

Contribution of Veta La Palma to the study of climate change
 Contribución de la finca Veta La Palma al estudio del cambio climático

VETA la PALMA

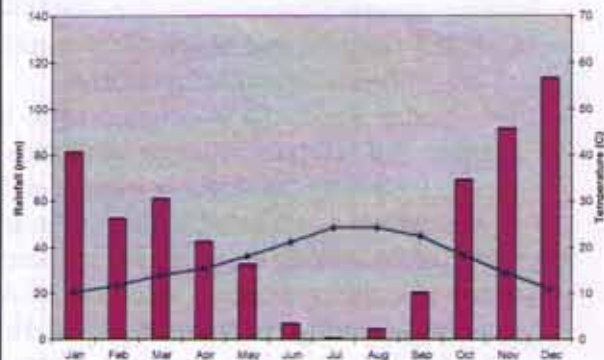
The importance of Veta la Palma derives from its strategic location in the Guadalquivir Estuary, an active geomorphologic system of Southern Spain. This estate, with 11,300 hectares, occupies one half of the largest island of the Guadalquivir delta, Isla Mayor. In 12,000 years BC this area was completely covered by the sea, and it was not until 400 years BC that a bay was formed. During the 20th century, when the estate owned by a British family, the property was drained using a complicated system of dykes and canals. For more than 50 years the estate was not a wetland any more. It was when Pesquerias Isla Mayor took over the estate, that it was decided to turn back the estate into what it used to be, a wetland. The existing drainage system was reversed so the area could be flooded with appropriate control. This process has been an important success. Biodiversity has come back to the island, and in fact, this estate has become internationally recognized for its role in conservation. Veta la Palma is part of the Nature Reserve of Doñana, and supports the bird diversity of the National Park of Doñana. The abundant fish produced through aquaculture, the Guadalquivir delta, the agricultural systems and the wetlands provide excellent habitat and food for high numbers of diverse fauna.

Veta la Palma is now facing several threats, continuous erosion and sedimentation, possible changes in the Guadalquivir system, continuous sea level rise of approximately 0.2mm per year, desertification, and large numbers of birds consuming a great proportion of the fish production. Some of these risks will hopefully be avoided, but others will require adaptation and mitigation strategies if the present importance of Veta la Palma is to be preserved.

Area: 11.300 hectares
 Altitude range: 0 – 2 metres ASL.
 Municipality: Puebla del Rio
 Province: Sevilla
 Country: Spain
 Biogeographical region: Mediterranean



1979 - 200



Representative species

Phoenicopterus ruber,
Fulica cristata, Oxyura leucocephala
Podiceps nigricollis, Calidris alpina,
Anguilla anguilla, dorado,
Phragmites australis, Salicornia spp

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Key messages

- Veta la Palma is situated on an strategic point for biodiversity conservation and climate change.
- The geomorphologic process is very active in the estate, since the delta of the Guadalquivir River is in continuous change.
- During the last decade precipitation has decreased and maximum temperatures have increased significantly.
- Especially, summer months are becoming extremely hot and dry.
- The trend that temperatures and rainfall have followed over the last decade is likely to continue under any of the predicted climate scenarios.
- Due to the location of Veta la Palma, erosion, desertification and sea level rise are the main risks arising from climate change that will affect the estate.
- Although the estate has few opportunities to mitigate climate change, this needs to be considered with future adaptation measures that will need to be taken.
- The aquaculture activities, the coastal line and the biodiversity are the areas likely to be most affected.
- Continuing with environmental measurements and biodiversity census will assist decisions on adaptation to future climate conditions.
- The important water system developed for the aquaculture activities needs to be adapted to future environmental variables in order to ensure the profitability of this activity and also the biodiversity.
- Veta la Palma is internationally considered among the best privately owned properties for bird conservation in Europe, and therefore, it is expected that support will be received for its adaptation to climate change.

