Investigating Succession and sand dune management on the Mediterranean Coast (AQA A2)

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Investigating succession and sand dune management

On the Mediterranean Coast

Teachers' Notes

This study takes students through the unique landscape of the Camargue, one of the largest wetland areas in Europe, covering 780km2. Designated a Regional Natural Park in 1970, the area has an incredible variety of bird and animal life as well as distinctive human traditions. The study is based on the dynamic but fragile dune system of the coastal zone, on the western edge of the Camargue. Primary succession on the dunes is investigated, and students are introduced to the problems of managing a fragile ecosystem in an area that hosts upward of 5 million tourists annually. Developments since the 1960s have had profound impacts on the dune system, with noticeable results on dune morphology and ecology. Management strategies, both actual and hypothetical, are discussed and evaluated.

The journey to the coast from the Eagle's Nest takes 3-4 hours, but the rewards are well worth the trip – this unit is often the highlight of the week for many students. It is also possible to arrange a guided visit to the Camargue Visitor Centre and Bird Reserve near Ste. Marie de la Mer, where an English-speaking guide will introduce students to the bird-life of the Camargue and some of the management issues in this Regional Natural Park. Surrounded by intensively farmed agricultural land, the problem of eutrophication is strongly felt in this region. Enormous application of organic pesticides in the 1960's, to control the local population of mosquitoes has left its mark. Tourism in the area has lead to the drainage of large areas for the development of hotel and apartment complexes. Land has also been drained to allow the cultivation of cereal crops – although rice is still an important crop.

Key syllabus areas

Unit 4 POPULATIONS AND ENVIRONMENT

3.4.7 Ecosystems are dynamic systems, usually moving from colonisation to climax communities in the process of succession.

Reference Texts

Bishop and Prosser (1997) 'Landform Systems' Collins Educational

Burton, S & Jeanes, A. (1997) 'Central Southern France' Hodder and Stoughton.

Digby, B (Ed.). (1995) 'The Physical Environment' Heinemann

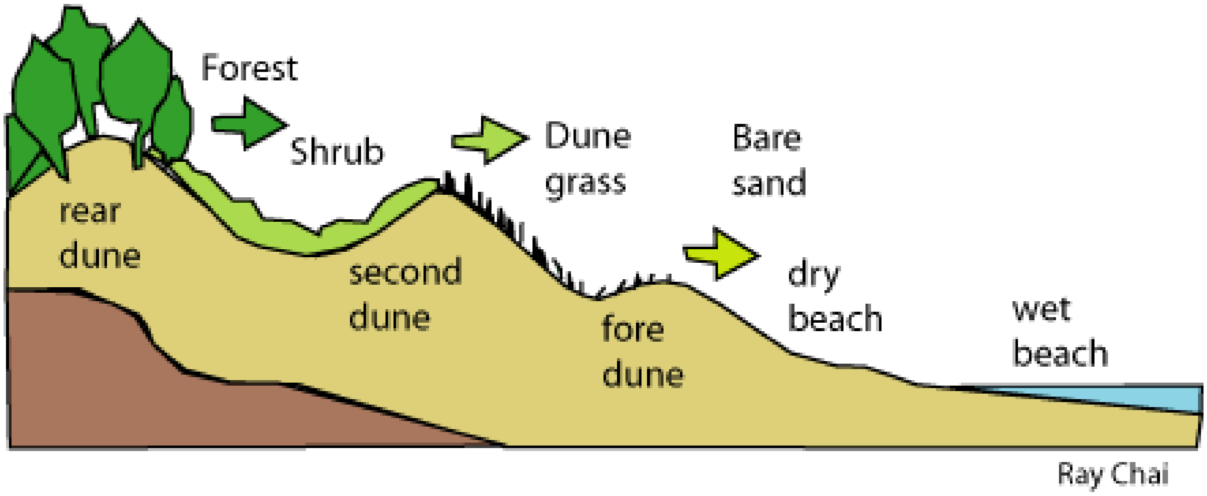
Waugh, D. (1990) 'Geography - An Integrated Approach' Nelson.

