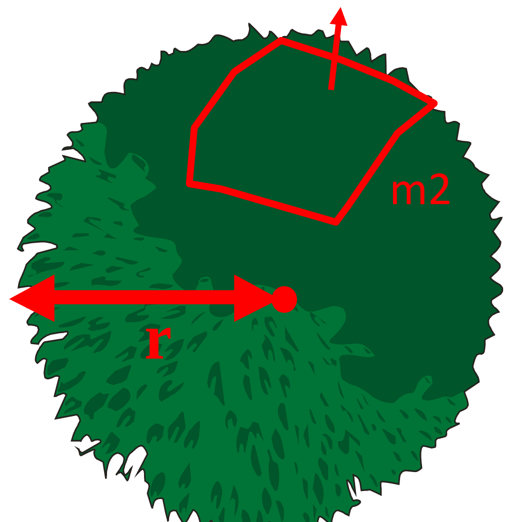
Nº pollen/anther



nº catkin/ m²

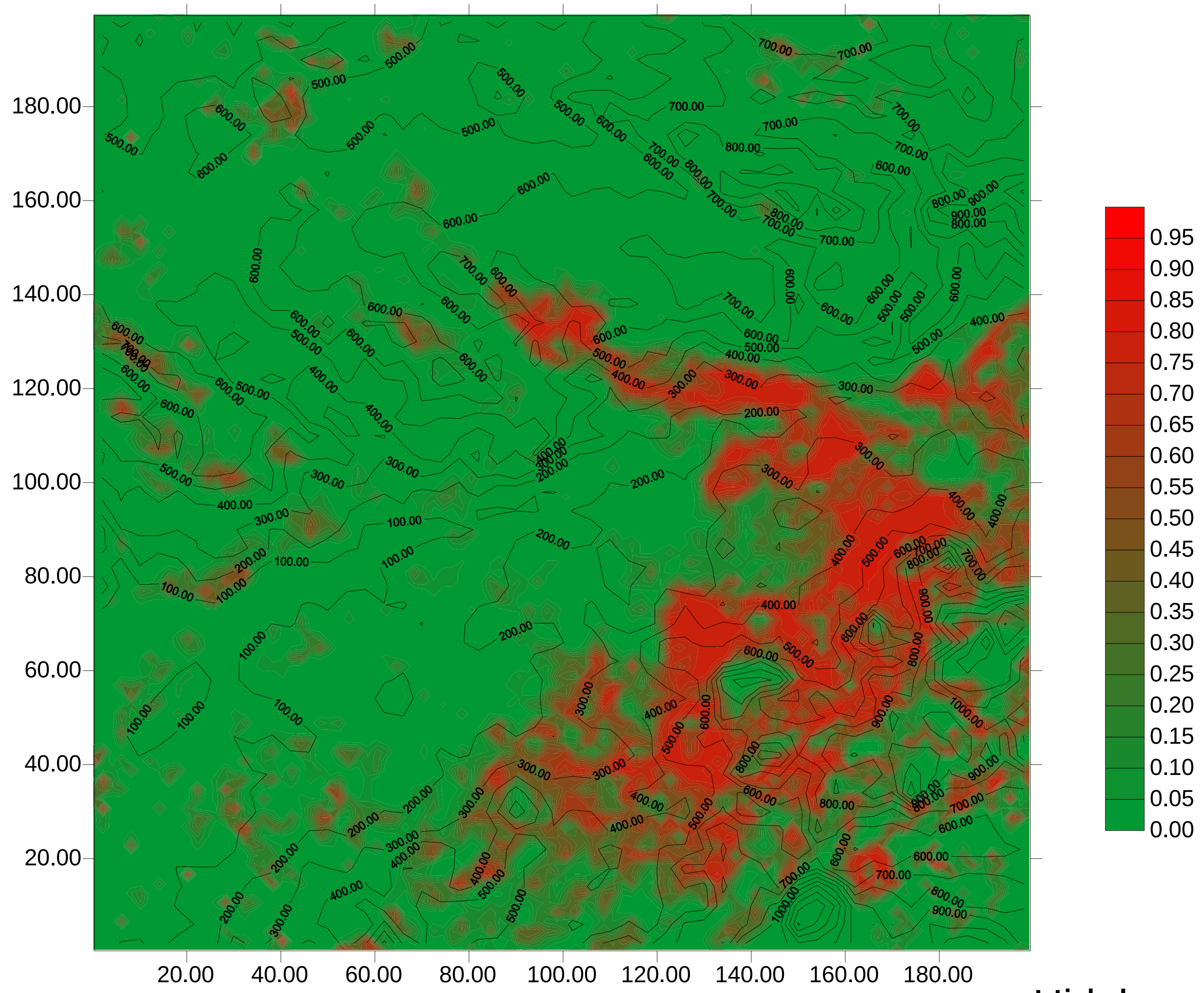


$4\pi r^2$



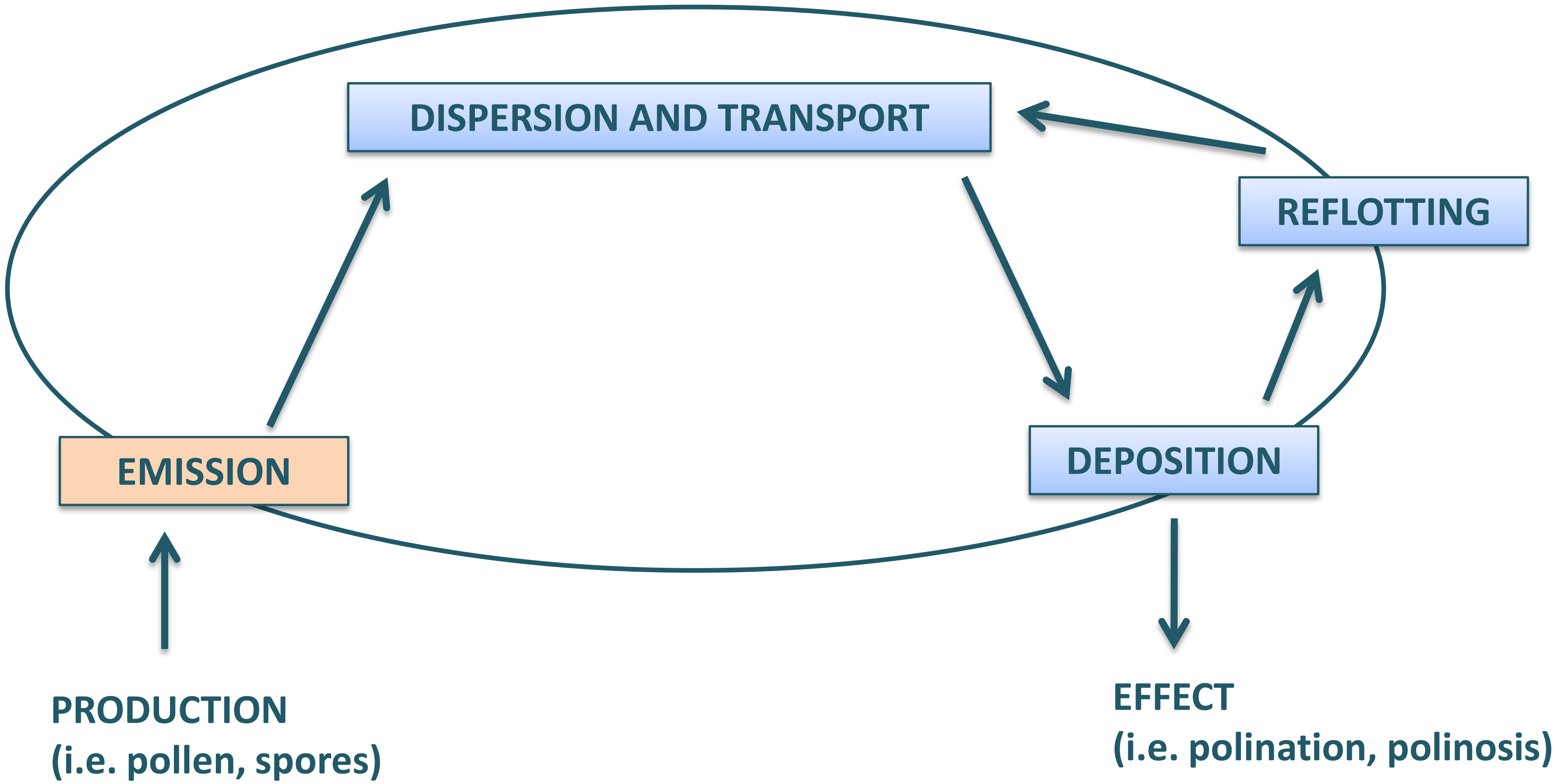
A.S.T.H.M.A. Project

Olea Potential Production Map in Cordoba area



Hidalgo et al. (2002)

AEROBIOLOGICAL PROCESSES

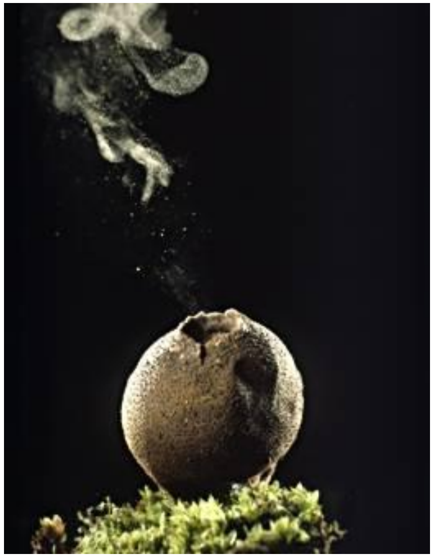


Particle emission

It is needed some energy for particle emission to the air:

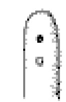
a) active, explosive or hygroscopic mechanisms;
b) passive, through a external agent.

