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Setting Favourable Reference Values for Annex I bird species at Oroklini marsh as part of the LIFE project: "Restoration and Management of Oroklini Lake SPA in Larnaca, Cyprus"

LIFE10 NAT CY 000716 OROKLINI

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Nicosia, 2014

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This report has been produced and published by BirdLife Cyprus as part of the project ‘Restoration and Management of Oroklini Lake SPA (CY6000010) in Larnaca, Cyprus’ which is co-funded by the LIFE financial instrument of the European Union.

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Cover photo: Oroklini Lake © Melpo Apostolidou

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Abbreviations

BD – Birds Directive
FRV – Favourable Reference Value
IBA – Important Bird Area
PVA – Population Viability Analysis
FCS – Favourable Conservation Status
HD – Habitats Directive
MVP – Minimum Viable Population
SPA – Special Protection Area

Glossary

Birds Directive (BD) and **Habitats Directive (HD)** – Two directives of the European Union that relate to the conservation of wildlife and nature. The Birds Directive is formally termed the 'Council Directive 2009/147/EC on the conservation of wild birds' and the Habitats Directive is the 'Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora'.

Favourable Conservation Status (FCS) – This term is defined in Article 1(e) of the Habitats Directive as when a habitat can be considered stable or increasing, the habitat is functioning as it should and will do so for the foreseeable future and, the species that are intrinsic to the habitat are also considered at favourable status.

Favourable Reference Value (FRV) – The FRV should be a population size at which the risk of extinction is acceptably low, the species is biologically functional within the ecosystem and there is no contraction or decrease.

Important Bird Area (IBA) – Areas that have been identified by BirdLife International, through the use of scientific criteria, as internationally important for the conservation of populations of one or more bird species.

Minimum Viable Population (MVP) – The lowest level at which a population can survive without going extinct, for a given set of population parameters.

Population Viability Analysis (PVA) – A process of assessing the viability of a population through modelling, to find the probability of extinction over a set time period with a given set of demographic and reproductive parameters.

Special Protection Area (SPA) – Areas that have been classified by Member States under the EU Birds Directive because of their importance for species on Annex I of the BD, or other regularly occurring migratory species. The classification and protection of such sites is an obligation under the EU Birds Directive.

Summary

The EU LIFE project "Restoration and Management of Oroklini Lake SPA in Larnaca, Cyprus" aims to implement actions directed at bringing Oroklini Lake Special Protection Area (CY6000010) to favourable conservation status. In order to attain favourable status, its qualifying species must also do so. To permit evaluation of whether or not the European Union Birds Directive Annex I bird species breeding at Oroklini Lake are at favourable conservation status, Favourable Reference Values (FRVs) for these populations must be set, which can then be used to evaluate current population levels and as conservation targets. This report describes the process of developing a set of methods for determining FRVs for populations of Cyprus birds at both site and national levels, and applies these methods to the six Annex I species that regularly breed or have bred at Oroklini. FRVs were set at both site level and national level. The FRVs set for the two Oroklini Lake Annex I SPA qualifying species are: Spur-winged Lapwing *Vanellus spinosus*, 15 breeding pairs at site level and 200 breeding pairs at national level; Black-winged Stilt *Himantopus himantopus*, 60 breeding pairs at site level and 300 breeding pairs at national level. National FRVs for the Stone-Curlew *Burhinus oedicnemus* and Kentish Plover *Charadrius alexandrinus*, two of the four other Annex I species that have nested at the site, are also developed and presented, but these two species have such small populations at Oroklini that site-level FRVs for them are not informative. FRVs for the remaining two species, Common Tern *Sterna hirundo* and Little Tern *Sternula albifrons*, cannot at present be developed owing to the irregularity of their presence at Oroklini and elsewhere in Cyprus. Apart from the latter two, it is now possible to compare current and future populations of these Annex I bird species against their FRVs and establish whether or not their populations are at favourable conservation status.

Introduction

The Project

This report is produced as part of the project "Restoration and Management of Oroklini Lake SPA (CY6000010) in Larnaca, Cyprus" (LIFE10 NATCY716), implemented with the support of the LIFE financial instrument of the European Union (EU). The report was prepared by BirdLife Cyprus, one of the five beneficiaries of the LIFE Oroklini project.

In response to degradation of the natural environment and the adverse effects of this on wildlife and ecosystems, the EU has passed two Directives to protect the natural environment of Europe, the Birds Directive 2009/147/EC and the Habitats Directive 92/43/EEC, which together define a set of actions and targets for Member States, including the designation of Special Protection Areas (SPAs) through the presence of qualifying species. The main objective of the LIFE Oroklini project is to bring the Oroklini Lake SPA to Favourable Conservation Status (FCS, as defined in the Habitats Directive) in relation to the species for which it qualifies as an SPA, i.e. Black-winged Stilt *Himantopus himantopus* and Spur-winged Lapwing *Vanellus spinosus,* while taking into account the requirements of the other species at the site for which it has also been designated a Site of Community Importance (SCI) under the Habitats Directive. This report therefore considers the two qualifying species as well as another four Birds Directive Annex I species that regularly nest or have nested at the site: Stone-curlew *Burhinus oedicnemus*, Kentish Plover *Charadrius alexandrinus*, Little Tern *Sternula albifrons* and Common Tern *Sterna hirundo*. The restoration and management of the site is also expected to benefit other regularly occurring migratory species for which the site is important.

The three-year LIFE project started in 2012 with the involvement of five beneficiaries in Cyprus. These are the Game and Fauna Service (the competent authority for birds in Cyprus and lead beneficiary of the LIFE OROKLINI project), BirdLife Cyprus (project coordinator), the Environment Department (the competent authority for SCIs in Cyprus), the Department of Forests, and Voroklini Community Council.