Blondel, J. and Aronson, J. (1999) Biology and Wildlife of the Mediterranean Region. Oxford University Press.

General Information

The coast is a narrow zone where the land and sea overlap and directly interact. Of all the natural environments, coasts are the most varied and rapidly changing as they are influenced by atmospheric and marine process interactions.

Millions of tonnes of material are transported by the Rhone (the longest river in France) into the Mediterranean Sea. Long shore drift and the 'Ligure' current move this material from east to west, where wave action deposits it in the inter-tidal zone. (Appendix 1)



Generic diagram of sand dune formation.

Plant colonisation on the Mediterranean coast:

Grey "fixed" dunes	Yellow "mobile" dunes	Embryo Dunes	Beach
Sand stabilised by flowering plants, e.g. sea stock, helichrysum, sea wormwood, hare's tail grass, knapweed. Marram grass becomes less common as other plants invade and compete with marram for space and light.	Dunes grow rapidly as marram grass accumulates wind-blown sand, and grows through it. Clematis, sea spurge, and chamomile colonise. Dunes may be destroyed by tidal surges during winter storms.	Colonisation by marram grass, which has many xerophytic adaptations, including inrolled leaves, long, fast-growing roots, sunken stomata, and hairy leaves.	Nothing grows here to to frequent beach cleaning.

When winds blow from the sea the dry sand will be moved up the beach by saltation. Sand is trapped by berms, or obstructions such as drift wood or sea grass, at the point of the highest spring tides. These sand deposits will build up and become colonised by plants, such as marram grass, which are adapted to the maritime conditions and have long roots to enable them to survive on the shifting sands. The grasses trap more sand and their long roots help hold the dunes together, stabilising the area. This results in embryo dunes, which can grow in size and link to form a ridge. Over time these dunes stabilise and show distinct changes inland as shelter from the wind increases and the supply of sand is reduced. Further from the beach the dunes increase in size and the vegetation on them becomes more diverse. A cross-section of coastal sand dunes and plant succession is shown in Appendix 2.

Whilst dunes can, in theory, achieve a state of relative equilibrium, it is easy to upset the balance. Paths cut by humans and animals often expose areas of sand within the dune system. As the wind funnels along these tracks, “blowouts” may form. Fencing off areas facilitates dune re-stabilisation. Sand dunes can also be stabilised by planting marram grass and erecting brushwood fencing. Other problems may arise through dune migration - the inland movement of sand that has the potential to damage settlements and agriculture. Fencing can be used to restrict such movement. Groynes are used to slow down the rate of long shore drift, although this often leads to greater erosion further along the coast - which having been deprived of beach material is more exposed to wave attack.

Sand dune system at La Grande Motte.

Specific Information

The dune system is on the edge of the Camargue Regional Nature Reserve and UNESCO World Biosphere Reserve. The growing pressure on this region of southern France caused by the increasing number of visitors led to the development of a “Parc Naturel” – the Camargue. This ensures the protection of this fragile landscape. The Camargue forms part of the Rhône delta, developed as a result of the deposition of sediment from the river Rhône. Sandbanks have been formed and built up into a dune system that now separates a number of lagoons from the sea. The abundance of water - fresh and salt - and the flatness of the area and the abundance of strong winds have resulted in a unique environment that provides a variety of habitats.

The Camargue is an internationally-important area for migrating birds - over 300 species have been recorded here at different times of the year. A Nature Reserve was created in 1928 in the Etang deVaccares where human activity is limited. The coast is made up of a series of etangs (lagoons) and sandbars. Economic development is limited and is mainly concerned with tourist resorts. Embankments along the two arms of the river Rhône and a sea defence dyke were completed in 1860, making the Camargue an area of largely artificial water levels. However, it maintains a natural appearance through its size and diversity of ecosystems, even though neither the sea nor the river floods across it anymore.

