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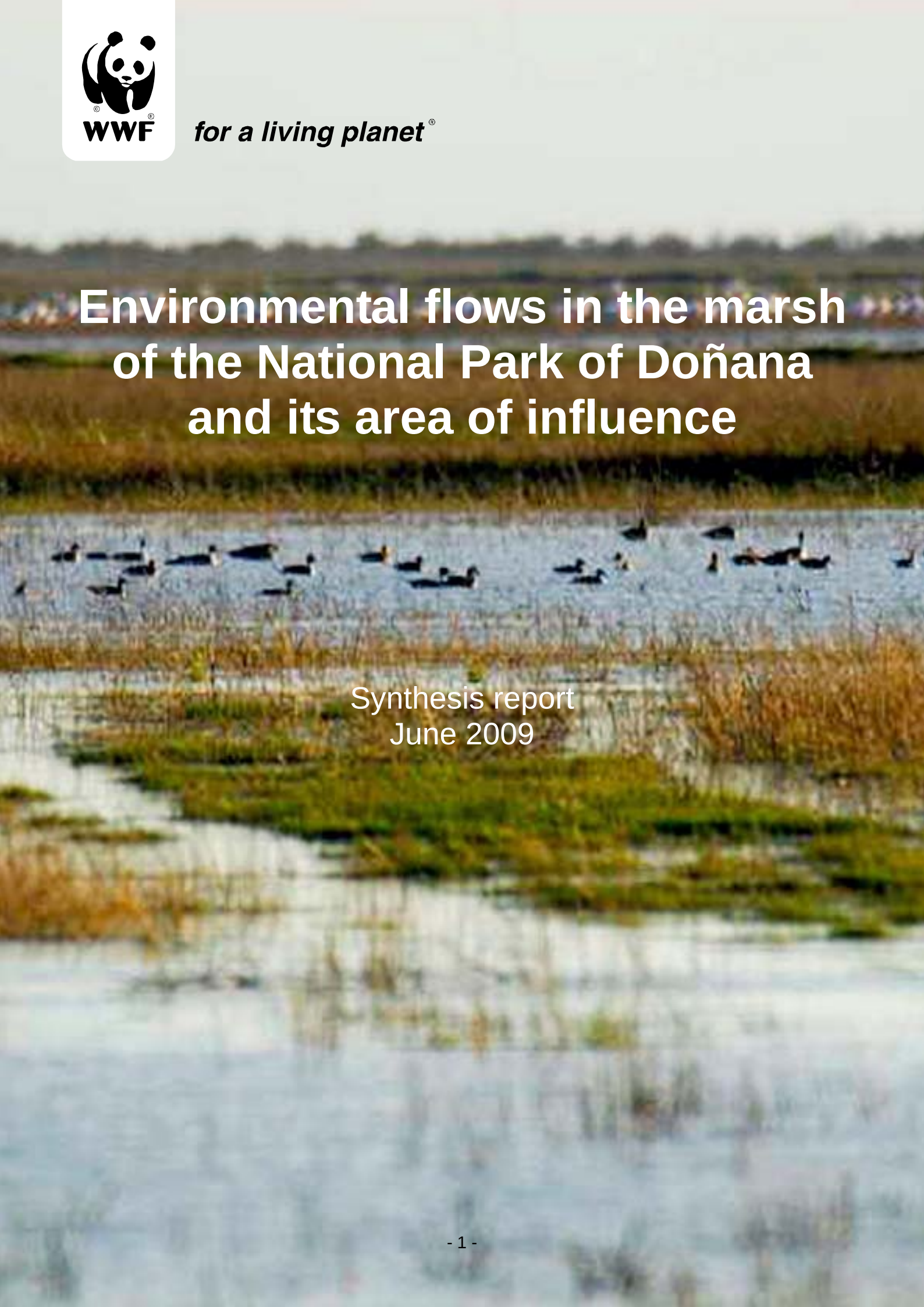

Environmental flows in the marsh of the National Park of Doñana and its area of influence

Synthesis report
June 2009

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1. INTRODUCTION

Alarming statistics on wetlands destruction have been gradually putting together over the second half of the twentieth century. A long list of activities and actions could lead to modifying the physical, chemical and biological properties of aquatic ecosystems. The Guadalquivir basin faces most of these problems, with a paradigmatic example in the Doñana Natural Area. This space for decades was subjected to intense public intervention to improve the socio-economic development of the inhabitants of this area. Beyond the expectations and achievements, this development model resulted in hydrological and ecological changes on a large scale, with a clear risk on the natural and cultural heritage of Doñana.

As reflected in the conclusions of the International Expert Meeting on the Water Regeneration of Doñana (MMA, 1999), the ecological restoration of these wetlands will only be achieved in the medium and long term if the water inputs to the marsh are guaranteed. In this context, the environmental flow determination means to quantify those volumes of water to be reserved for environmental conservation (rivers, streams and the marsh of Doñana) that later will be excluded of the different water uses.

Within the timetable envisaged by the Water Framework Directive, the "Guadalquivir Water Management Plan" has to be finished in December 2009. Under Spanish law, water requirements of wetlands will be identified in this Management Plan, i.e., a few months for discussion and approval (now is the time to address this issue).

The completion of this work is intended to collect and synthesize existing knowledge about the role of the water in the marshes of Doñana, in order to define the environmental flow needs of the marsh and its area of influence.

2. THE WATER DYNAMICS OF THE MARSH

2.1. DYNAMICS IN NATURAL CONDITIONS

The hydrological functioning of wetlands Doñana includes a diverse network of rivers, streams and lakes, as well as water from other sources (water transition from the estuary and discharges from aquifers). Understand this dynamic is a critical first step in the study of the water needs of the marshes of Doñana.

Under natural conditions (figure 1), most of the contributions of water were coming from several rivers and streams (Guadalquivir, Guadiamar, La Rocina Stream, El Partido Stream, etc.) including regular entries through the Guadalquivir estuary (ICONA, 1994; MMA, 2001; García Novo and Marín, 2005; García Viñas *et al*, 2005).

Groundwater, although quantitatively less important, were crucial for the maintenance of rivers and wetlands of Doñana. The aquifer system of Almonte-Marismas pours its waters at various points on the periphery of Doñana, allowing the formation of temporary pools characteristics of these areas (Hondón and Sopetón), as well as springs that drain into the marsh of Doñana (García Novo and Marín, 2005).