Oroklini Lake

Oroklini Lake lies to the northeast of Larnaca city, and includes Mediterranean salt meadows, scrub, reed beds and other aquatic and marginal vegetation, with highly variable open water bodies. Oroklini Lake falls within an Important Bird Area (IBA: 91 ha), which also includes some surrounding land (Fig. 1). Part of the site (57 ha) is classified as an SPA (CY6000010) under the Birds Directive (Fig. 2), for two nesting species: the Black-winged Stilt (for which Oroklini Lake is the most important nesting site in

Cyprus) and Spur-winged Lapwing (for which Cyprus has more than 50% of the EU breeding population). A similar but slightly smaller area of it (53 ha) is also an SCI (CY6000011) under the Habitats Directive for its halophytic marsh vegetation (Fig. 2).

Figure 1. The Important Bird Area (black outline) at Oroklini Lake.

Stone-curlew and Little Tern also breed or have bred at the site, while Kentish Plover and Common Tern nested there in 2007. In addition, a further 58 Annex I species visit during migration (in spring or autumn) or overwinter at the site, as do a further 36 regularly occurring migratory species not on Annex I, especially waterbirds. In total, about 190 species have been recorded at the site. The Red-crested Pochard *Netta rufina* nested there successfully in each of the last five years (2009–2013); these were the first nesting records for the species on the island (BirdLife Cyprus 2010, 2011, 2012, Kassinis *et al.* 2010, and unpublished records).

In addition to the designated sites of conservation importance discussed above, Oroklini in a broader sense includes remnant wetland habitat north of the Larnaca–Agia Napa A3 motorway, and east of the road which runs south from the motorway, on the east side of the main reserve area. These additional wetland areas are still important for some of the species discussed here (particularly Spur-winged Lapwing) and potentially so for others.

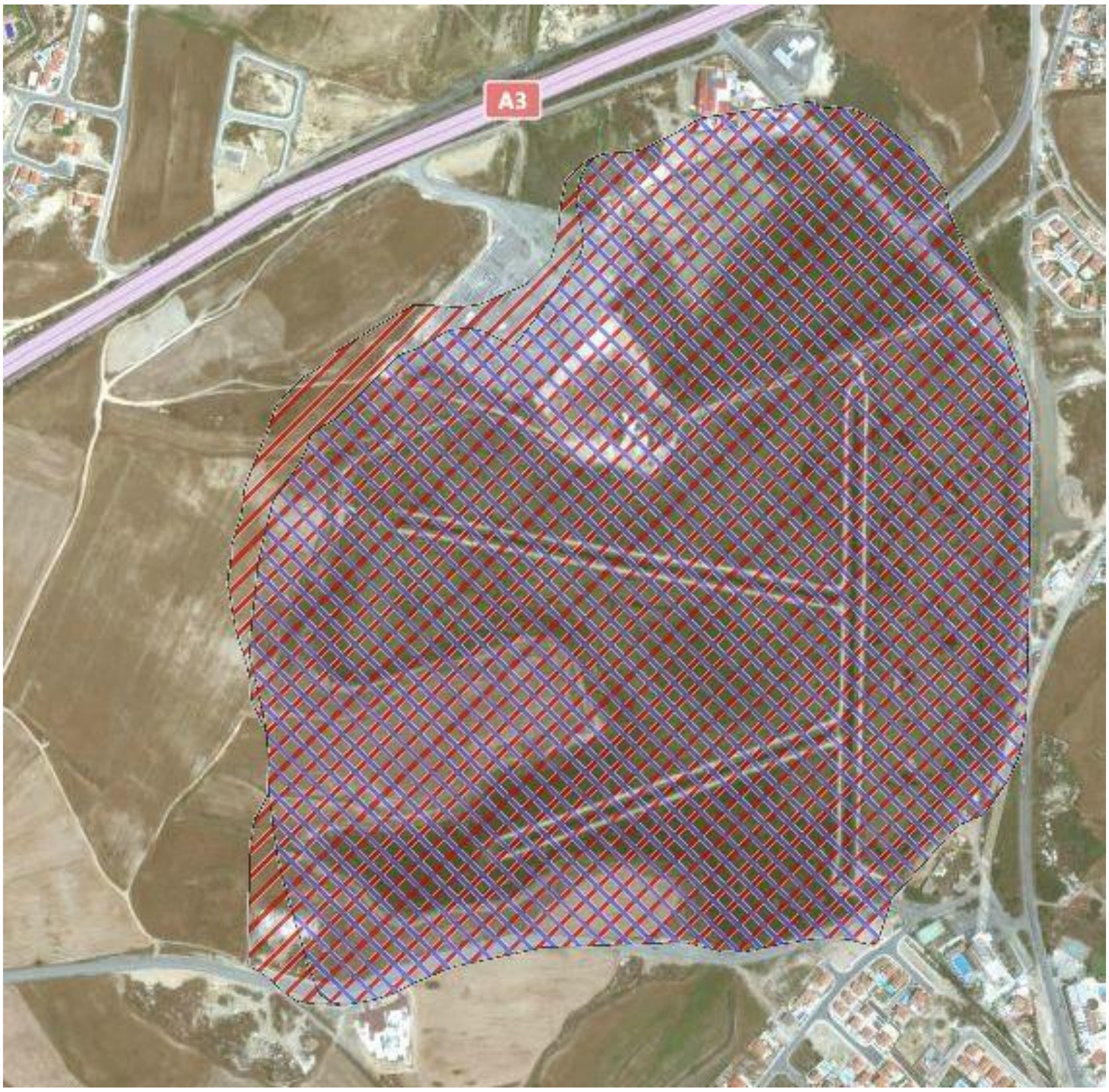


Figure 2. The areas included within the Special Protection Area (red) and Site of Community Importance (blue) at Oroklini Lake.

The Oroklini wetland faces numerous threats, including water shortages and lack of water management, disturbance and invasive alien plants, and indirectly, lack of public awareness about the importance of the site and its protection status. The LIFE project was implemented to address these pressures through a combination of direct conservation work and public awareness initiatives. One of the key aims of the LIFE project is to work towards achieving Favourable Conservation Status (FCS) for key species. This report develops Favourable Reference Values (FRVs) for key species of Oroklini and therefore constitutes the guiding document for the management of Oroklini Lake in terms of setting species management objectives for achieving FCS. Furthermore, this report provides guidance that should prove useful for the management of all SPAs on the island that are important for these species.