Aims

- To study an example of primary succession, a psammosere, and investigate how vegetation changes with increased distance from the sea, as affected by changes to the abiotic environment;
- To assess the relationship between vegetation cover, and the abiotic environment across the dune system;

Objectives

To carry out a microclimate investigation along the dune system, to identify limiting factors;
To use an interrupted belt transect to assess vegetation changes along the dune system, and to use a diversity index to quantify these changes;
To investigate soil changes along the dune system, concentrating on changes in pH, temperature, moisture, and depth;
To study the xerophytic adaptations seen in sand dune plants;

Hypotheses

The vegetation type changes across the dune system with distance from the sea – species diversity and total percentage cover increases with distance from the sea.
The soil characteristics (pH, depth, temperature and moisture) change with distance from the sea.
Microclimate variables change away from the sea (air temperature, wind speed and air humidity).

Equipment

pH kit and trowel
Soil moisture comparitor
Soil thermometer
Soil skewer
Ranging poles
Clinometer
Tape measure (minimum 30 metres)
Meter rule
Open frame quadrat
Plant Identification Booklet – Sand Dunes
Wind watch (or air thermometer and polystyrene chip)
Whirling hygrometer
Soil sample bags if required
Recording sheets and plain paper for field sketches

Method And Organisation Of Study

Three tasks can be carried out simultaneously:
Task One: To assess changes in vegetation cover across the dune system (recording sheet 1).

From the beginning of the embryo dunes, run the tape measure as far as it will go. Place open frame quadrat at intervals along the tape measure (depending on time available, we suggest 5 to 10m intervals), and record total % cover of vegetation, % cover of bare ground and % cover of each species present, and record the species richness – the number of different species in each quadrat. Record the maximum plant height in each quadrat.

Task Two: To assess microclimate change along the dune system.

Using the wind watch and whirling hygrometer, measure air temperature (oC), wind speed (m/s) and air humidity (%) at the top and bottom of each dune ridge. Note the distance along the dune profile transect.

Task Three: To assess soil change along the dune system.

Starting in the first quadrat, measure soil temperature (oC), soil depth (cm), soil pH every 20m. Collect a small 'soil' sample at the beginning, middle and end of the transect for analysis in the classroom on return.

Task four: To investigate xerophytic adaptations in sand dune plants:

Recording sheet 4 can be completed by students looking at adaptations to dry environments in sand dune plants (xerophytic adaptations). It is recommended that each pair of students is given a specimen to examine and gives feedback on the adaptations of their plant(s) to the rest of the group, enabling them all to complete this sheet. It is also possible to take plant specimens back to the centre for drawing annotated diagrams later on in the week.

Short study:

If time is limited and a less in-depth study is required, an investigation looking at four strategic locations along the succession sequence is possible. Recording sheet 3 collects data on the embryo dunes, at the top of the first dune ridge, in the wet slack and in the woodland. This shortened study concentrates on vegetation (collected using semi-random quadrats), microclimate and soil factors only at these locations and provides a strong contrast at these four sites. It also prevents the errors which may result when carrying out a belt transect, as students tend to pick the lines of least resistance across the dunes, where quadrats frequently end up on footpaths, and in dune blow outs.

The Eagles Nest. Recording Sheet 1: Vegetation Analysis Along The Dune System Using An Interupted-Belt Transect

Species	% cover of individual plants of each species Fill in the distance along transect below (m)																						
	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m
Marram grass																							
Sea spurge																							
Clematis																							
Woolly chamomile																							
Helichrysum																							
Sea worm wood																							
Sea stock																							
Total % cover plants																							
% cover bare sand																							
Maximum plant height (cm)																							

Total species richness																							

The Eagles Nest. Recording Sheet 2: Abiotic Measurments Along The Dune System Using An Interupted-Belt Transect

Abiotic Factor	Abiotic measurment Fill in the distance along transect below (m)																						
	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m
Microclimate variables:																							
Wind speed (m/s)																							
Air temp at 150cm (^{o}C)																							
Air humidity at 150 cm (%)																							
Soil variables:																							
Soil pH																							
Soil depth (cm)																							
Soil temp (^{o}C)																							

Don’t forget to collect a small ‘soil’ sample at the beginning, middle and end of your transect line!