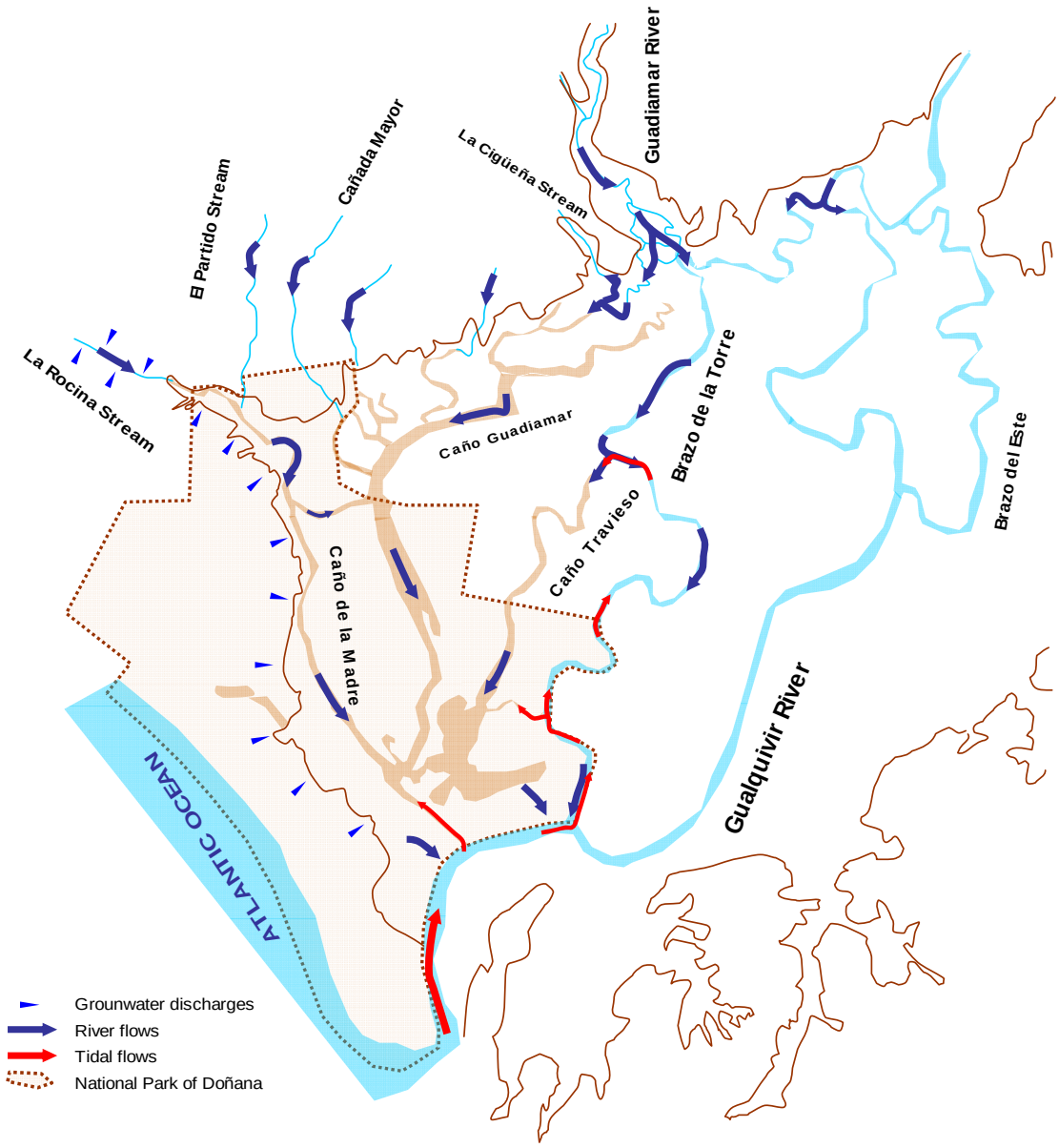

Figure 1. Outline of the natural hydrological functioning of the marshlands of Doñana. SOURCE: Original in ICONA, 1994. Modified by the author.

Doñana wetlands showed a typical annual cycle. According to the Water Plan of the National Park, the accumulated water produced the progressive flooding of the marshes in the months of October to November, reaching its peak in January or February (Casas and Urdiales, 1995). When the marsh reaches its maximum capacity (approximately 135 hm^3), excess water is evacuated towards the Guadalquivir River. Beginning in spring, evaporation losses are not offset by the river inputs, leading to dry out the marsh in the summer.

2.2. CHANGES IN THE DYNAMICS OF THE MARSH

The most profound changes in Doñana have taken place in the second half of the twentieth century. Taken together, these changes reduced the original area from 150,000 has to 30,000 has (Casas and Urdiales, 1995, MMA, 2001, García Novo and Marín, 2005)