The role of Favourable Reference Values in setting conservation objectives and attaining Favourable Conservation Status

One means of safeguarding wildlife is through the creation of reserves that protect a specific habitat or species (Margules & Pressey 2000), and by setting well-defined management objectives for them. From a political and economic point of view, clear objectives are important for monitoring the effectiveness of policies and determining whether funds invested lead to achievement of policy goals. Similarly, in order to determine the effectiveness of conservation efforts it is essential to define a clear target, or "favourable conservation status" (FCS) for habitats or populations at a level which may be expected to be maintained over the long term, and to monitor the feature of interest (status of the habitat or population) against the target.

There is much current debate as to what criteria may be used to determine FCS (Tear *et al*. 2005). All EU Member States are obliged to set conservation objectives for sites (or habitats) and species under the two EU nature directives, in order to achieve FCS for both habitats and species. Setting a conservation objective linked to FCS depends on the definition of the latter. The Birds Directive does not provide detailed guidance on what is considered FCS, but the more recent Habitats Directive defines criteria according to which a habitat or species can be considered as being at FCS. For a species, these criteria are:

1. the species is able to maintain itself as a viable component of its wild habitats in the long term;
2. its range is not being reduced nor is likely to be reduced in the future;
3. it has sufficient habitat to maintain its populations in the long term.

To facilitate the assessment of FCS, the concept of Favourable Reference Values (FRVs) has emerged. FRVs permit the quantification of conservation objectives, and the measurement of progress towards them. Whilst no formal definition of FRV exists, it can be generalised as the population size or breeding density that a species must possess so as to be considered not at risk of extinction, and more specifically meets the above criteria. BirdLife International recommends that an FRV should also be high enough to allow a species to fulfil its ecological functions and to allow for resilience to climate change. The task for EU Member States is to set FRVs for the species and habitats that they are obliged to protect, which are scientifically sound and realistic in light of irreversible changes that may have occurred to habitats. Such FRVs should allow assessment of the degree to which Member States have achieved FCS for species and habitats, as well as providing solid targets for conservation action.

As yet there is no single accepted method for setting FRVs, and neither the Habitats Directive nor the Birds Directive prescribes a single method for use across Europe, although FRVs are expected to be transparently determined and comparable between countries. Setting an FRV is a difficult task and any methodology must take into consideration numerous factors, such as differences in species life history, amount of habitat available with and without restoration, minimum viable population sizes etc. In this report a methodology for Cyprus has been developed, and an explanation given as to why this method is considered appropriate.

FRVs are conservation targets, not biological population parameters, and are inherently subjective in that they are based on choices between management options for a site and must take into account limitations to management. Therefore, throughout this report we refer to “setting”, “determining” or “selecting” FRVs, rather than “calculating” them. However, the main aim of setting an FRV is to secure a species in Cyprus or at a particular site in the long term. The methodology developed in this report seeks to minimise the subjectivity inherent in this process by calculating population parameters (minimum viable population and hypothetical maximum population) in comparison with which a reasonable, realistic and feasible FRV can be selected. The resulting FRVs are not automatically expected to be in all cases the “natural” population level or any particular historical population level, although for many species the FRV is expected to represent a sustainable level similar to historical population sizes. For some species, an FRV may be set higher than the “natural” level, such as for wetland birds: Cyprus has few natural wetlands but many artificial ones. The artificial wetlands (dams) contribute to a potential to maintain waterbird populations higher than they were before such habitat was created, although past and continuing degradation of the natural wetlands, in some cases caused by water management projects and/or habitat loss through building and urbanisation, and in many cases effectively irreversible, reduces this potential. On the other hand, for some species, especially very rare ones or those at the edge of their geographic range, it is not entirely within the control of habitat managers in Cyprus to set an FRV at a population level that is intrinsically viable in the long term, since the few birds present on the island or at a particular site may not represent a biologically viable population. Rather, their maintenance will depend on exchange and movement between Cyprus and other parts of a larger population. However, as conservation targets, FRVs can be chosen which, even if below the MVP, indicate Cyprus’s intention to attempt to maintain these numbers. Finally, for some species, an FRV is not expected to be met every year, and will rather be a long-term average target, or target to be met in most years. This applies particularly to national-level FRVs for wetland species, including those covered by the present report, where populations at artificial, semi-natural and natural wetlands depend heavily on both rainfall, while artificial wetlands will also be affected by abstraction levels.

FRV methodology tested and proposed by BirdLife Cyprus as part of the LIFE Oroklini project

Selection and development of the methods

All FRV methods used by other EU countries were reviewed. A method commonly used by other EU countries so far is the **Baseline approach***,* used in some form by the UK and Belgium, as well as by the USA (Rich *et al*. 2004, JNCC 2007, Louette *et al.* 2011). The Baseline approach involves setting the estimated population level at a selected historical point-in-time as the FRV. While this approach has some advantages (e.g. it can be carried out for a large number of species in a short time) it was not considered suitable for Cyprus, for several reasons. One of the prerequisites for the Baseline approach to produce useful FRVs is an accurate historical record of bird numbers extending reasonably far back in time. These figures are then used as a baseline against which current populations can be compared, to decide whether they are at favourable status. While BirdLife Cyprus and the Game & Fauna Service have records on species occurrence and numbers going back a considerable time, there is little information on total population size for different species in any given year. In addition, the Baseline method suffers from fundamental uncertainty over whether the (arbitrarily) selected baseline population size itself represents favourable conservation status (Tear *et al.* 2005). For instance, population sizes may fluctuate as a result of year-to-year variations in resource abundance and climate (Lindén 1998). Furthermore, irreversible habitat loss may have occurred since the adopted baseline, which may prevent it from being re-attained (Mehtala & Vuorisalo 2007). It was therefore decided at the preparatory workshop for this project that the Baseline approach would not be used for Cyprus, owing to its lack of scientific basis and resulting uncertainty around the values to set (Christodoulou-Davies *et al.* 2012).