The Eagles Nest. Recording Sheet 3: Short Sand Dune Survey.

Species	Site 1. Top of first dune ridge					Site 2. Bottom of first dune ridge					Site 3. Wet slack community.					Site 4. Climax woodland.				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Marram grass																				
Sea spurge																				
Chamomile																				
Clematis																				
Helichrysum																				
Sea wormwood																				
Sea stock																				
Rush species																				
Reed species																				
Mosses																				
Pine																				
Bramble																				
Total number of species																				

Microclimate variables:				
Air humidity (%)				
Air temperature (oC)				
Wind speed (m/s)				
Soil factors:				
Soil pH				
Soil moisture				

Don't forget to collect a small 'soil' sample at the beginning, middle and end of your transect line!

Eagle's Nest. Recording sheet 4: Xerophytic adaptations in sand dune plants.

Find as many of these species as you can and try to identify at least two of their adaptations to the abiotic environment. You can bring specimens back to the centre to complete this exercise the following day.

Species	Description	Sketch
Marram grass *Ammophila arenaria*		
Sea spurge *Euphorbia paralias*		
Clematis *Clematis rubra*		
Chamomile *Anthemis maritima*		
Helichrysum *Helichrysum stoechus*		
Woolly medick *Medicago marina*		
Sea stock *Mattiola sinuate*		
Sea wormwood *Artemisia maritime*		
Bramble *Rubra sp.*		

Data Processing And Analysis

The idea behind these presentation techniques, is that all the data collected during the day be presented on a single piece of A3 graph paper. See the completed results sheet that is kept in the resources room.

Task one: To present changes in vegetation cover across the dune system.

Plot kite diagrams for % cover bare ground, % total plant cover and % cover marram grass from the sea edge to the back of the dune system. Include a horizontal scale bar. Present the species richness and species diversity figures as line graphs beneath the kite diagrams.

Task two: To assess microclimate change along the dune system.

Beneath the appropriate position on the kite diagram, add small bar charts or line diagrams of air temperature, humidity and wind speed, to illustrate how these factors change along the dune system.

Task three: To assess soil change along the dune system.

Below the correct point on the kite diagram scale, record soil depth as a series of vertical lines beneath the base line, soil pH as a figure on the base line and soil temperature as a line graph.

Task four: To study adaptations in sand dune plants.

Complete the adaptations recording sheet and if required, prepare annotated diagram of a plant specimen which illustrates its xerophytic adaptations.

Task five: Dry a small soil sample and calculate % moisture in the soil at increasing distance from the sea. What do you notice about the change in the soil's colour. How can this be explained?

Follow Up Work and Discussion Points

- How did the vegetation change across the dune system? Did species diversity and total percentage cover increase with distance from the sea?
- In what way did the soil characteristics (pH, depth, temperature) change with distance from the sea? Were the changes as you expected – did they fit the classic sand dune soil development model? If not, why not?
- What happened to the air temperature, wind speed and air humidity with increased distance from the sea?
- How do the microclimate and soil factors influence the vegetation community along a sand dune succession, from the young, embryo dunes closest to the sea, to the old, stable dunes and woodland at the back of the dune system?
- In extreme environments (ie. closest to the sea), the diversity of organisms is usually low. This may result in an unstable ecosystem in which populations are usually dominated by abiotic factors – has your investigation supported this idea? Which abiotic factors do you think are most important in controlling the vegetation community on the embryo dunes?
- In less hostile environments (ie. further from the sea), the diversity of organisms is usually high. This may result in a stable ecosystem in which populations are usually dominated by biotic factors – has

your investigation supported this idea? What biotic factors do you think control the vegetation community on the back of the sand dune system?