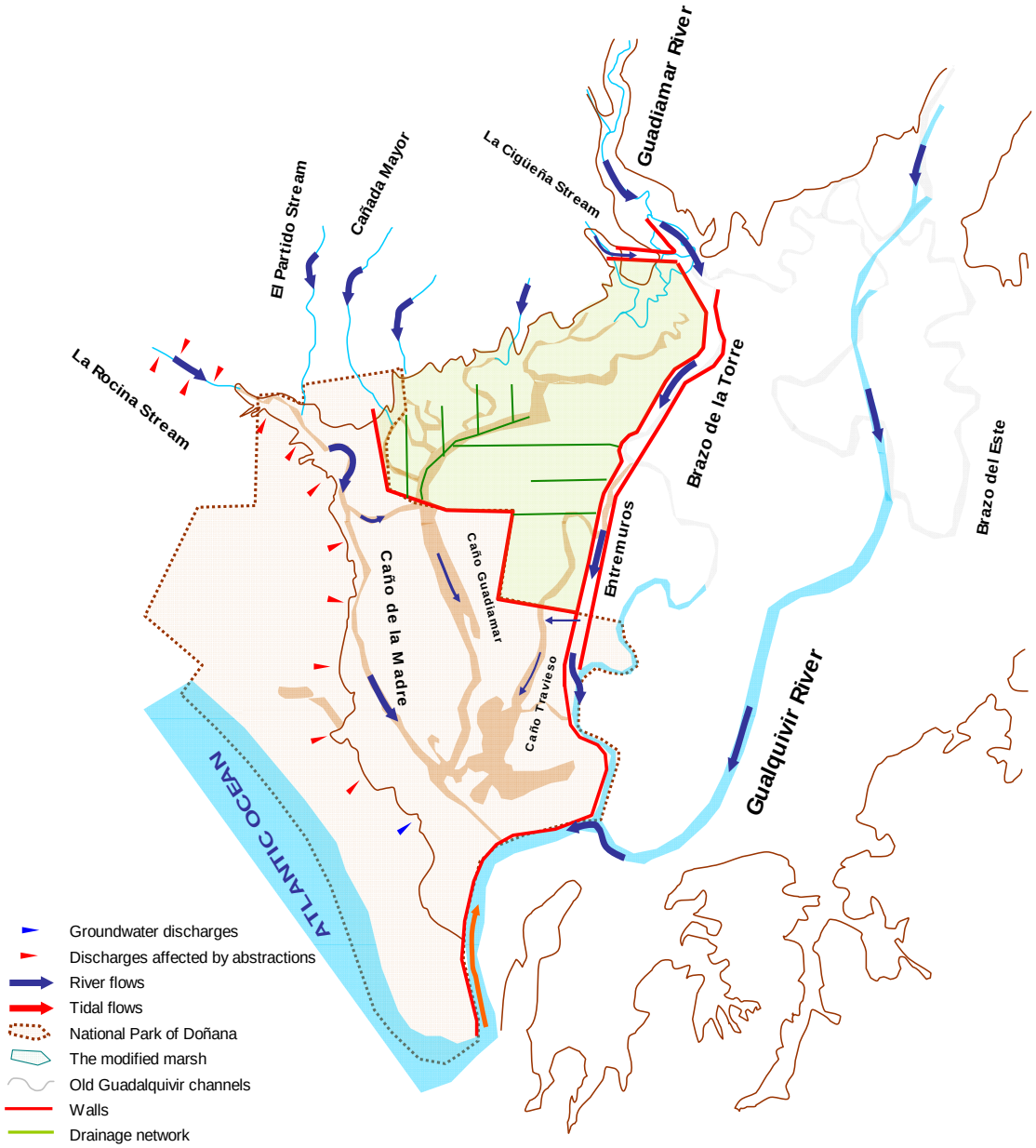

Figure 2. Outline of the modified hydrological functioning of the marshlands of Doñana in 2000. Source: Original in ICONA, 1994. Modified by the author.

As a result of different human interventions (modifications of natural channels, dam construction, leveling, building the drainage network, etc.), there was a drastic change in the hydrodynamic of the wetlands (figure 2). One of the consequences of these hydrological changes has been the loss of functionality of the main arteries that distribute the water within the marsh. Another consequence has been the drastic reduction in water inputs to the marsh. Despite the many nuances that can be done with reference to the values presented, figure 3 reflects a rough chronology of the most important interventions and a rough quantification of them.

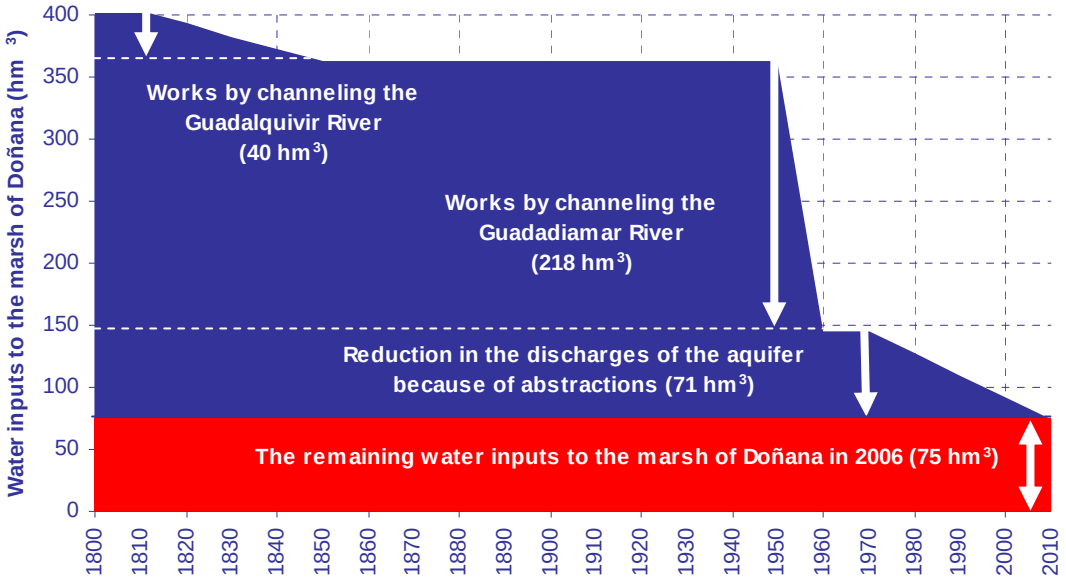

Figure 3. Chronology of the reduction of the river inputs to the marsh of Doñana with indication of the main human interventions. Source: Data from SACRAMENTO (CHG, 1998) and the "Official Network of Gaging Stations"

Table 1 shows the comparative values of the water inputs in natural conditions compared to current conditions. Taking into account the river and groundwater inputs, one can say that overall, Doñana's wetlands currently receive less than 20% of its natural contributions.

Tabla 1. Differences in the water inputs to the marsh of Doñana by comparing natural and current conditions. Source: Own data from SACRAMENTO (CHG, 1998) and the "Official Network of Gaging Stations"

	WATER INPUTS (hm^3)		REDUCTION (%)
	NATURAL CONDITIONS	CURRENT CONDITIONS	
Guadalquivir River	40	0	100,0
Guadiamar River	218	0	100,0
Other contributions[1]	145	74	49,0
	403	**74**	81,6

[1] Among these contributions are considered the various streams they bring water to the marsh (La Rocina Stream, El Partido Stream, etc.)

2.3. THE HYDROLOGICAL RESTORATION OF DOÑANA

With the objective of recovering the natural water inputs, in 1981 was designed the "Doñana Water Regeneration Plan" (MMA, 2001). This plan was aimed to restore the functionality of the Guadiamar and Travieso channels, to incorporating the waters from the Guadiamar River and the restoration of the Montaña del Río (physical element that regulates the water flow between the marsh and the Guadalquivir River).

Despite the various initiatives undertaken in the 80 and 90, Doñana marshes had not recovered its water inputs. In these circumstances arises the ambitious project of the hydro-ecological restoration of the marsh called "Doñana 2005". This project was

conceived as an open catalog of actions to curb the trends of degradation observed in previous decades, to restore their natural patterns of hydrological dynamics and the connectivity with the Guadalquivir estuary.

Figura 4. Appearance of the "Caño Guadiamar" north of the National Park.

3. THE ENVIRONMENTAL FLOW STUDY

3.1. ENVIRONMENTAL FLOWS IN DOÑANA

The main water contribution to the marsh was coming from the set of rivers in the area (in natural conditions the Guadiamar River, La Rocina Stream, El Partido Stream, etc.). The main water contribution to the marsh was coming from the set of rivers in the area (in natural conditions the Guadiamar River, La Rocina Stream, El Partido Stream, etc.). In order to address this study in coherence, it is necessary to consider the interdependence that exists between the river flows and the marsh.