Other methods used already in Europe include **Population Viability Analysis** (PVA) and the **Habitat approach**. In PVA, population modelling is used to calculate the probability of extinction of a species or population over a predefined period of time. The model parameters are then adjusted so as to find a population size that has an acceptably low risk of extinction (the Minimum Viable Population or MVP), and an FRV is ideally set higher than the MVP, at a value depending on a range of practical factors to be taken into account. The Habitat approach involves calculating the amount of habitat in a given area which is considered suitable for the species under consideration and using this to derive the carrying capacity of the area, based on knowledge of breeding densities. Looking back at changes in land use over time allows assessment of changes in the amount of suitable habitat that was available and estimation of the population size this could have supported, although it is important to consider that some changes to habitat are irreversible. A major advantage of this method is that it generates predictions that can be valuable for management.

The FRV approach developed by LIPU (BirdLife Italy) for Italy (Gustin *et al*. 2009, Brambilla *et al*. 2011) combines elements of the PVA and Habitat methods plus an additional method, the **Range method**. The Range method was found necessary in Italy because of the large size of the country's mainland and the existence of two large islands, Sicily and Sardinia, both of them larger than Cyprus. The larger area means that the range of a species may be discontinuous, creating isolated populations whose viability must be assessed independently. The LIPU approach was considered to be the most scientifically defendable of those reviewed (Christodoulou-Davies *et al.* 2012), combining the best elements of the three methods mentioned, whose applicability to a species depends on its life history and population size. The LIPU approach is the most scientifically rigorous among the approaches used to date, and relies less heavily on expert opinion and historical data than other approaches, although both of these types of information are still intrinsic to the process. The LIPU approach was therefore further developed for Cyprus, as it should provide the most rational FRVs as well as being transparent and reproducible. The three methods tested so far by BirdLife Cyprus and incorporated within an overall approach based on that of LIPU are: PVA, the Habitat method and aspects of the Range method. Essentially, the procedure followed for reaching an FRV, was to estimate a hypothetical maximum population based on the Habitat method, a minimum population (MVP) by PVA, and then to set an FRV at an appropriate point (based on expert opinion) between these two where possible, at a level considered realistic (i.e. taking into account practical considerations). For Cyprus in general, and for the species covered by this report in particular, it is not so necessary to use the Range method as in Italy, owing to the island's relatively small size, such that most bird species do not have separate isolated populations within the island. However, some aspects of the Range method (e.g. consideration of fragmentation and historical range) may be valuable for other species in Cyprus and may be factored into the Habitat method where relevant.

The most innovative part of the approach developed here for Cyprus lies in the procedure for selecting the methods to be used for each species, which differs from that used by LIPU. The PVA and Habitat methods were used by LIPU as alternatives (for different species). For example, for populations larger than 2500 pairs, the PVA method does not provide reliable results and therefore was not used for such species (Brambilla *et al.* 2011); instead, the Habitat method alone was used. However, for Cyprus, where possible (i.e. where PVA is applicable), both PVA and Habitat methods have been applied to each species, because the figures produced by each are less informative alone; further, where PVA was not possible, rule-of-thumb methods for examining minimum viable population sizes have been employed as guides. Rondinini & Chiozza (2010) came to a similar conclusion, finding that, due to the imperfect nature of biodiversity data, a combination of methods produced the most robust target, and, for species or populations with different characteristics, different methods provide the most useful information.

The Kentish Plover may be used as an example of how the PVA and Habitat methods may be combined (full detail for this species is given in its species account, below). Its population in Cyprus is suitable for PVA but there is little information on its breeding success in the country, and indicative values from the literature produce a population that appears viable at unrealistically small sizes. This may actually be true, but this MVP is not useful as an FRV, as it would be inadvisable to set an FRV so low, for reasons of stochasticity. The Habitat method may therefore be employed to produce an estimate of the hypothetical maximum population that the island might hold, assuming extensive but conceivable conservation interventions favourable to the species. A more useful FRV may then be set between these lower and upper bounds, based largely on known population levels and management considerations.

The PVA program Vortex allows sensitivity testing to be carried out on any of the parameters entered into the population dynamics model. This is an important tool that was used for each species to elucidate the factors that most affect the viability of a population. Sensitivity testing on Vortex showed that small changes in population parameters sometimes radically change the outcome (e.g. in the case of Kentish Plover, reducing breeding success slightly can shift the population from increasing to rapidly declining), in which case MVPs cannot be calculated with great confidence. This difficulty was found to be common, for many species, and poses a major challenge for the PVA method, because breeding and mortality values are often poorly known and vary from place to place. For these reasons, calculated MVPs have been used only to indicate a line between the species being highly threatened (below the MVP, i.e. with a population considered likely to go extinct within 100 years = Red on a traffic light scale) and at "unfavourable-inadequate" conservation status (i.e. above the MVP but still not considered safe = Amber on a traffic light scale). Thus, we used PVA principally for generating an MVP and for sensitivity testing. Unlike LIPU, we did not then use PVA to generate a larger population size (by adjusting the model parameters) that could be taken as an FRV, because the population dynamics data from Cyprus did not allow this to be done with great confidence. Instead, FRVs were set at levels higher than the MVP by using the Habitat approach and taking into account additional information available, as described under each species account.

At the preparatory workshop on the FRV methodology, following guidance from BirdLife International (Christodoulou-Davies *et al.* 2012), it was decided that, as part of the process of calculating FRVs, a list of present or future threats should also be generated as far as possible, to draw attention to aspects of a species' biology, population dynamics or habitats that should be monitored or manipulated, such as causes of high mortality or low reproductive rate, known persecution along flyways or suspected susceptibility to changes in climate. Where sensitivity testing on population dynamics parameters or a literature search on the species suggested such threats, they are discussed under each species account.