- How were the plants which successfully colonised the dunes adapted to the extreme conditions there? Make a list of xerophytic adaptations shown by typical sand dune plants, such as hairy leaves, inrolled leaves, sunken stomata, thick, waxy cuticles, white undersurface to the leaf, etc.
- The dunes at La grande Motte are vital to the local tourist industry. How have the dunes been managed for tourists and conservation?
- How has beach cleaning disrupted the natural succesion processes operating on this sand dune system?

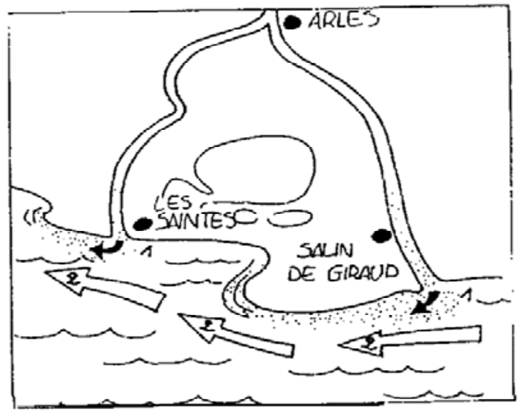
Students should make notes under the following headings, contrasting the communities at the initial stages and final stages of succession. This completed version is for your guidance:

Abiotic and biotic factors:	***Characteristics of the pioneer community:***	***Characteristics of the climax community:***
Abiotic environment: Soils	Nutrient poor, thin soils with extreme pH; dry with low organic content.	Nutrient rich, thick soils; high organic content with good water-retaining characteristics.
Abiotic environment: Microclimate	Extreme and often harsh microclimate with extremes of temperature, wind exposure.	More equitable microclimate without extremes of temperature between winter and summer.
Species diversity	Low	High
Growth rate of individual organisms	Fast	Slow
Population growth rate	Fast (J-shaped growth curve)	Slow (S-shaped growth curve)
Life-cycles of organisms in these stages	Organisms generally short-lived. May pass through metamorphic stages with short adult stage.	Organisms generally longer-lived. High degree of parental investment in the young. Adults longer lived
Size of organisms	Generally small organisms	Range of sizes to occupy range of niches available
Adaptation of organism	Generalist	Specialist
Niche specialisation	Low level of specialisation	High level of specialisation
Gross productivity of ecosystem	Low	High
Stability of ecosystem	Unstable, susceptible to change	Stable, more resistant to change
Competition between organisms	More inter-specific	More intra-specific
Complexity of food chains	Chains short and simple	Food webs complex and extensive

Appendix 1: Formation of sand dunes on the Mediterranean coast.

From the Rhone to the sea

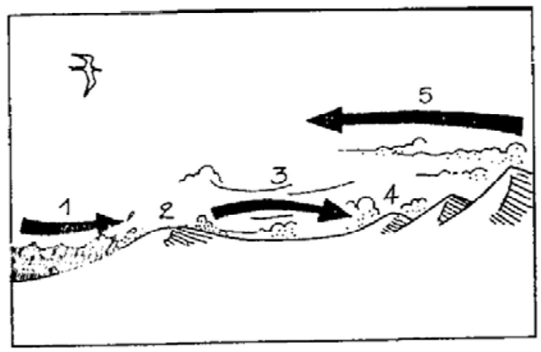
The Rhone transports millions of tons of sediment to the sea each year (1). Once in the sea, a current called the Ligure (2) moves the sandy sediments along the coast from east to west, giving the coastline its particular shape.



From the sea to the dunes

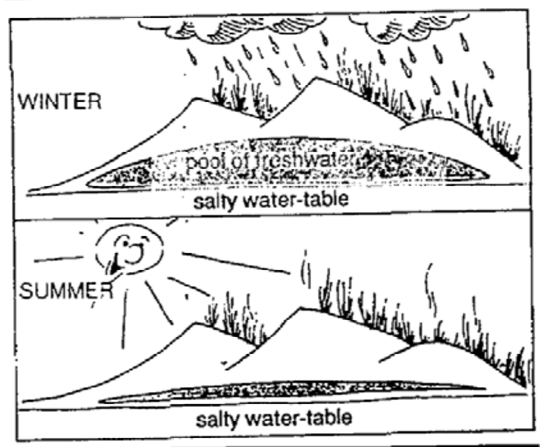
In the Camargue, the dunes result from the action of the opposing winds.