Fungal spore emission



Lycopodium

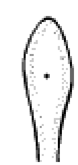
Peziza



Passive spore emission

Active spore emission

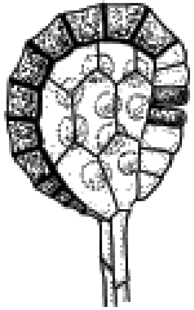
Cladosporium



http://www.unex.es/polen/LHB/)

Lower plant active spores emission

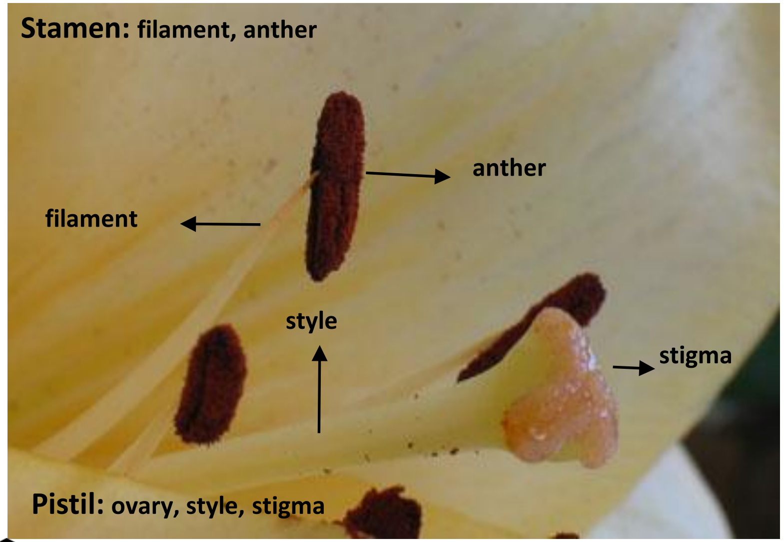
MOSS: i.e. *Polytrhichum*

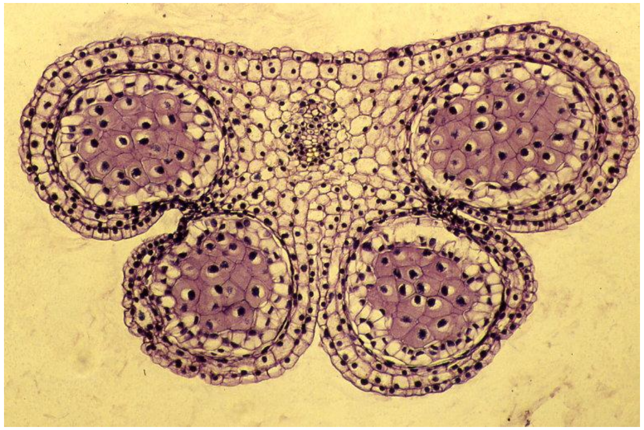


FERN: i.e.*Pteridium*

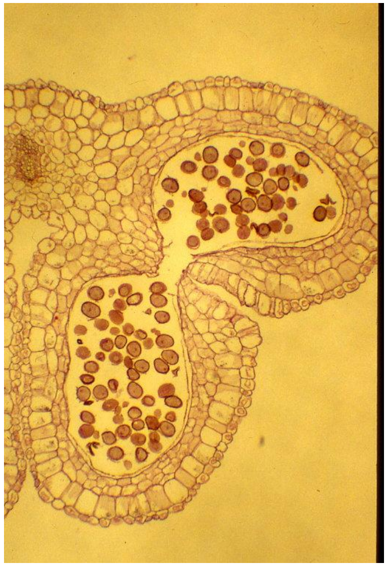
http://www.unex.es/polen/LHB/)

Higher Plant pollination

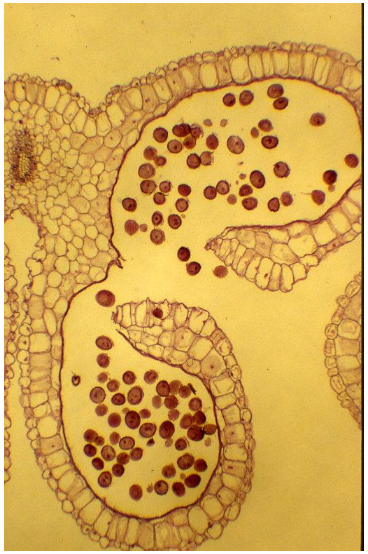




Section young anther



Mature anther

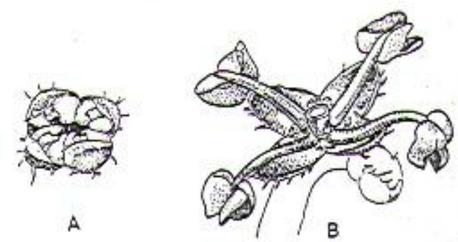


Anther dehiscence

Photo (Sulmont, 2005)