Applying the PVA method

The use of PVA software and MVPs in conservation biology is widespread, although the decision as to what is considered a viable population is essentially arbitrary and has been set at different levels by individual researchers depending on the species or timescale of interest (Reed *et al.* 2002). Examples of viable population definitions include a population that does not go extinct within a set amount of time, or a population that does not fall below a certain size within a given amount of time, or even more strictly, a population that shows no decrease over a given amount of time. One of the most common definitions of a viable population is one that has a probability ≤ 0.01 (not more than 1 %) of going extinct in the next 100 years; this was the definition used by LIPU (Brambilla *et al*. 2011) and has been adopted by BirdLife Cyprus for this report. A population fulfilling this criterion has a risk of extinction considered adequately small over a manageable timescale. While the timescale could be increased, say to probability of extinction ≤ 0.01 in 1000 years, this would reduce the reliability of predictions, as the model would include more assumptions. This is of greater concern the less accurate the data are, such as when local data are inadequate for a species and data must instead be used from the same species in a different country, as is the case for many species in Cyprus.

To calculate whether or not a population is considered viable, the best estimates of each parameter of the population (including breeding productivity, mortality etc.) are put into a model or software package, and a probability of extinction is generated. The PVA modelling software used for this study was Vortex, a publicly available program that is used widely by the scientific community (Lacy 1993). To find an MVP using software such as Vortex, all the necessary information is fed into the program and then the initial population size is varied to determine the smallest population that has a chance of extinction of < 1 % in 100 years.

Availability of relevant population data from Cyprus:

Research on the use of PVA software to predict a population's risk of extinction suggests that a dataset of ≥ 10 years produces reasonably accurate predictions (Brook *et al*. 2000, McCarthy *et al*. 2003). Thus, while Cyprus lacks longer-term data on breeding numbers and population dynamics for many bird species, including most of those on Annex I of the Birds Directive, this was considered not to be an insurmountable problem, as Cyprus should be able to use reliably a relatively short domestic dataset, i.e. for species with breeding and mortality rate records available for a number of years. Following the LIPU approach, a literature search was conducted for each species, which provided a range of figures for breeding parameters. Depending on whether or not a population is expanding, contracting or stable, appropriate values from the literature can then be chosen for parameters such as mortality (low, high or medium respectively) or breeding success (high, low or medium respectively): for example, an expanding population could result from low mortality and/or high reproductive rate. However, if reasonable data were available from Cyprus then these were used even if they contradicted this expectation: e.g. if a species has an expanding population in Cyprus despite having a lower mean fledging rate per breeding pair than the highest found in the literature, then the Cyprus value was used. The reasoning behind this includes the fact that the effects of different parameters on the fate of a population are not entirely independent of one another; for example a low mortality rate may allow for reduced reproductive success without drastically affecting the fate of the population. If, however, the mortality rate is increased, then small changes in reproductive success will have a strong influence on the viability of a population. Because of this, data from Cyprus populations are preferable, since they should more closely reflect the factors that influence the Cyprus populations, whereas data from populations in other countries may obscure important information as to which parameters currently have the greatest effect on a population's long-term viability in Cyprus.

Procedure for species with data insufficient for use of PVA

Rule-of-thumb values for MVPs have been a contentious topic and no widely accepted values exist, but the "50/500" rule (Franklin 1980) has been employed in this way, where a population of at least 500 breeding individuals may be considered to provide long-term genetic viability with no significant loss of genetic variability from the population over many generations, while a population of at least 50 breeding individuals may be taken as providing short-term genetic viability (over a few generations). These figures were originally derived by genetic experiment and among other shortcomings they do not take into consideration the effects of stochastic events (e.g. rare, severe, environmental fluctuations) on the viability of a population and so may underestimate the population size necessary for long-term persistence (Caughley 1994). Accordingly, Shaffer (1981) advised the use of these values as rough guides, rather than conservation targets. Research on MVP values for birds has shown populations of more than 200 individuals to be persistent in the short term (50–75 years: Boyce 1992), thus providing field evidence that refines the above guideline from genetic studies when applied to bird populations; this value may therefore be used as a rule-of-thumb MVP.

Incorporating results from the Habitat method

While an MVP was generated by PVA or rule-of-thumb as described above, a hypothetical maximum population that the whole island of Cyprus might hold was investigated using the Habitat method, where the suitable breeding habitat for a species in the island is mapped and its area is then multiplied by what is thought to be a reasonable value for breeding density for the species in that habitat. For species with good data on habitats, this was the primary method by which the FRV was determined. However, even for species that were suited to the PVA approach the Habitat method was still applied as it provides additional information for the species and results in an FRV with increased confidence. Following Seoane *et al*. (2004), CORINE land cover maps were considered adequate for the mapping of most habitats, although where higher resolution habitat maps were available they were used to improve accuracy. For Oroklini, a high-resolution map divides the site into 15 habitat types, more finely than CORINE which shows only five, more general, habitat types. For national-level calculations, a map was created from all the CORINE land cover polygons of habitat types suitable for the species, taking into account other key features such as proximity to urban areas and elevation. A literature search for additional factors important to breeding populations of a species was conducted and, where possible, information found was integrated into the map or taken into consideration when assessing the suitability of individual areas of habitat.