Current climatic and biophysical conditions and changes with climate change

a) Climatological information

The Iberian Peninsula is considered to be the area in Europe most affected by climate change. All climate change scenarios indicate marked increases in temperatures, especially during the summer period, and severe decreases in summer precipitation. Veta de la Palma is just located in one of the areas of Spain most likely to be affected in future, where temperatures are expected to increase from 1.4 up to 7.5°C depending on the time of the year and scenario. Under the ACACIA B1 low scenario the precipitation is likely to decrease during the summer period. However, more severe impacts are expected under the ACACIA A2 High scenario where we could expect a decrease of 73% ($\pm 82\%$) during the summer and an increase of 19% ($\pm 73\%$) during the winter period. Such conditions are not very encouraging for this region when the average annual precipitation is 576mm and average annual temperature is 16.8°C. This data is based on the Manual Meteorological Station of Palacio de Doñana, in the proximity of Veta la Palma. Data in this location have been collected since 1979, and therefore the statistical analysis looks at differences between the period 1979 -1990 (rather than the normal 1961-1990) and 1991-2004. Results indicate that rainfall has decreased significantly ($-26.2 \pm 24.97\text{mm}$) over the last decade, although there is not a clear pattern in the changes in distribution.

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Whereas months such as March and November have suffered from decreases in rainfall in other months such as May and December precipitation has increased. More interesting are the results from the temperature analysis. Whereas the annual temperature has not increased over the same period, closer examination of the data indicates a general and significant increase from April to September. Similarly minimum temperatures overall have not increased but significant increases have occurred during February, March and the summer months. Maximum temperatures have increased by 1.27 ± 1.26 in the last decade mainly due to the marked increases during the spring and summer months. As this trend is expected to continue, this region of Spain is clearly facing desertification problems that need to be considered in the management and development of any activity within the estate.

b) Coastline and water conditions

Veta la Palma is located on the Atlantic coast of Andalusia, surrounded by the Guadalquivir River and one of its branches, the Brazo de la Torre. The highest point of the estate is only 2 metres above sea level; therefore, with its location by the sea and being surrounded by waters and the low altitude across the entire estate meant that this area has been flooded on many occasions. It was between 1926 and 1928 when the estate belonged to a British company, that dykes and a complex canal system were built to avoid flooding and allow cultivation. As a result, Veta la Palma was not able to be described as wetland any longer and biodiversity in the region completely changed. Recently, in 1982, when Pesquerias Isla Mayor took over the estate, it was decided that the drainage system would be turned into a reverse system, where instead of being used for drainage activities it would be used for flooding activities. Clean water of excellent quality is now pumped through the canals to the land both for aquaculture and rice production. The river Guadalquivir is tidal up to Alcalá del Río, (the tidal range is 4m at Veta and 2m at Seville), but when the state reservoirs in the sierras [are emptied] [reach over-capacity] in winter, the salt is flushed down to the mouth of the river and the fresh water can be used to irrigate the rice. The aquaculture on the other hand requires brackish water. The typical volume pumped is almost 1 million m³ a day. Although the changes have required great efforts, this has been successful not only for the economic sector but also in that nowadays, Veta la Palma is considered to be the most important privately owned property for the protection of aquatic birds of Europe. More than 300 kilometres of canals, the main rivers, small lagoons or as they are called locally "lucios", and the coastline give the estate very special conditions. Its strategic location and the way the estate has developed in the last decade would allow Veta la Palma to adapt to decreases in precipitation as the water is pumped from the river estuary. However, the approximate 2.2mm rise of sea level per year needs to be taken into consideration when managing the canal and dyke system depending on planned future activities.

c) Soils

A clay cap, about 20m thick, which overlies the Marismas. Above the clay, the movement of water flooding and retreating from the land gives Veta la Palma characteristics of sandy and limestone [?] soils. Due to soils being washed continuously the organic matter on the top is very thin. Moreover, the influence of the sea increasing

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salinity with depth limits the potential of the soils for agriculture production. The pH of soils in Veta la Palma ranges from 7 to 8.

d) Ecosystems and biodiversity

Grazed meadows, lagoons, marshes, land elevations of around 2 metres high (*vetas*), fresh water river and canals and the coastline represent the main ecosystem in Veta la Palma. The mix of water, salt, food and vegetation cover provides excellent habitat for many animals to reproduce, feed and live, especially for birds using the Strait of Gibraltar on their migratory movements.