The sand deposited on the edge of the beach (1) by the waves and the currents dries (2) and is then carried further inland by the winds (3), accumulating to form the dunes (4). The Mistral, a northwestly and often very strong wind, blows back some of the sand to the sea (5).



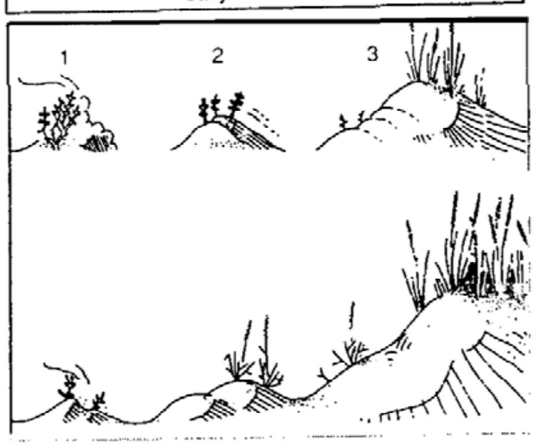
The dunes and water

In the winter rain-water filters slowly through the sand to collect in the form of a pool of freshwater above the deeper, salty water-table ; the two do not mix.
In spring and summer, this water-table nourishes the dune vegetation. This water source is soon depleted so the plants have to adapt to a summer drought.



A succession of plants stabilise the dunes.

The *glassworts* (1) are the first to establish, being plants that can survive on saltwater. By blocking the wind, these plants enable the sand to collect around the base creating a "micro"dune. As the dune gets bigger the influence of the saltwater lessens enabling other species, such as *marram grass* and *sand couch*, which have huge root system to establish themselves (3). The presence and diversity of these plants indicate the state of the dune and its stability.



Appendix 2: Further Information On The Camargue.

The Camargue is part of the large Rhône delta and forms the largest wetland site in Europe. It is an internationally important area for migratory birds with over 300 different species recorded in any given year. Sediment from the Rhone has been deposited to form banks, whilst the sea has been responsible for removing sediment from the mouth of the river and using it to build up a dune system which separates lagoons from the sea.

The population of the Camargue is sparse - this is due to the high flood risk. Most settlements and lines of communications tend to be found on the ridges of higher ground. In 1860, defence dykes were completed - the area is now made up of mainly artificial water levels, which greatly reduces the risk of flooding. The natural appearance of the area is retained through its shear size and diversity of ecosystems.

The Camargue Regional Park was set up in 1927 to ensure that conflict between the various activities and uses of the area are minimised. The main objective of the Park is 'Protection of nature and the environment'. The most fragile areas are designated Nature Reserves - these cover an area of 13,000 hectares and are closed to the public. The Park has an elaborate land-use plan that lays down precise regulations on the balance between natural areas and populated areas, plus nature conservancy along the coastline. Regional councils and departments all try to acquire the most threatened areas.

Working form the coast inland, there are a number of distinct zones:

Beach and Sand Dunes: these mark the barrier between land and sea. They are a popular area for tourists but they are a fragile ecosystem that can be easily destroyed through trampling;

Salt Pans: salt is a major industry in the area. Salt water is pumped from the sea and slowly circulated through lagoons, where the water gradually evaporates away. Eventually the very salty water reaches the salting beds by now it is completely saturated with salt. From the sea to the salting beds the water will have travelled some 50kms. The average annual harvest of salt is 600,000 tonnes;

Brackish Lagoons: these contain both freshwater and saltwater fish. Limited fishing is carried out here, as there are very few professional fishermen. There is also some duck hunting. It is obviously important that both activities are managed properly to maintain the equilibrium of these ecosystems;

Freshwater Marshes: the reeds that are found here are cut and used for thatching or matted to form wind breaks;