The area of land cover polygons identified as suitable to the species in question was also sometimes amended after consultation with local experts, to produce a more accurately determined area of actually suitable habitat. For instance, an area that by CORINE land-cover type was deemed suitable for a species could be excluded if it were at an altitude unsuitable for the species, or reduced by a suitable proportion if factors adversely affecting the species were operating, such as a road bisecting an area when the species in question is known to show reduced densities in the presence of disturbance from roads. Once this process was carried out for all land-cover polygons the total area of suitable habitat was calculated by summing all the individually adjusted areas. This total was then multiplied by a figure for breeding density derived from local records or literature, to produce a hypothetical maximum number of the species that the island might hold. It may be necessary to use several different breeding densities in these calculations depending on how the species reacts to environmental factors. For well-known species different breeding density values across the range of habitats may be available but if not, multipliers may be used for different parts of the habitat. For example, if it is known that a species has a breeding density of 10 pairs/ha at altitudes 0–800 m but only 5 pairs/ha at altitudes >800 m, then the identified habitat areas may be multiplied by the known breeding densities. If however available information simply states that breeding density is reduced at higher altitudes (but not by how much), then a decision must be taken as to the factor by which the known breeding density should be reduced: the exact multiplier used will be an educated guess, most likely based on discussion with experts.

The accuracy of the Habitat method is different for different groups (taxa or guilds) of birds (McPherson & Jetz 2007), and was found to be more easily applied to some species than others. Of particular relevance to this report, the predictive abilities of the method for bird species of wetland habitats are heavily influenced not only by inter-annual variability but also by small-scale habitat variations, and overcoming this issue requires higher-resolution land-cover maps for wetlands. Such maps are available for Oroklini but for few other sites in Cyprus. This difficulty also applies to some other groups of birds not covered by the present report. For example, some birds of prey frequently use any form of open land for hunting, while their populations are determined more by availability and distribution of nesting sites, which are poorly explained by CORINE land-cover maps.

Another complication applies particularly but not exclusively to birds that breed colonially, for which there may be a difference between the area and habitat type needed for nesting and that needed for feeding. In such a case, the Habitat method as outlined above could, if based on nesting density, generate an unrealistically high population size because the nesting density of a colonial species multiplied by the available area for nesting may produce a population much larger than could be supported by other resources, e.g. food. Therefore, the Habitat method was adapted by examining both overall densities in foraging habitat and nesting densities within breeding sites or colonies, with the hypothetical maximum island population for the species capped at the lower of the two figures produced by these calculations.

Local information and expert review were then used to decide on an FRV population size for the species that is both viable (using the definition discussed above) and "reasonable", i.e. somewhere between the MVP calculated by PVA or rule-of-thumb and the hypothetical maximum population calculated by the Habitat method. It was not considered reasonable to use the maximum calculated by the Habitat method as the FRV, for the following reasons:

- Habitat mapping and the determination of breeding densities incorporate great uncertainties, so that the maximum calculated is truly hypothetical and will in most cases not be realistic as a conservation target.
- If several species use the same area, particularly if their habitat requirements are different or their resourse requirements overlap, then management to maximise the number of one species may adversely affect one or more others. In such cases, sites cannot be managed to favour all species equally, and aiming for a maximum for a given species may be inadvisable.
- The maximum number an area can hold may not be attainable every year (especially for wetlands, where available habitat depends on rainfall), and may not be sustainable in the long term. Natural fluctuations in population size mean that a population may often be expected to be below the theoretical maximum.

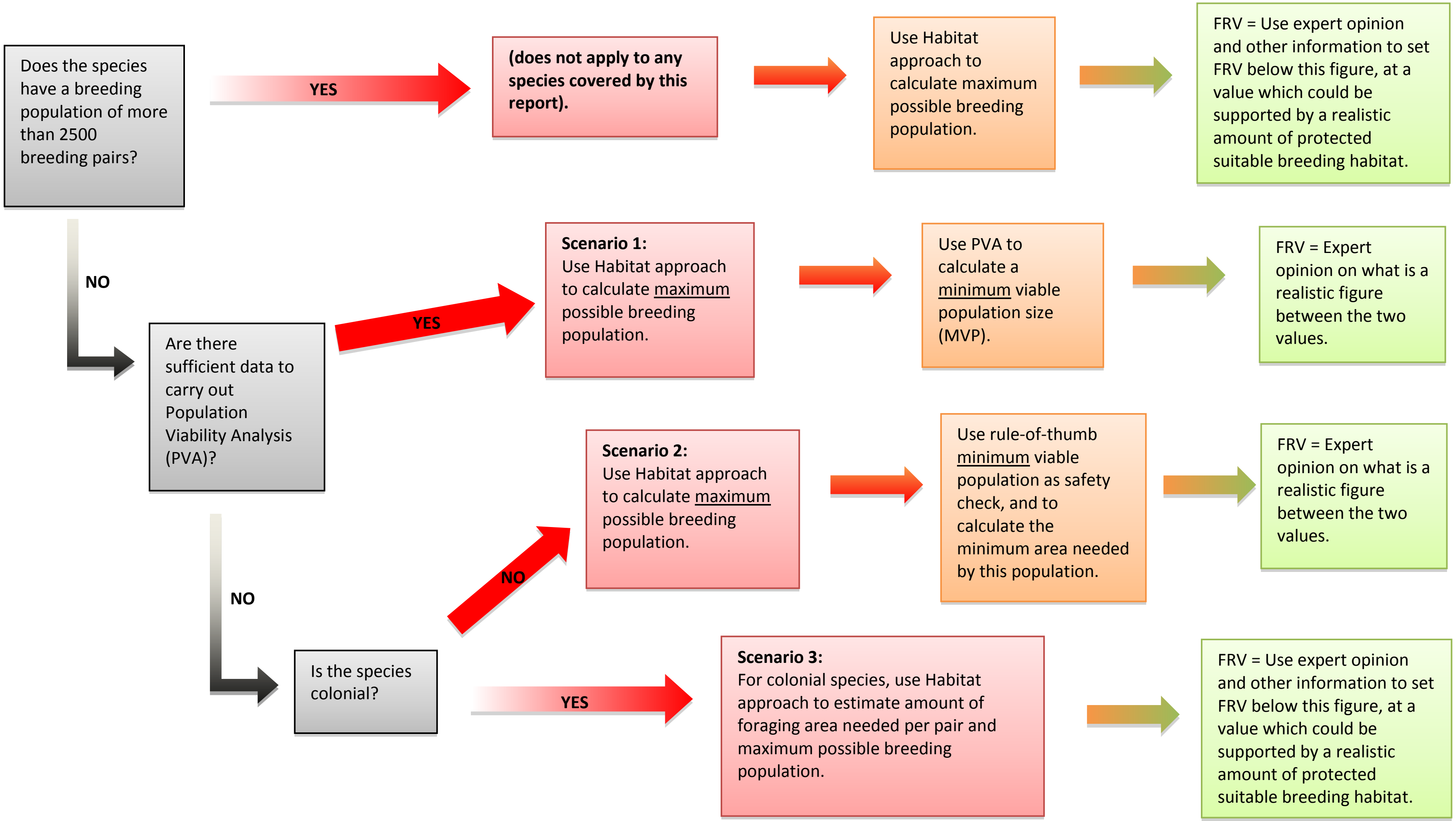
In addition to producing a hypothetical maximum population, the Habitat method may also be used in conjunction with values for MVPs, especially with rule-of thumb MVPs for species for which PVA could not be used, to help to generate useful FRVs. Since MVPs represent the lowest end of a range and are thus not acceptable in themselves as conservation targets, an MVP may be used along with the Habitat method, to estimate the minimum area needed to attain the MVP. For instance, a species with breeding density of 1 pair/ha in good habitat would need a minimum of 100 ha of good habitat protected in order to support an MVP of 200 breeding individuals. Due to their inherent uncertainty, such estimates of the minimum amount of habitat needed should be used with rule-of-thumb MVPs with extreme caution but, in the absence of more robust data, can be of value in recommending management to combat further habitat loss.