Pollen emission

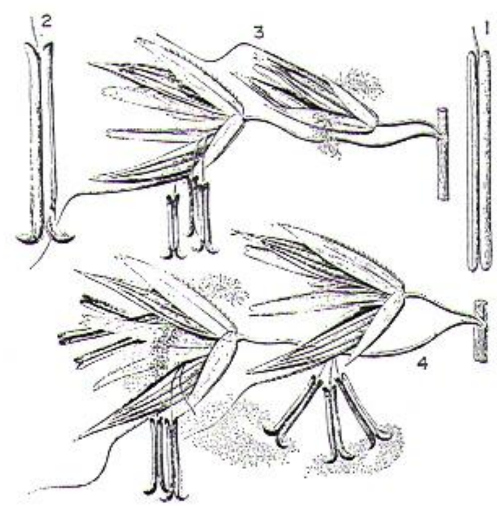
Parietaria



Some Angiosperms, active mechanisms for pollen dispersal

Cupressus

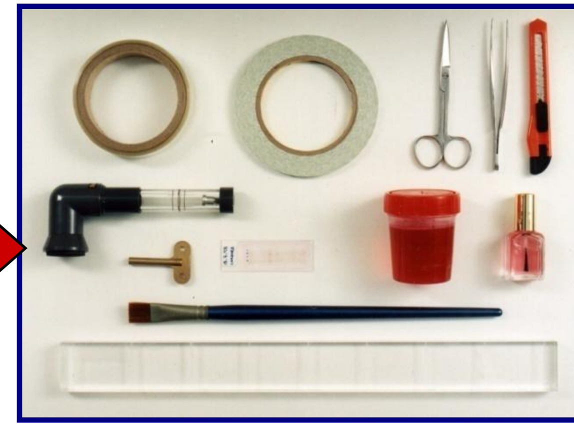
Poaceae

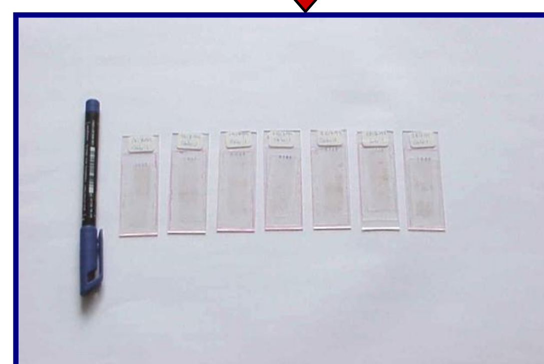


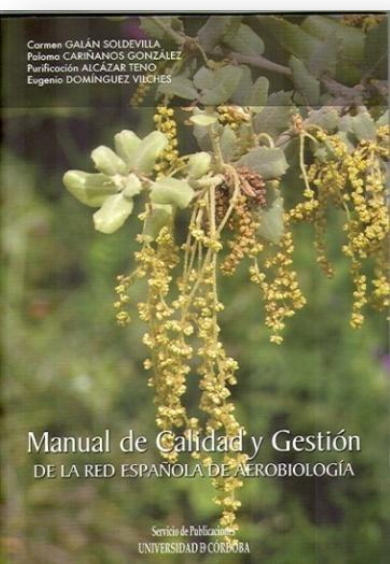
Gymnosperms,
passive mechanisms for pollen dispersal

Most Angiosperms,
passive mechanisms for pollen dispersal

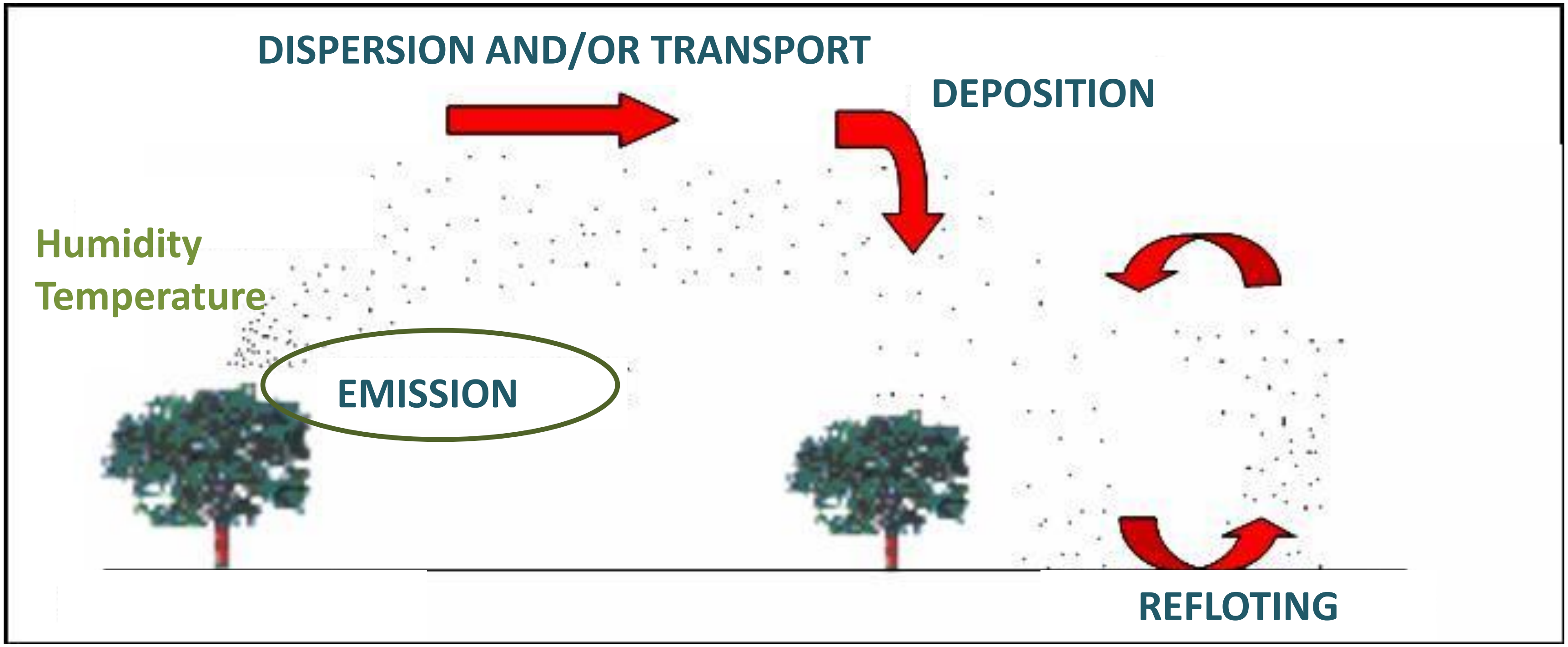
Spanish Aerobiology Network (REA) Protocol