The work of scientists and experts involved in the calculation of environmental flows has increased substantially in recent decades, offering an extraordinary evolution in concepts and analytical techniques. Despite this progress, still lack a strong consensus among scientists and managers to adopt a methodological approach fully satisfactory (Arthingthon et al, 2006).

Recently are growing criticism by the application of overly simplistic methods, especially with regard to the scarcity of experimental results, arbitrary criteria, limited visions, etc. (Arthingthon et al, 2006; Parasiewicz et al, 2008; Souchon et al, 2008). Beyond the discussion of the methods, the decision to adopt an environmental flow

regime is a choice between alternatives which consider the environmental benefits of each of these alternatives.

For these reasons, in this study has been employed a Decision System to calculate the water needs of Doñana, similar to the ELOHA conceptual framework (Ecological Limits of Hydrologic Alteration). It is a scientifically framework robust and flexible for assessing and managing environmental flows, where knowledge is systematically organized around the relations between hydrology and ecology within a broader context of decision making (Arthingthon et al, 2006, Poff et al, 2009).

3.2. APLICATTION OF THE CONCEPTUAL FRAMEWORK

3.2.1. Hydrology and ecology

3.2.1.1. Hydrology *vs*. conservation: a general model

At the beginning, the environmental flow studies were addressed through deterministic methodologies, which define a boundary separating ecological and non-ecological, conservation and destruction. Currently, the environmental flow studies are addressed from a more open and complex framework, considering that different flow conditions will provide different ecological conditions (King and Brown, 2006). The Biological Condition Gradient (USEPA, 2005; Davies y Jackson, 2006) is a scientific model that describes the biological response against increasing levels of pressure, so that the biological deterioration will be increased as much as the stress factor is increasing (e.g. hydrological alteration). In general is accepted the next expression: "the greater the hydrological alteration the lower the biological condition" (Figure 5).

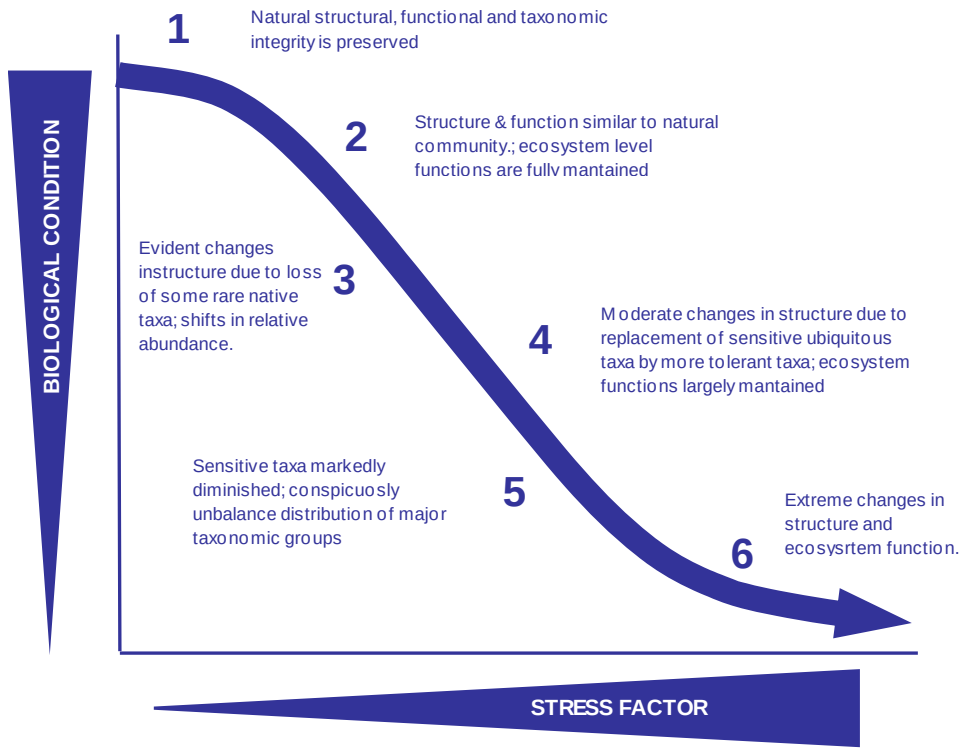

Figure 5. The "Biological Condition Gradient Model". Source: Original in Jackson and Davies, 2006. Modified by the author.

3.2.1.2. Hydrology *vs.* vegetation.

The high diversity and rarity of plant communities of Doñana gives them a great value (García Murillo et al, 2007), that is increased because of the role played by the vegetation for other wildlife groups (birds, amphibians, fish, etc.) and its role in the ecological functioning of wetlands (nutrient cycling, turbidity control, etc.).

From 1998 to 2000 was carried out an extensive study to determine the hydraulic variables that control the vegetation distribution in the Doñana marsh (García Viñas, et al. 2005). Combining this information with the water levels, hydraulic parameters were calculated for each plot (number of days with water, the amount of water cm-day etc.). These results allowed grouping the different plant associations according to their hydraulic regime (Table 2 and Figure 6) and allowed developing a "vegetation model" that predicts changes in plant communities in terms of the flooding regime of the marsh.

Plant comunidty	Dominat species	Elevation* (m.a.s.l.)	Number of flooded days
Almajar	*Arthrocnemum macrostachyum*	1,58 -1,83	57
Almajar mixto	*A. macrostachyum/Juncus subilatus*	1,60 - 1,36	95
Junquillar negro	*Eleocharis palustris*	1,54 - 1,34	166
Castañuelar	Scirpus maritimus	1,35 - 1,18	139
Bayuncar	Scirpus litoralis	1,21 - 1,00	184
Lucio	Sin helófitos	1,28 - 0,821	179