Finally, in addition to contributing to hypothetical-maximum and minimum-viable population calculations, the Habitat method can be used in conjunction with historical records, e.g. of colony locations, to produce a list of areas (historical and potential breeding sites) that should be protected. Even in the absence of a more formal method for determining an FRV, this at least indicates the advisability of protecting the maximum number of such sites, including incorporating them into the network of SPAs and IBAs.

Steps followed to determine and apply the methods to each species

A flowchart showing the process for deciding which combination of methods should be used for a species is given in Fig. 3. This decision tree was applied to the species covered by this study: Scenario 1 may be illustrated by the Stone-Curlew and Kentish Plover, and Scenario 2 by the Spur-winged Lapwing. Scenario 3 concerns colonial species, including the Black-winged Stilt, Common Tern *Sterna hirundo* and Little Tern *Sternula albifrons*. In summary, the basic principle of the procedure for reaching an FRV, to be followed as far as possible, was to estimate a hypothetical maximum population based on the Habitat method, an MVP by PVA or rule-of-thumb, and then to set an FRV at an appropriate point between these two where possible, at a level considered realistic (i.e. taking into account practical considerations). The details differ for each species depending on population, habitat and management factors, and are described more fully under each species account.

Figure 3. Decision tree for selecting methods to use when calculating a species' FRV.



Continuation and improvement of the FRV methodology

This section discusses further some difficulties identified during the current project, with recommendations as to how they might be addressed in future FRV programmes. Currently, irrespective of the methods applied to each species, the FRV calculation process is heavily reliant on expert opinion. To change this will principally require more detailed habitat maps and better knowledge of the biology of each species, especially its population dynamics and habitat quality and use.

Data collection on key population parameters

As discussed earlier, the use of breeding data and mortality rates gleaned from publications relating to other countries introduces error into the process, so the collection of these data in Cyprus should be prioritised. The parameters most often found to have a large effect on population viability, through sensitivity testing in PVA, were: mean number of fledglings per pair, breeding attempt success rate, mortality rates of adults and juveniles, and percentage of males and females taking part in reproduction. The last two of these parameters could be calculated through the use of an intensive ringing programme for a species or population. Additionally, this would produce valuable data about the demographics of a population, particularly valuable to species where such information could provide a warning of imminent decline. Considering the cost of survey, data collection and analysis, Annex I species should be prioritised.

In addition to the survey requirements for determining FRVs, the future assessment of whether or not a species is at FRV will also require breeding surveys across different habitats.
Furthermore, while some population density data does exist for Cyprus breeding species, this is often non-systematically collected, sparse or derived from surveys based on a variety of methodologies. This is especially true for widespread and more common breeding species. The systematic and long-term collection of population density data for all breeding species, using reliable and consistent methodology is important if the Habitat approach is to be used effectively. Improved data on the distribution of breeding species would also be of great value for FRV setting.

Mapping of key habitat features

While for some species the CORINE land-cover maps are sufficiently detailed, this may not be the case for species with more specialised breeding or nesting requirements, as discussed above for wetland species. Such habitat types are poorly represented on CORINE maps and a key mapping need is high-resolution maps for all wetlands. This may be expensive, and in the case of wetlands made complex by yearly variation in water levels that alter the habitat structure, but an effort should nevertheless be made to improve maps of important but limited sites. Similarly, basic information such as topography is only available at poor resolution, whereas more accurate digital elevation maps would provide more useful information about certain sites and also help to highlight potential sites of interest.

Creation of a species database (local and international)

To speed up the process of gathering information on species, and for updating FRVs and management recommendations, a central database should be created holding key data on species, which should be updated frequently to ensure its accuracy and highlight changes. The database should follow a clear format that allows for quick comparison between the past and present for each species. This could be achieved through codification and input templates, ensuring that data submitted are in set units, are dated, referenced and labelled or attributed to an area that can be found by others (e.g. through the use of coordinates rather than local names).

While locally collected data on breeding and mortality parameters from Cyprus are important, there should also be a larger database on species parameters from elsewhere, and an international database might be proposed, for use throughout Europe or even more widely. This would act as an important reference source against which national values could be compared.