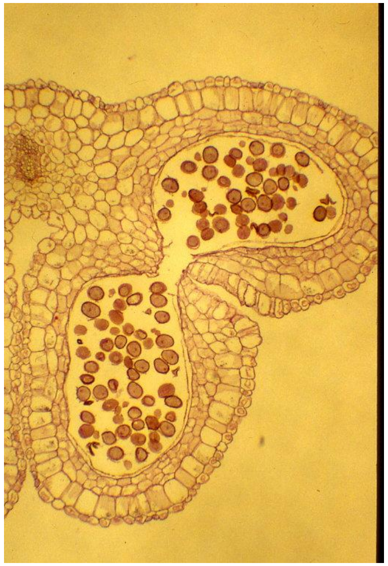




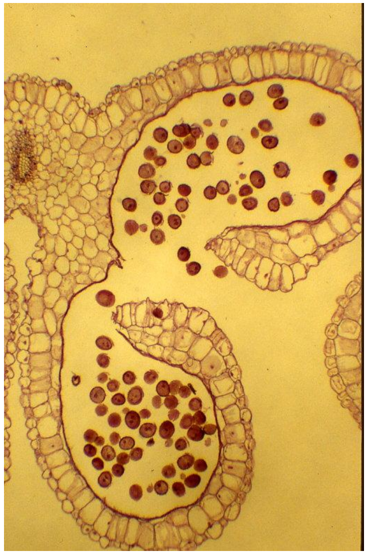
AEROBIOLOGICAL PROCESSES



Pollen release



Mature anther



Anther dehiscence

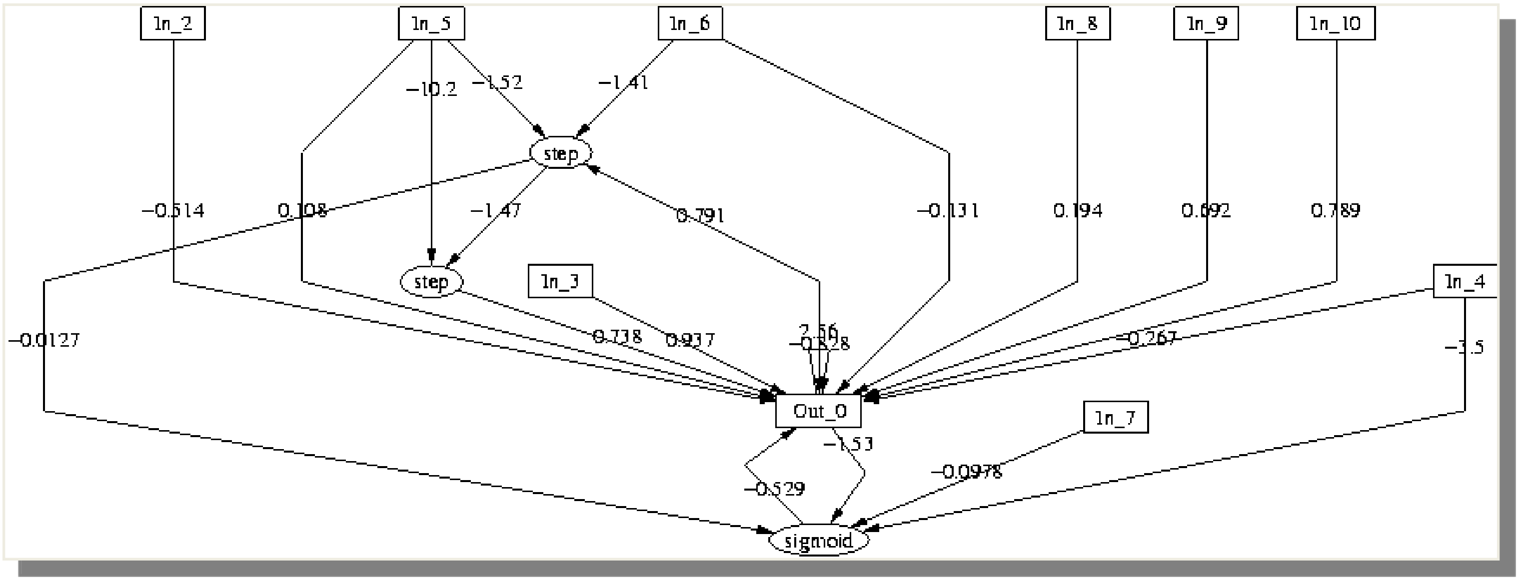
A number of hours before anthesis the anther is able to dehisce. At anthesis the dehydrating endothecium cells bend the locule walls bordering the pore in outward direction.

Mature pollen in the anthers is completely saturated and holds no internal room for air.

After dehiscence of pollen sac, water evaporates extremely rapidly from the pollen grain and the pollen becomes fully buoyant.