The majority of the estate is covered with different grasses and some woody species called *almajos*, adapted to poor and saline soils. In the *vetas* the dominating species are *Salicornia fruticosa* and *Arthrocnemum fruticosum* whereas in more saline and normally flooded areas the most commonly found species are *Salicornia* (glassworts), and the *almajo* *Arthrocnemum macrostachyum*. The emergent vegetation in lagoons and marshes varies from the border to the centre, *Phragmites australis* being the dominant species in the deeper areas and the canals. The aquatic vegetation also represents an important plant community at Veta la Palma. All these habitats are carefully looked after aiming not only the productivity in the estate but mainly biodiversity conservation. This estate is part of the Doñana Nature Reserve and is on the border to the National Park of Doñana, therefore, any management activity affects the biodiversity. Fortunately, the management of Veta la Palma has especially been focused on biodiversity conservation for the last two decades. As a result, the populations of many birds have significantly increased and also more bird species are starting to be seen. The major habitat changes occurring since 1979 explain the variation in bird numbers and diversity. Over the last two decades, the estate has been transformed into what used to be in the past, a very important wetland. It general could be said that many species have increased their numbers, but this increase mainly relates to the mentioned habitat changes. It is very likely that climate has also affected the bird population, but it is difficult to delimit which proportion of the changes related to increases in temperatures and reduction of precipitation.

It is necessary to continue carrying out bird censuses in the area, as Veta la Palma is at a very strategic point. Changes in the actual habitats would significantly affect many bird populations. Additionally important, as Veta is a migratory stop for many bird species, the censuses allow understanding of the impacts of changes in habitats and climate happening both in Europe and Africa.

Although Veta la Palma has been designated as part of the Natura 2000 Network mainly because of the bird community, the flora and fauna of the estate is extremely important and valuable. In the box presented below are included all vertebrate species existing in Veta la Palma considered under threat (*EN*: *Endangered*; *R*: *Rare*; *VU*: *Vulnerable*). These categories strictly follows IUCN and the “*Redbook of Threatened Vertebrates of Spain*” criteria. In particular, Veta is one of the major feeding grounds for *Phoenicopterus ruber*. The breeding colony, one of the largest in the western Mediterranean, is at Fuente de Piedra, 130km east, because the clay of the Marismas is too intractable for the birds to mould for their nests.