*Location of 80% of plots sampled

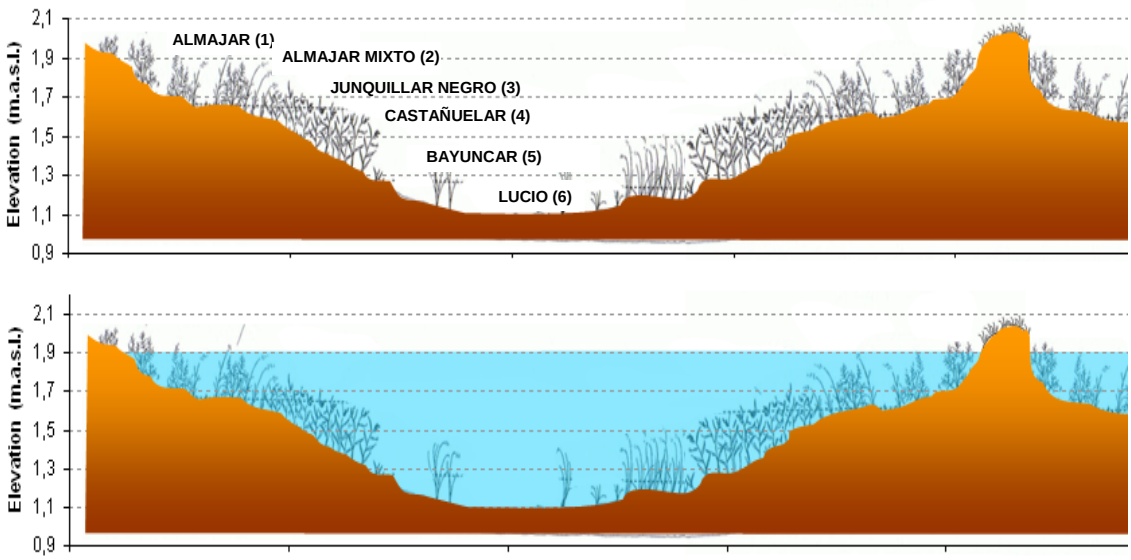

Table 2 and Figure 6. Distribution of plant communities in the marsh of Doñana depending on elevation and number of flooded days. Source: Original in García Viñas *et al,* 2005. Modified by the author.

Within the “Natural Resources Monitoring Program” of the Doñana National Park, the

Doñana Biological Station assessed the vegetation changes for the period 1990-2004, by comparing the Ecological Map of Doñana (Bravo et al. 1998) with the Vegetation Map of the Marsh (EBD-CSIC, 2009). These results are consistent with the hydrologic analysis. The flooding time series of the Doñana National Park have shown low flooding levels (Aragonés et al, 2005).

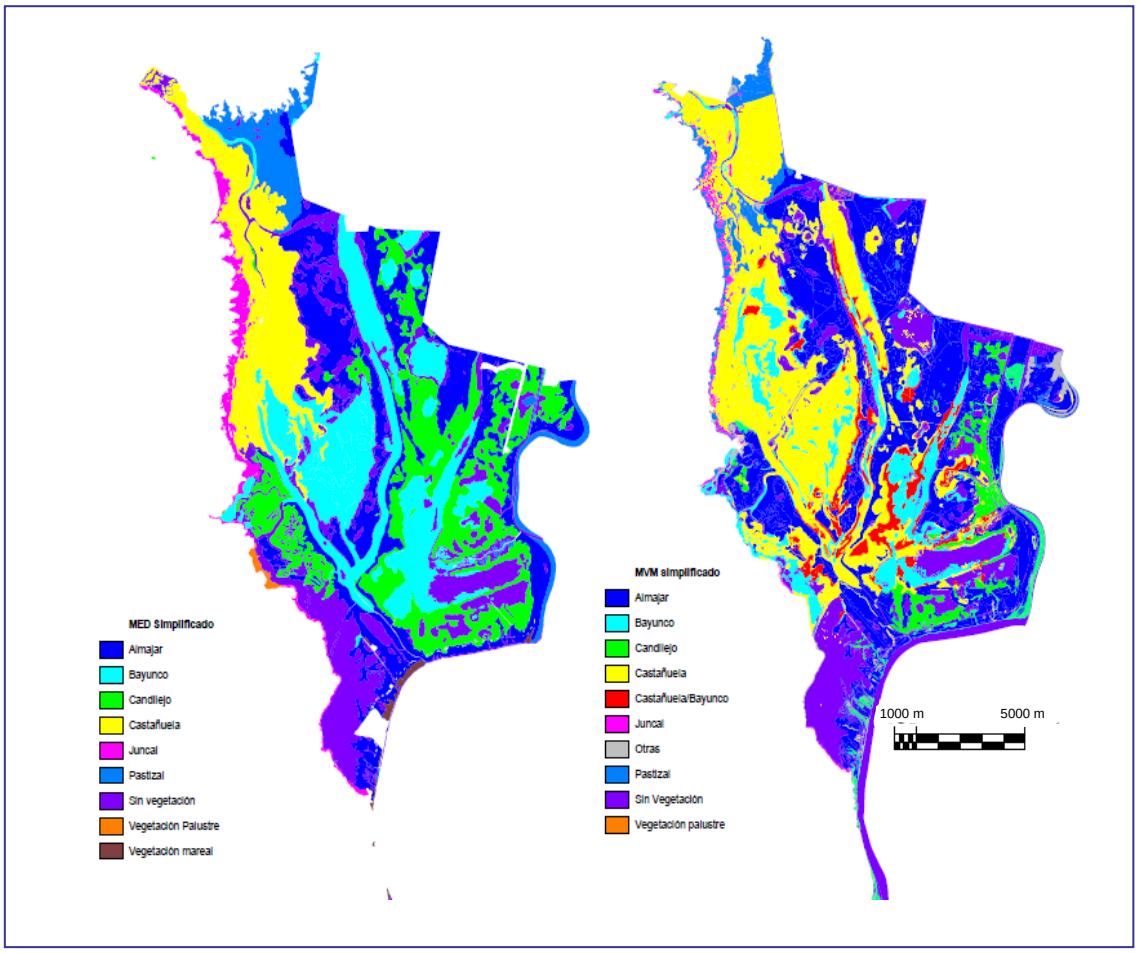

Figura 7. Vegetation changes in the marsh of Doñana for the period 1990-2004. Source: Original in *EBD-CSIC, 2009*.

3.2.2. The legal framework of the environmental flows in Doñana: objectives and criteria

Besides the general legal provisions on environmental flows, the basic laws are supplemented by the particular characteristics of Doñana as a protected area. The conservation objectives of the Doñana National Park were set out in Law 91/1978 (special legal regime aimed at protecting the integrity of the gea, fauna, flora, water and air). In this respect, in compliance with Master Plan for Use and Management of the Doñana National Park (approved by Royal Decree 1772/1991), was approved in 1994 the Water Management Plan of the Doñana National Park (ICONA, 1994).

The water management within the National Park should simulate an operation as close as possible to natural conditions. This approach led to a management model that has been guided by the following criteria (ICONA, 1994):

- The water should flow through their traditional channels, in both quantity and quality similar to the natural conditions.
- The water should not stop at one point longer than it would under natural conditions.
- The water should not cover areas that would never be flooded in natural conditions
- Water must be able to maintain a flow of free and regular exchange with the estuary.
- You must ensure a minimum surface of flooded marsh in years of drought.

In the case of the Doñana Natural Park (declared by Act 2 / 1989), their environmental objectives are set out in the Plan of Arrangement of Natural Resources, among them the "conservation and restoration of natural hydrological dynamics for the existence of the marsh and lagoon systems.