Photo (Sulmont, 2005)

Recurrent Neural Network

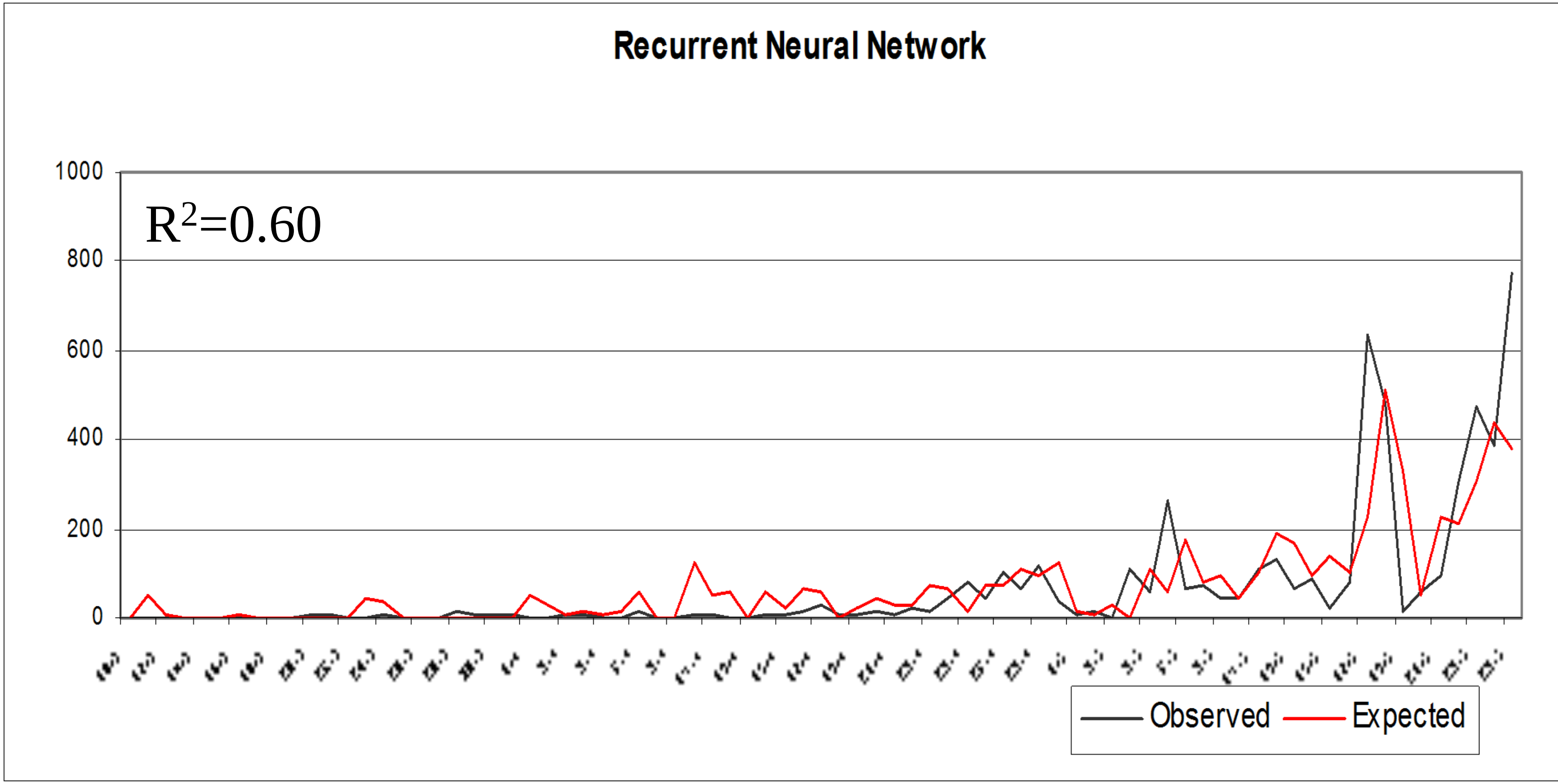


Maximum temperature (D-1)
Minimum temperature (D-1)
Humidity (D-1)
Accumulative rainfall (D-1)
Accumulative average temperature (D-1)
Accumulative humidity (D-1)
Accumulative pollen concentration (D-1)
Pollen concentration (D-1)

Transference functions	Equations
sigmoid	$f(x) = 1/\,1 + e^{-x}$
step	$f(x) = \begin{cases} 1 & \text{if } x \geq 0 \\ 0 & \text{if } x < 0 \end{cases}$
linear	$f(x) = x$