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Mammals			<i>Aythya nyroca</i> Ferruginous Duck	
<i>Lutra lutra</i> Otter	VU			EN
<i>Myotis blythii</i> Lesser mouse-eared Bat				
	VU		<i>Botaurus stellaris</i> Bittern	E
<i>Rhinolophus ferrumequinum</i> Greater Horse-shoe Bat	VU		<i>Cercotrichas galactotes</i> Rufous Bush-Robin	EN
<i>Rhinolophus mehelyi</i> Mehely's Horseshoe Bat	EN		<i>Ciconia ciconia</i> White Stork	VU
			<i>Ciconia nigra</i> Black Stork	EN
			<i>Circus aeruginosus</i> Marsh Harrier	VU
Fish			<i>Circus pygargus</i> Montagu's Harrier	VU
<i>Alosa alosa</i>	EN		<i>Chlidonias hybridus</i> Whiskered Tern	V
<i>Alosa fallas</i>	EN		<i>Chlidonias niger</i> Black Tern	EN
<i>Aphanius spp.</i>	EN		<i>Coracias garrulous</i> Roller	
<i>Chondrostoma willkommii</i>	VU		<i>Egretta garzetta</i> Little Egret	
<i>Cobitis paludica</i>	VU		<i>Falco peregrinus</i> Peregrine Falcon	VU
<i>Gasterosteus gymmurus</i>	EN		<i>Fulica cristata</i> Crested Coot	EN
<i>Leuciscus pyrenaicus</i>	VU		<i>Gelochelidon nilotica</i> Gull-billed Tern	VU
<i>Rutilus lemmingii</i>	VU		<i>Glareola pratincola</i> Collared Pratincole	VU
Amphibians			<i>Grus grus</i> Crane	VU
<i>Triturus pygmaeus</i>	VU		<i>Haematopus ostralegus</i> Oystercatcher	R
			<i>Himantopus</i> Black-winged Stilt	
Reptiles			<i>Larus genei</i> Slender-billed Gull	R
<i>Caretta caretta</i>	EN		<i>Marmaronetta angustirostris</i> Marbled Teal	EN
<i>Chelonia mydas</i>	EN		<i>Monticola saxatilis</i> Rock Thrush	VU
<i>Dermochelys coriacea</i>	EN		<i>Neophron percnopterus</i> Egyptian Vulture	VU
<i>Emys orbicularis hispanica</i>	VU		<i>Netta rufina</i> Red-crested Pochard	R
<i>Eretmochelys imbricat</i>	EN		<i>Numenius arquata</i> Curlew	R
<i>Mauremys leprosa</i>	VU		<i>Nycticorax nycticorax</i> Night Heron	R
<i>Testudo graeca</i>	EN		<i>Oxyura leucocephala</i> White-head Duck	EN
Birds			<i>Pandion haliaetus</i> Osprey	EN
<i>Alcedo atthis</i> Kingfisher	VU		<i>Pelecanus onocrotalus</i> Great White Pelican	
<i>Anas querquedula</i> Garganey	R			
<i>Apus caffer</i> White-rumped Swift	VU			
<i>Aquila adalberti</i> Spanish Imperial Eagle	EN			
<i>Ardea purpurea</i> Purple Heron	VU			
<i>Ardeola ralloides</i> Squacco Heron	EN			
<i>Asio flammeus</i> Short-eared Owl	R			

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<i>Phoenicopterus ruber</i> Greater Flamingo	<i>Pterocles alchata</i> Pin-tailed Sandgrouse
R	VU
<i>Phoenicurus phoenicurus</i> Redstart	<i>Pterocles orientalis</i> Black-bellied
VU	VU
<i>Porphyrio porphyrio</i> Purple Gallinule	<i>Tadorna ferruginea</i> Ruddy Shelduck
VU	EN
<i>Platalea leucorodia</i> Spoonbill	<i>Tadorna tadorna</i> Shelduck
VU	R
<i>Plegadis falcinellus</i> Glossy Ibis	<i>Recurvirostra avosetta</i> Avocet
EN	R
<i>Podiceps nigricollis</i> Black-necked Grebe	<i>Sterna albifrons</i> Little Tern
R	R
	<i>Sterna caspia</i> Caspian Tern
	R
	<i>Streptopelia turtur</i> Turtle Dove
	VU

Current economic activities and potential impacts of climate change

a) Agriculture

A total area of 3,500 hectares is dedicated to agricultural activities in Veta la Palma. Although as previously mentioned, the quality of the soils is not ideal for agriculture in general, the production of rice is excellent on the estate. An area of 1,000 hectares is dedicated to rice production, having yields of approximately 5 tonnes per year, higher than in many other locations adjoining the estate. The other products cultivated on the estate are wheat and barley, which enter in rotation with legumes in order to fertilize the soils. Otherwise, no other fertilizers are added to the ground. Decreases in precipitation and increases in temperatures will probably have an effect on soil salinity, which would make agriculture harder on the estate in the future.