3.2.3. Environmental flow proposals for Doñana and its area of influence.

After completing the hydrological, ecological and policy analysis, the environmental flow needs for Doñana and its area of influence will be:

1. **For each of the rivers and streams that drain into the wetlands, the proposed ecological flow regime will be formed by the set of its natural hydrological values.**

2. **In line with the proposals for the rivers and streams, the water requirements for the marsh of Doñana will be configured by the set of ecological volumes that dump in the same.**

Among the arguments supporting these proposals include:

a) The conservation objectives for the Doñana Natural Area established in the various laws.

b) The documents analyzed in this study show that increasing the natural hydrological dynamics improves the ecological recovery. The natural flow dynamics is a prerequisite for achieving the conservation objectives of the Doñana Natural Area.

c) Despite that there are some limitations and uncertainties in the knowledge of Doñana (particularly as regards the quantification of the natural hydrological regime of rivers and wetlands, the response of species to environmental changes, etc.), these environmental flow proposals are scientifically well founded.

d) The ecological flows of the rivers that discharge to the marsh of Doñana are linked to this protected area by Order ARM/2656/2008. This rule provides that the determination and implementation of the "environmental flow regime" for a protected area shall not relates exclusively to its surface, but also to the elements of the hydrographic system that may have an impact appreciably over the area, despite being out of it.

3.3. ENVIRONMENTAL FLOW PROPOSALS FOR DOÑANA

Figure 7 shows the environmental flow sites addressed in this study. In total we have considered 6 river sites (4 in the Guadiamar River) and the water inputs to the marsh (equivalent to the cumulative contributions of its tributaries).

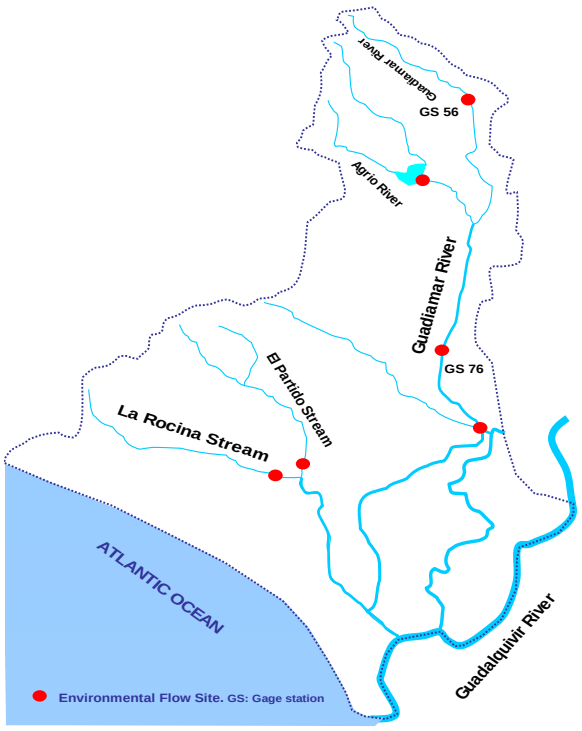

Figure 7. Location of the environmental flow sites
Source: Prepared by the author

The proposed ecological flow regimes are based on the hydrological data provided by the hydrological model (CHG, 1998).

At this point, it should distinguish two aspects. Although the proposals seek to achieve the "natural hydrological regime" (overall objective), we have considered a set of "target flows" that will be required to be kept in the river for management purposes (operational management objectives). To quantify these flows we have characterized the natural flow regime in "normal years" and "dry years", adopting a methodological approach similar to the Range of Variability Approach (Richter et al, 1997).

Table 3 and 4 summarizes the environmental flow proposals for rivers in dry years and medium years in terms of hydrological conditions.

Table 3. Environmental flow proposals for rivers in dry years. Source: Data from SACRAMENTO (CHG, 1998).

ENVIRONMENTAL FLOWS FOR RIVERS IN DRY YEARS												
m^3/s	OCT	NOV	DEC	JEN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
LA ROCINA STREAM	0,03	0,06	0,07	0,08	0,18	0,16	0,12	0,09	0,07	0,06	0,06	0,05
EL PARTIDO STREAM	0,12	0,20	0,38	0,56	0,89	0,88	0,71	0,53	0,34	0,27	0,21	0,17
AGRIO RIVER	0,05	0,07	0,19	0,24	0,33	0,34	0,33	0,19	0,14	0,11	0,08	0,06
AGRIO RESERVOIR	0,11	0,10	0,16	0,23	0,27	0,27	0,31	0,29	0,21	0,17	0,15	0,13
GUADIAMAR AT G.S 56	0,07	0,08	0,09	0,09	0,10	0,11	0,11	0,09	0,08	0,08	0,08	0,07
GUADIAMAR AT G.S. 76	0,35	0,39	0,65	0,80	0,96	0,88	0,97	0,79	0,57	0,51	0,46	0,41
GUADIAMAR AT B. TORRE	0,43	0,49	1,01	1,13	1,67	1,50	1,38	1,11	0,88	0,73	0,62	0,55

Table 4. Environmental flow proposals for rivers in medium years. Source: Data from SACRAMENTO (CHG, 1998).

ENVIRONMENTAL FLOWS FOR RIVERS IN MEDIUM YEARS												
m^3/s	OCT	NOV	DEC	JEN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
LA ROCINA STREAM	0,15	0,14	1,06	2,26	2,08	1,60	0,90	0,34	0,25	0,21	0,18	0,16
EL PARTIDO STREAM	0,67	0,93	2,54	5,78	6,76	5,64	3,43	2,05	1,44	1,14	0,90	0,71
AGRIO RIVER	0,32	0,51	0,94	1,81	1,96	1,82	1,56	0,98	0,65	0,48	0,37	0,28
AGRIO RESERVOIR	0,35	0,51	0,68	1,33	1,48	1,57	0,99	0,69	0,47	0,40	0,36	0,36
GUADIAMAR AT G.S 56	0,11	0,13	0,15	0,34	0,52	0,49	0,31	0,19	0,13	0,12	0,12	0,11
GUADIAMAR AT G.S.76	1,02	1,44	2,86	5,03	5,06	5,59	3,33	2,20	1,33	1,13	0,97	0,88
GUADIAMAR AT B. TORRE	1,49	2,12	4,54	7,49	9,24	8,91	5,19	3,33	2,14	1,75	1,46	1,35

For its part, Table 5 and figure 8 show the water needs in the marsh of Doñana according to different climatic and hydrological conditions. In this case, the monthly contribution of water to the marsh is the sum of ecological flows of its tributaries.