$R^2 = 0.81$; $p < 0.01$

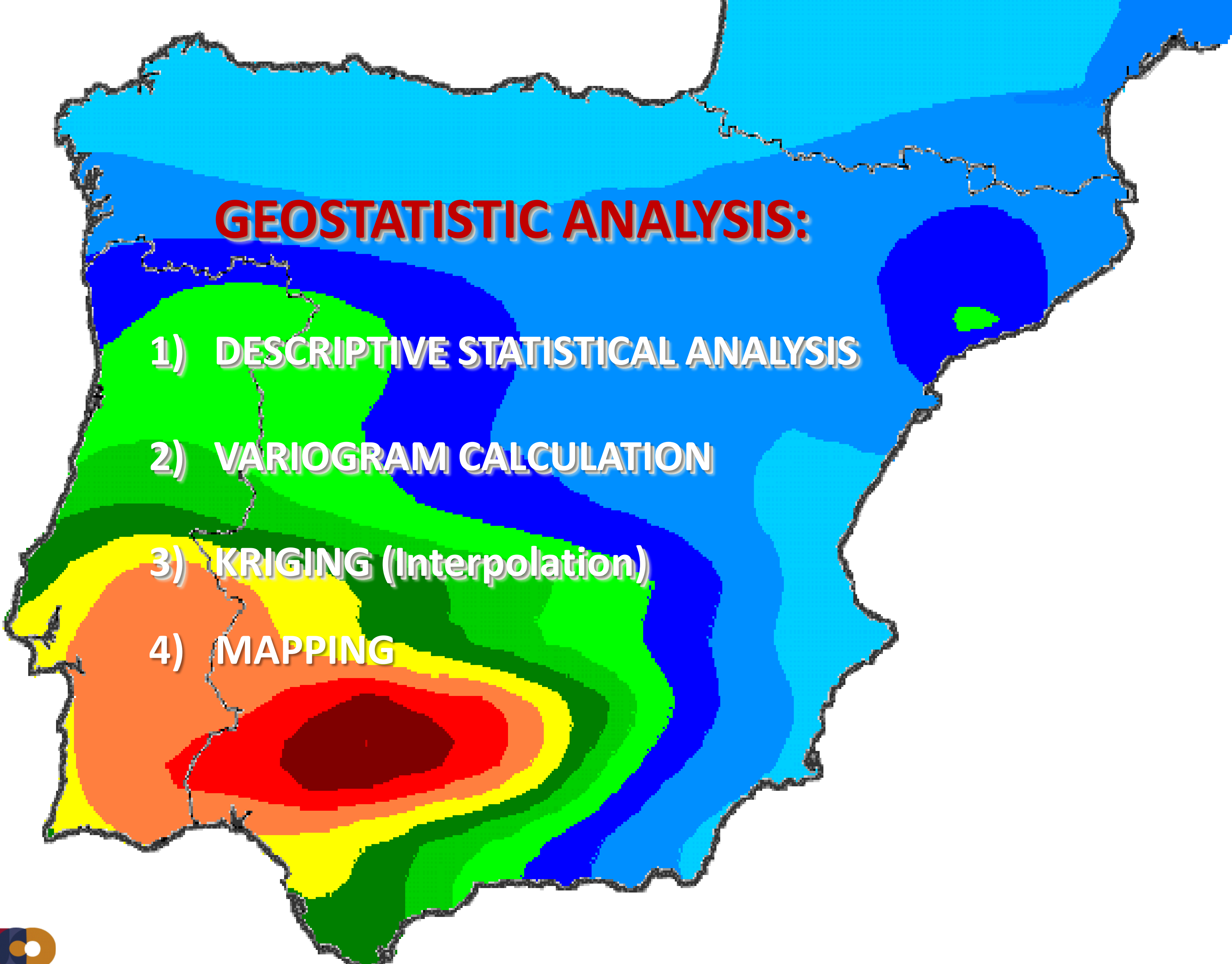
Sánchez-Mesa (2005)

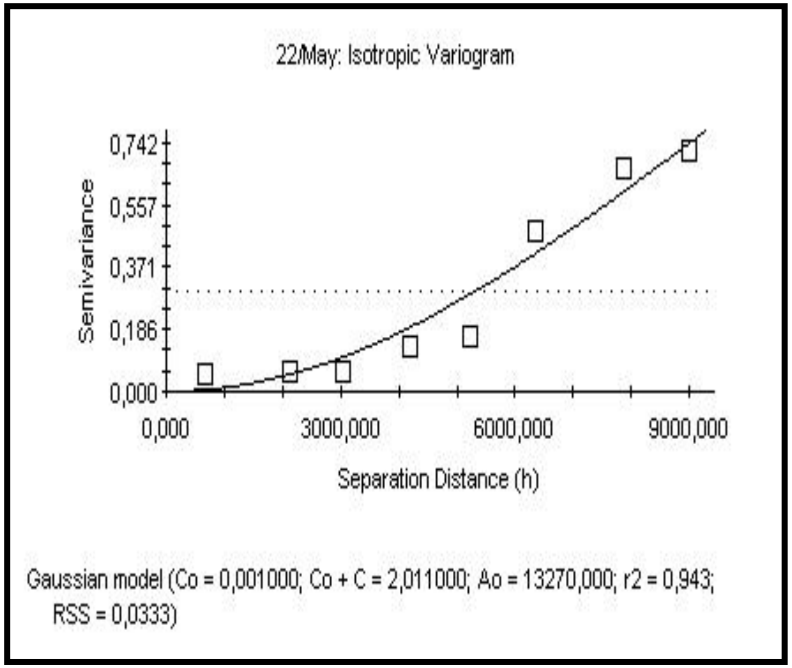


Sánchez-Mesa et al. (2005)

GEOSTATISTIC ANALYSIS:

1) DESCRIPTIVE STATISTICAL ANALYSIS
2) VARIOGRAM CALCULATION
3) KRIGING (Interpolation)
4) MAPPING

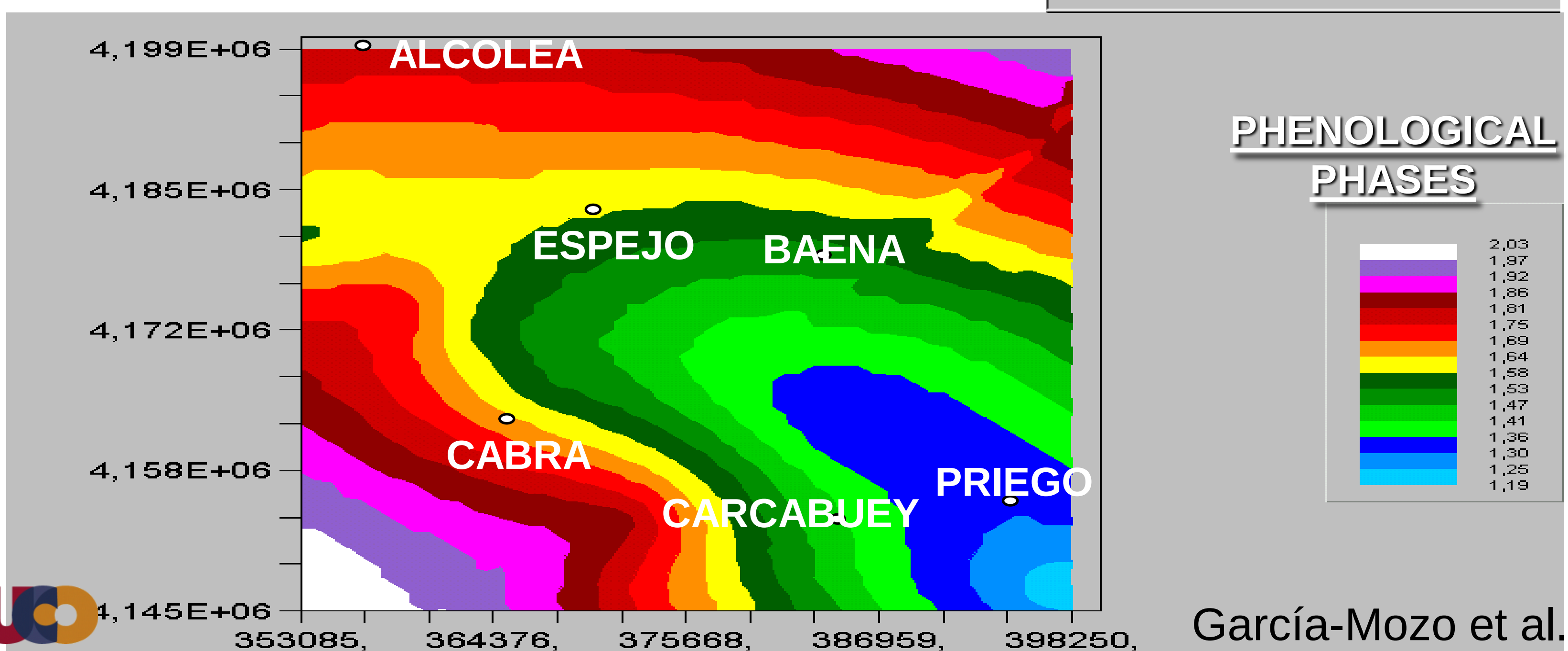




C:\ARCHIVOS DE PROGRAMA\GSWIN5\demo2d.krg (147880 bytes)

GS+ Output: Block Kriging Interpolation File v3.0
Set:
Dimensions: 2; Interval source: Calculated
Interpolation interval (x; y): 836,3889; 817,5
X-coor: m east
range: 353085,00 - 398250,00
Y-coor: m north
range: 4144875,00 - 4198830,00
Z-est:
range: 1,19 - 2,03
Z-sd: (SD)
range: 0,000E+00 - 8,024E-01
Mean Z-estimate (sd): 1,62 (3,318E-02)
Valid N: 3685; Missing N: 0; Missing Value Indicator: -99

X-Coordinate	Y-Coordinate	Z-Estimate	EstStdDev	n
353085,00	4144875,00	2,03	6,724E-01	16
353085,00	4145692,50	2,03	6,643E-01	16
353085,00	4146510,00	2,02	6,561E-01	16
353085,00	4147327,50	2,02	6,478E-01	16
353085,00	4148145,00	2,01	6,393E-01	16
353085,00	4148962,50	2,01	6,362E-01	16
353085,00	4149780,00	2,01	6,274E-01	16
353085,00	4150597,50	2,00	6,184E-01	16
353085,00	4151415,00	1,99	6,092E-01	16
353085,00	4152232,50	1,98	6,000E-01	16
353085,00	4153050,00	1,97	5,907E-01	16
353085,00	4153867,50	1,96	5,812E-01	16
353085,00	4154685,00	1,96	5,660E-01	16
353085,00	4155502,50	1,95	5,578E-01	16
353085,00	4156320,00	1,94	5,495E-01	16
353085,00	4157137,50	1,93	5,409E-01	16
353085,00	4157955,00	1,92	5,321E-01	16
353085,00	4158772,50	1,91	5,231E-01	16
353085,00	4159590,00	1,90	5,138E-01	16
353085,00	4160407,50	1,89	5,043E-01	16
353085,00	4161225,00	1,88	4,946E-01	16
353085,00	4162042,50	1,87	4,846E-01	16
353085,00	4162860,00	1,86	4,743E-01	16
353085,00	4163677,50	1,85	4,638E-01	16
353085,00	4164495,00	1,84	4,529E-01	16
353085,00	4165312,50	1,83	4,418E-01	16
353085,00	4166130,00	1,82	4,303E-01	16
353085,00	4166947,50	1,81	4,186E-01	16



García-Mozo et al. (2006)

AEROBIOLOGICAL PROCESSES