Higher Ground: these areas are the summer pastures for bulls and horses;

Agricultural Land: mainly found on the alluvial deposits of the Rhône and on higher ground. Cereals and fodder crops tend to be grown on the non-irrigated land, whilst vineyards, rice paddies, and market gardening are found on the irrigated areas. Rice cultivation was the major crop of the Camargue between

1950 and 1970, when paddy fields covered up to 20,000 ha of land. Since then overproduction resulted in falling prices until it became uneconomic to grow so much rice and the crop declined to about 1/3 of its original extent. However, the former paddies were then used for other crops as the process of flooding the fields meant that the salt in the soil was washed out. About 80,000 sheep still graze the Camargue. During the summer months they are moved to alpine areas (transhumance).

Other points of interest include:

Camargue Horses: the white horses live in semi-freedom on land which is unfit for cultivation. Breeding stallions are selected by the horse breeder and kept with the herd all year round. Most foals are born between April and June. They are born black or dark grey, often with a white blaze on the forehead. As yearlings they will be branded and broken in at around 3 years. They are used for herding and more recently in the tourist industry for pony-trekking;

Camargue Cattle: the cattle are kept in similar conditions to the horses - in semi-freedom on the poorer pasturelands. Again they are bred under natural conditions and branded as yearlings. There are about 50 herds containing around 6,000 head of cattle. They were formally used for farm work, e.g. pulling ploughs, but are now bred solely for meat and the Camargue bull contest;

Flamingos: the Camargue flamingos are part of a circum-Mediterranean population, with the delta as the only regular breeding site. Nests are on islands in the brackish water. The artificial control of the water levels provides security from land predators. The number of breeding pairs is approximately 20,000. Mating takes place from January, with egg-laying occurring in April. Each female lays 1 egg in a depression on a volcano shaped mound of mud, which is made with the beak. Both parents take part in the incubation process that lasts for 28 to 30 days. Each stint of incubation can last up to 4 days, since the partners may have to go long distances (up to 70kms) in search of food. When the chicks are born they are covered with a white down which is quickly replaced with grey feathers. The true plumage develops slowly with each successive moult, taking about 4 to 5 years for the true pink colour to be attained. The chick stays on the nest for a week, before moving to an enormous 'crèche' with other chicks. Their parents feed the chicks for about 10 weeks, until they can fly.

Appendix 3 Xerophytic adaptations in dune plants (Teacher sheet)

Species	Description	Adaptations
Marram grass *Ammophila arenaria*	Tall, tough grass at the front of the dunes. U-shaped in x section.	Stomata inside U. Lots of hairs on inside of U – water vapour builds up to slow evapo-transpiration. Deep, fast growing roots.
Sea spurge *Euphorbia paralias*	Bottle brush with green flowers at tip of stems. Front of the dunes. Break the stem and there is white 'latex' on the inside. Hairless.	Few stomata. Closely packed leaves slow evapo-transpiration (moist air builds up around leaves and reduces concentraion gradient from inside leaf to outside).
Clematis *Clematis rubra*	Scrambling, straggling plant. Dark green leaves which are pinnate (clusters of 3-5 on stem). Purple flower. Feathery seeds which blow easily – good colonist.	Slightly waxy leaves with few stomata. Spreads easily.
Chamomile *Anthemis maritima*	Slightly succulent, fleshy leaves – bit like parsley. Front of the dunes. Daisy-like flowers – white petals with yellow centre.	Few sunken stomata. Succulent leaves, so retains moisture.
Prickly saltwort *Salsola kali*	Upright plant about 10-30cm tall. Leaves like fat spines, in whorls around stem.	Succulent plant – retains moisture. Spiny so deters grazing.
Helichrysum *Helichrysum stoechus*	Woody plant in clumps on main dune ridge. Thin leaves 1-2cm long. Slightly greyish looking due to hairs. Flowers yellow cluster on top of stems. Aromatic.	Hairy leaves – reduce evapo-transpiration. Slightly woody and aromatic – deters grazing. Aromatic oils help it survive fire.
Woolly medick *Medicago marina*	Tri-foliate plant (like clover) but in clumps on main dune ridge. VERY hairy!	Hairs slow down evapo-transpiration.
Hare's tail grass *Lagarus ovatus*	Very hairy grass. Seed head a little cluster like a rabbits tail.	Hairs slow down evapo-transpiration.
Sea stock *Mattiola sinuata*	Green-grey leaves. Thinish (few mm) and longish (1-3cm). Flower purple with a white and yellow centre.	Hairs slow down evapo-transpiration.
Italian catchfly *Silene italica*	Leaves in opposite pairs – grey-green and hairy. Flowers white and petals delicate and folded in – inroll in the evening (pollintaed by moths).	Sticky stem traps bugs that may feed on it. Don't digest them, although their remains may fall on ground near plant. Hairs slow evapo-transpiration.