b) Aquaculture

Since Pesquerias Isla Mayor acquired Veta la Palma, aquaculture has been the most important economic activity on the estate. A total area of 3,200 hectares is artificially inundated using what it used to be a drainage system in the past. These 3,200 hectares are divided into 44 "gavetas" of an average of 70 hectares each. The quality of the water, which is continuously recycled, is excellent allowing for high production of fish. The fish are pellet-fed to a size of 14cm and then put into the *gavetas* to grow. The main species farmed in Veta la Palma are the eel, grey mullet, sea-bass, dorado, and shrimps. Fishing takes place twice a week allowing the estate to continuously take fresh fish into the markets. The high bird population attracted by the landscape but mainly by the food availability is highly decreasing the productivity of Veta la Palma, and an equilibrium needs to be reached. Another problem that Pesquerias Isla Mayor is facing in relation to the aquaculture of the estate, is the future plan for changes [what changes?] in the Guadalquivir River, which would have a direct impact on the water quality and on the pumping system. Additionally, a decrease in annual precipitation would require more water being pumped into the system, meaning more energy consumption and therefore, cost. However, an even more important impact would be the variation on water salinity, which could affect the species of fish produced in the estate. The actual erosion process happening in the Guadalquivir estuary is already affecting the aquaculture as sediments continuously enter. This threat would be pushed to higher levels with sea level rise and possible increase in storms.

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c) Livestock

Pasture lands in Veta la Palma cover an area of 4,600 hectares. These are extensively used by bulls, cows and horses, which highly contribute to the conservation of the marshlands of the estate. Approximately, 1,000 head of a mix of *Ybarra* fighting bulls, *Limousin* and *Charolais*, and *Mostrenca* herd range in this area. *Limousin* and *Charolais* animals are bred to produce meat, whereas the *Mostrenca* bulls are a typical breed of the region, adapted to the life on marshland. Additionally 800 *Arabic* and *Spanish* horses co-habit with the cattle.

As climate in Veta is becoming drier and hotter, there risk that the marshlands will become less productive. Although the number of animals ranging on the marshes is extremely low in relation to the size of the area they use, it may become necessary to reduce the number of heads at certain point.

Carbon Balance

Although energy and fertiliser inputs were unavailable for analysis, N²O and CH₄ [needs a subscript 4 to be inserted after CH!] emissions from rice growing and livestock have been estimated at over 3,000tC equivalent, of which 76%, applying IPCC default methodology, is attributable to methane emissions from rice

Adaptation strategies

Veta la Palma is located at a strategic point, not only in terms of biodiversity but in terms of exposure to climate change. Veta la Palma is one of the estates considered in this study more likely to be affected by climate change. Desertification, erosion and sea level rise are major forces that may affect both the economy and the biodiversity of the estate. Fortunately, Veta la Palma has developed a complex systems of canal that allows for regulating the water across the estate. Because the reservoirs in the sierras require 600mm to fill, but often receive 1,000mm or 1,200mm, there does not appear to be an immediate threat to the winter flushing of the river. Close monitoring of the sea level will however be required. Moreover, water analysis would help to understand how the expected reduction in annual precipitation would affect the oxygenation and salinity of the water, which would directly impact on the aquaculture activities. The management of Veta la Palma needs to bear in mind the development of climate and what problems the estate is likely to face in the future. Only on that basis can the estate set future objectives.

It is fortunate that this area is internationally recognized and therefore, it is expected that Veta la Palma will receive support in the development of future projects. The fact that this estate already carries out biodiversity census, controls water quality and composition, and recently started collecting climatic data will help it to adapt to any change.

Mitigation strategies

The management of Veta la Palma is focused on productivity and biodiversity conservation. The proportion of forest in the estate is extremely low. If rice production is continued, the options of Veta la Palma to mitigate climate change are reduced; the dry and hot climate together with poor soils do not provide a good ground for forest or bio-fuel crop production. However, feed wheat could be grown for bio-ethanol. It would be suggested that the estate integrates in its management the development of a carbon

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account balance. This would not help to mitigate climate change but to monitor their role in the carbon cycle.

Acknowledgements

Family Hernandez Baeza
Miguel Medialdea
Parque Donana

MJS
21.I.2006