WATER NEEDS OF THE MARSH OF DOÑANA													
	hm^3/year	OCT	NOV	DEC	JEN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
HYDROLOGICAL CONDITIONS	Very dry	1,5	1,7	3,6	4,4	5,8	6,3	5,1	4,2	3,1	2,6	2,2	1,8	**42,3**
	Dry	2,3	4,6	6,9	9,1	10,9	14,1	11,5	6,9	4,5	3,6	3,0	2,6	**80,1**
	Medium	5,2	7,2	15,2	33,2	32,6	34,1	25,3	12,8	8,8	6,2	5,1	4,8	**190,3**
	Wet	8,5	24,1	44,3	61,1	71,5	64,2	45,3	26,6	14,5	11,1	9,0	7,1	**387,2**
	Very wet	17,8	67,8	130,7	144,2	153,4	127,3	91,1	46,3	19,0	14,2	11,4	9,0	**832,3**

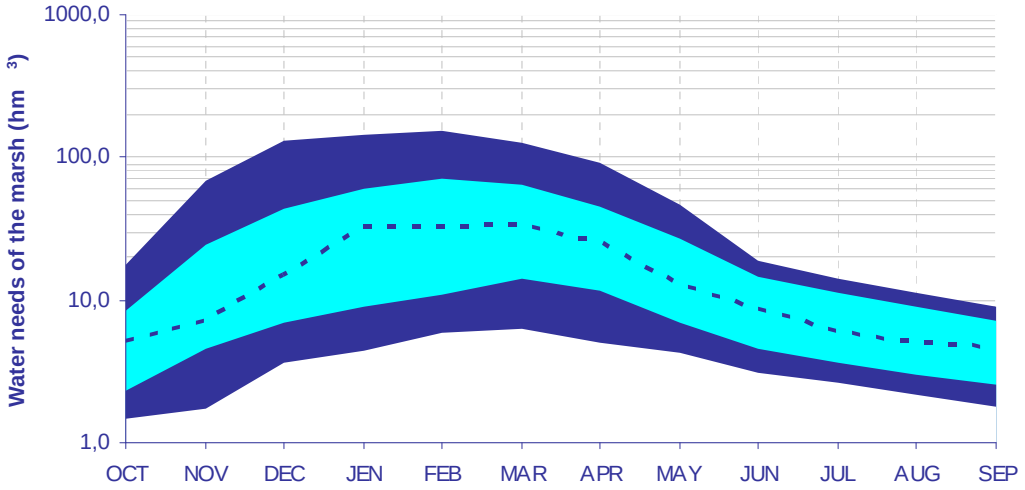

Figura 8. Water needs of the marsh of Doñana in different hydrological situations. Source: Based on data from table 5.

4. CONCLUSIONS

1. **The great interventions in the Doñana area have produced a drastic reduction in its water inputs (less than 20% respect to the natural ones).**
2. **The biological communities exhibit some clear trends of change. For example, for the period 1990-2004 some of the plant species that need more water have reduced their surface area more than 60%, in some cases reaching 80% reduction. These changes in vegetation have direct consequences for some bird species that are threatened or have disappeared (such as the Common Bittern, the Marbled Teal, etc.)**
3. **Considering the current hydrological conditions, it will be difficult to achieve the Doñana conservation objectives . The recovery of the water inputs should become a key management objective. In this regard we recall the need to complete the project "Doñana 2005" and rearrange the use of the aquifer system Almonte-Marismas to avoid adverse effects on the rivers and associated wetlands.**
4. **The environmental flow regime to restore the ecological integrity should be the Doñana's own natural flow regime. It is well established in the legal framework and has been confirmed by the ecological and hydrological studies undertaken for this purpose. In quantitative terms, the water needs of the Doñana marsh are estimated in 200 hm3 in normal years and 80 hm3 in dry years.**
5. **The environmental flows of the rivers and streams that drain into the marsh of Doñana are legally linked to it. The sustainable management of their catchment areas is a key element in achieving sustainable management of Doñana**

5. RECOMMENDATIONS

RECOMMENDATION 1

Incorporate in the "Guadalquivir Water Management Plan" an environmental flow proposal that considers the unique characteristics of Doñana and is fully consistent with the established legal framework. In the absence thereof, it is recommended to incorporate the environmental flow proposal defined in this report.

WWF's proposals

To enable, enrich and consolidate the incorporation of Doñana's water needs in the "Guadalquivir Water Management Plan", it is recommended:

- Request the opinion from the persons responsible for the management of the protected areas involved (Doñana Natural Area, Protected Landscape of the Guadiamar River, etc.), in order to assess the consistency of the environmental flow proposals with their objectives and management rules.
- Integrate these environmental flow proposals in the future "Water Management Plan" of the National Park of Doñana, without prejudicing possible revisions and improvements.
- Analyze the "environmental flows" of the lower Guadalquivir River (not considered in this report) and its suitability in the conservation of all the natural systems connected structurally and functionally to it (including the marsh of Doñana).
- Ensure the realization of a technical and scientific debate on the water needs of Doñana and its area of influence, and monitor the implementation of environmental flow proposals (particularly through the "Processes and Natural Resources Monitoring Program" of the Doñana National Park).

RECOMMENDATION 2

Initiate urgently a consultation process involving all stakeholders, which analyzes the water uses and demands for the Doñana area, the ecological water needs and potential implementation.

WWF's proposals

To advance this process and ensure implementation of environmental flows is specifically recommended:

- Urge the competent authorities and stakeholders to launch the consultation process on the implementation of the water needs of Doñana and its area of influence.

- Set the time limits and program for the development of the future "Implementation and Adaptive Management Plan for the Environmental Flows", as stated in the legal framework.

RECOMMENDATION 3

Declare the "Special Protection Regime" for the rivers and streams that drain in Doñana and the underlying aquifer system.

WWF's proposals

To improve the water management in the Doñana area, WWF proposes:

- Urge the competent authorities (Junta de Andalucía, Basin Agency, etc.) to declare the "Special Protection Regime" for the rivers and springs that drain into Doñana and the underlying aquifer system.
- Develop a Management Abstraction Strategy, which defines the ecological sensitivity in every river and the threshold values from which are stopped these abstractions.
- Declare the aquifer system of Almonte-Marismas at risk of overexploitation and in process of salinization, as laid down in Articles 171 and 244 of the Royal Decree 849/1986 as amended by Royal Decree 606/2003.
- Develop a Water Abstraction Plan for the aquifer system of Almonte-Marismas, where:

    - Define the aquifer discharge to maintain the ecological flow of rivers and streams associated with it (consistent with the objective of achieving good quantitative status of groundwater bodies in the terms defined by the Water Framework Directive) . These volumes would be equivalent to the ecological flow regime proposed in this report, and are the only way to provide the ecological flow.
    - Define the aquifer discharges to maintain the Good Ecological Status of the associated wetlands to the aquifer (again consistent with the objective of achieving Good Quantitative Status).