Evening primrose *Oenothera erythrosepala*	Tall plant (1m). Leaves in rosette. Bright yellow flowers in clusters on a separate flowering stem.	Flowers open at sunset (moth pollinated) and last just one night. Stem hairy so protects flowers from insects.
Geranium *Geranium rotundifolium*	Leaves divided almost to base – and overall shape is rounded. Tiny pink flowers.	Leaves are hairy, slowing down evapo-transpiration, and deters insect browsers.
White stonecrop *Sedum album*	Tiny, fleshy, egg-shaped leaves held close to stem. Often tinged red. White flowers in clusters on tops of stems.	Succulent plant – stores moisture.
Giant reed *Arundo donax*	Largest grass in region – looks a bit like bamboo.	Introduced from SE Asia, now wide spread. Frequently planted as a wind break. Very competitive – shades out all else around it.
Soft rush *Juncus effusus*	Bright green, cylindrical stem. Rush not tough to the touch. Flowers in clusters on side of stems.	Thrives in 'wet' slacks beyond the road. Tough, waxy cuticle protecting spongy pithy inside of leaves.
Black bog rush *Schoenus nigricans*	Short rush-like plant, but flower cluster on top of the stems instead of on the side.	Thrives in 'wet' slacks beyond the road. Tough, waxy cuticle protecting spongy pithy inside of leaves.
Sharp rush *Juncus acutus*	Bright green, cylindrical stem. Rush very tough to the touch, tips can pierce skin! Flowers in clusters on side of stems.	Thrives in 'wet' slacks beyond the road. Tough, waxy cuticle protecting spongy pithy inside of leaves.
Round-headed club rush *Scirpus holoschoenus*	Short rush-like plant, but flower clusters 2-3 bobbles on the side.	Thrives in 'wet' slacks beyond the road. Tough, waxy cuticle protecting spongy pithy inside of leaves.
Sea holly *Echinophora spinosa*	Very spiny plant – leaves like very thin holly leaves.	Can loose a large percentage of plants moisture – tolerates drying out well. Spiny to deter browsing.
Sea heath *Frankenia spp.*	Leaves tiny in globe-like clusters – a bit like heather. Plant very woody.	Woody stems deter grazing. Tightly clustered leaves reduce water loss by evapo-transpiration.
Felty germander *Teuchrium polium*	Smallish leaves – longer than broad, with wavy edges. Downy. Tiny pink flowers in season.	Woody stems deter grazing. Hairs slow water loss by evapo-transpiration and deter browsers.
Aleppo pine *Pinus halepensis*	Bark silver-grey on younger branches, reddish-brown and cracked on older branches. Egg-shaped cones 5-12cm	Extremely drought resistant – often planted to stabilise sand dunes.

	long. Needles in pairs, 6-13cm long.	
Maritime pine *Pinus pinaster*	Bark redd-sh-brown becoming deeply cracked. Cones egg-shaped 8-22cm long. Needles in pairs 18-25cm long.	Extremely drought resistant – often planted to stabilise sand dunes.
White poplar *Populus alba*	Grey-green furry leaves, white on underside.	Hairy leaves slow water loss by evapo-transpiration.