- Define maximum abstractions for the aquifer system and those areas of place based on the above values.
- Adapt the water abstraction according to different management situations (drought, dry years, wet years, etc.).

- Link the future "Special Plan of the irrigated crops in the north of the crown forest area" with the localities and volumes designated by the "Water Abstraction Plan" of the Almonte-Marismas aquifer

RECOMMENDATION 4

Promote and pursue initiatives to achieve optimal recovery of the hydraulic connectivity between the rivers and the marsh of Doñana.

WWF's proposals

Understanding that the optimal recovery of the hydraulic connectivity is a key issue to achieve the ecological recovery of the marsh (the proposed environmental flows can not intervene in such recovery without this hydraulic connectivity), was requested:

- Complete the unfinished "Doñana 2005" Project, particularly the connection of the tidal marsh with the Guadalquivir River and Brazo de la Torre (action already designed and approved in several meetings of the Board of Doñana).
- Beyond the Action 5 of the "Doñana 2005" Project (action aimed to recover the Guadiamar Channel that now has been postponed without date), urges the parties concerned to launch a broad social and technical discussion about:
    - Withdrawal by full of channeling "La Cigüeña Stream"
    - Withdrawal of channeling the Guadiamar River right from its inception to the bridge of Don Simon.
    - Withdrawal of the irrigable area of Sector-III (Almonte-Marismas Project) as incompatible with the floods that would come from the Guadiamar River and La Cigüeña Stream.
- Complement the action of improving the hydraulic connectivity with the improvements in the functionality natural (riparian restoration, flooding areas, etc.), particularly in the set of streams that discharge to the marsh (La Rocina, Algive-Cigüeña-Pilas, El Partido, etc.).

6. REFERENCES

Aragonés. D., R. Díaz-Delgado y J. Bustamante. 2005. "Tratamiento de una serie temporal larga de imágenes Landsat para la cartografía de la inundación histórica de las marismas de Doñana". *Actas del XI Congreso Nacional de Teledetección*. Tenerife.

Arthington, A.H., S.E. Bunn, N.L. Poff y R.J. Naiman. 2006. "The challenge of providing environmental environmental flow rules to sustain river ecosystems". *Ecological Applications* 16:1311-1318.

Casas, J. y C. Urdiales. 1995. "Introducción a la Gestión Hidráulica de las Marismas del Parque Nacional de Doñana" en *Bases ecológicas para la restauración de humedales en la cuenca Mediterránea*. Montes, C. (ed.) Consejería de Medio Ambiente, Junta de Andalucía. Sevilla.

Confederación Hidrográfica del Guadalquivir (CHG), 1998. "Estudio de Recursos Hidráulicos de la cuenca del Guadalquivir". Informe Técnico.

Davies S. P. y Jackson S.K. 2006. "The Biological Condition Gradient: A Descriptive Model for Interpreting Change in Aquatic Ecosystems". *Ecological Applications*: Vol. 16, No. 4 pp. 1251–1266

EBD-CSIC, 2009. "Protocolo de seguimiento de la vegetación en la marisma". www-rbd.ebd.csic.es/Seguimiento/mediobiologico/formacionesvegetales/dinamicamarisma/ProtocoloVegetacionMarisma.pdf. (Consulta en mayo de 2009).

Garcia Murillo, P., J. R. Fernández, S. Cirujano, A. Sousa. 2006. "Aquatic Macrophytes in Doñana Protected Area (SW Spain): an Overview". *Limnetica*. Vol. 25. Núm. 1-2. Pag. 71-80

García Novo, F. y C. Marín. 2005. "Doñana: Agua y Biosfera". Ed. Ministerio de Medio Ambiente. Confederación Hidrográfica del Guadalquivir. Madrid. ISBN: 84-609-6326-8.

García Viñas, J. I., Mintegui, J.A. y J. C. Robredo. 2005. "La vegetación en la marisma del Parque Nacional de Doñana en relación a su régimen hidráulico". Serie Técnica Naturaleza y Parques Nacionales. Ed. Organismo Autónomo Parques Nacionales.

ICONA. 1994. "Desarrollo Sectorial del Plan Rector de Uso y Gestión del Parque Nacional de Doñana en Materia de Manejo de los Recursos Hídricos". Ministerio de Agricultura, Pesca y Alimentación. Madrid.

King, J., C. Brown. 2006. "Environmental Flows: Striking the Balance between Development and Resource Protection". *Ecology and Society* 11(2): 26

Ministerio de Medio Ambiente (MMA). 1999. "1ª Reunión Internacional de Expertos sobre la Regeneración Hídrica de Doñana". Ponencias y conclusiones. Huelva.

Ministerio de Medio Ambiente (MMA). 2001. "Documento Marco para el Desarrollo del Proyecto Doñana 2005". Regeneración hídrica de las cuencas y cauces vertientes a las marismas del Parque Nacional de Doñana. Informe técnico. Madrid.

Parasiewicz, P., J. Nestler, N. L. Poff y R. A. Goodwin. 2008. “Virtual reference river: a model for scientific discovery and reconciliation”. Pages 189-206 in M. S. Alonso and I. M. Rubio, editors, Ecological Management: New Research. Editors, Nova Science Publishers, Inc., Hauppauge, NY (ISBN: 978-1-60456-786-1)

Poff N.L**.**, Richter B., Arthington A.H., Bunn S.E., Naiman R.J., Kendy E., Acreman M., Apse C., Bledsoe B.P., Freeman M., Henriksen J., Jacobson R.B., Kennen J., Merritt D.M., O’Keeffe J., Olden J.D., Rogers K., Tharme R.E. y Warner A. 2009. “The Ecological Limits of Hydrologic Alteration (ELOHA): a new framework for developing regional environmental flow standards”. *Freshwater Biology*, (In Press).

Richter B. D., J.V. Baumgartner, R. Wigington y D.P. Braun. 1997. “How much water does a river need?” *Freshwater Biology* 37: 231-249.

Souchon, Y., C. Sabaton, R. Deibel, D. Reiser, J. Kershner, M. Gard, C. Katopodis, P. Leonard, N.L. Poff, W.J. Miller, and B.L. Lamb. 2008. “Detecting biological responses to flow management: missed opportunities, future directions”. *River Research & Applications* 24:506-518

USEPA, 2005*. “*Use of Biological Information to Better Define Designated Aquatic Life Uses in State and Tribal Water Quality Standards: Tiered Aquatic Life Uses*”.*

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– ensuring that the use of renewable natural resources is sustainable
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