Favourable Reference Values for Oroklini Lake SPA qualifying species at site and national levels

Spur-winged Lapwing *Vanellus spinosus*

There is little information available on the breeding biology of the Spur-winged Lapwing from anywhere, and its population in Cyprus is increasing, a factor which precludes the use of PVA . The Habitat approach was therefore employed (= Scenario 2, Fig. 3), with two calculations carried out to determine the hypothetical maximum number of breeding pairs each site might hold. First, the total usable foraging area of the site was divided by an estimate of overall (= foraging) territory size, and second, in order to check whether nesting sites rather than foraging area could be limiting, the total possible nesting area at the site was divided by an estimate of nest territory size (= minimum area needed for a nest site, not including foraging territory). The results of these calculations provide guides for determining the FRVs, as described below.

Site Level:

In the Evros Delta (Greece), Makrigianni *et al*. (2008) found a mean overall territory size (= foraging area including nesting area) of 6.3 ha with some overlapping of territories, while a previous study on the Nestos Delta (Greece) (Cramp & Simmons 1983) put the overall territory size at 2.6 ha. The total area of the Oroklini site considered suitable as foraging habitat for Spur-winged Plover (which for this species includes nesting habitat, so foraging territory size = overall territory size) is 91 ha, including fields outside the IBA and an area north of the A3 motorway (Figs 1 & 2), but excluding unsuitable vegetation types and open water within the reserve. Based on these figures, the maximum number of Spur-winged Lapwings that Oroklini might be able to hold is estimated at 14–35 pairs (91 divided by the Evros and Nestos mean territory sizes respectively). The total area considered potentially suitable as nesting habitat at Oroklini is 50 ha (from maps and N. Kassinis pers. comm.). Spur-winged Plover nests have been found as close as 19 m apart (Makrigianni *et al.* 2008), and nests uniformly spaced at this separation would occupy 0.11 ha each. Dividing the area considered suitable as nesting habitat (50 ha) by this figure for nest spacing (0.11 ha), produces a hypothetical maximum-density nesting population of 450 pairs, which is obviously unrealistic in this case, since it does not take into account foraging habitat restrictions. Thus, as expected, it is foraging area (i.e. ultimately, resource abundance) which acts as the limiting factor for the number of breeding pairs that this site can hold, and the maximum of 14–35 pairs is taken forward for deriving the FRV.

The number of pairs breeding at Oroklini in recent years may reach the lower end of this range, with up to 15 pairs thought to have bred there in one year (N. Kassinis pers. comm.). However, the Spur-winged Lapwing may show aggression towards other species such as the Kentish Plover, which shares its habitat and is an Annex I species in Cyprus. Thus, although the potential of Oroklini as a breeding site for Kentish Plover is limited (see below), it could be unwise to aim for the upper end of this range, because that is based on the smaller of the two literature values of territory size and because achievement of such a level could further reduce the suitability of the site for other species. With this in mind, the site level FRV for Spur-Winged Lapwing at Oroklini is placed at 15 breeding pairs. This target is considered ambitious (an increase over current average levels) but realistic (equal to the maximum in recent years and close to the number produced by using the larger of the two values for territory size in the literature). This should be achievable as an annual norm by ensuring that there are regularly available adequate nesting and feeding areas around the site. Despite their potential competition, the creation and/or maintenance of these areas could also provide habitat for the Kentish Plover. The Kentish Plover may require more extensive open flats for feeding than Spur-winged Lapwing, but the requirements of both of these species for nesting are, in broad terms, low halophytic vegetation close to freshwater, with little to no visual obstruction around the nest (Fraga & Amat 1996, Makrigianni *et al*. 2008).

National Level:

The CORINE land-cover types appropriate for this species (and for Black-winged Stilt and Kentish Plover) were 411, 421 and 512 (Inland Marshes, Salt Marshes and Water Bodies respectively), which are mapped in Fig. 4. This map clearly demonstrates the need for improved (including higher resolution) mapping of wetlands in Cyprus, since these land-cover types do not reveal many of the wetlands included in the BirdLife Cyprus Wetland Birds Survey, or in some cases (e.g. Akrotiri, Famagusta) do not represent their full extent. On the other hand, some wetlands identified by CORINE land cover are known not to be suitable for the species covered by this report, e.g. those with steep terrain surrounding the water body.

The list of wetlands used for calculating the population sizes of the wetland species covered here was therefore refined, with some areas that were identified as wetland by CORINE excluded from the calculations, as they were considered unsuitable for these species, while other known wetland sites and parts of sites that do not appear as wetland on the CORINE maps but which are known to be important to the target species, or could potentially be so at least in some years, have been added (e.g. parts of the salt lake complexes, Agia Eirini, Galateia, Mia Milia). The list of wetlands used to generate national-level FRVs for the Spur-winged Plover, the Black-winged Stilt and the Kentish Plover may be found in Table 1, and the sites not revealed by CORINE land-cover are labelled in red on Fig. 4. The selection of these sites was based on their known or probable importance as actual or potential breeding sites for one or more of these three species, i.e. one or more of them is known to have bred

Table 1. Potentially suitable foraging and nesting habitat areas at the wetland sites used for the determination of FRVs for Oroklini waterbirds, and the hypothetical maximum numbers (H-max.) of each species derived from these areas (method described in the text); the lower figure of the two hypothetical maximum population sizes derived for each species is indicated in green.

	Spur-winged Lapwing				**Black-winged Stilt**				**Kentish Plover**			
Site	**Potential foraging area (ha)**	**H-max. foraging territories**	**Potential nesting area (ha)**	**H-max. number of nests**	**Potential foraging area (ha)**	**H-max. foraging "territories"**	**Potential nesting area (ha)**	**H-max. number of nests**	**Potential foraging area (ha)**	**H-max. foraging "territories"**	**Potential nesting area (ha)**	**H-max. number of nests**
Evretou Dam	6	1	6	50	0	0	0	0	6	1	6	85
Akrotiri Wetlands	1470	250	1470	13000	720	1180	230	11000	1470	170	1470	21000
Polemidia Dam	12	2	12	110	0	0	0	0	12	1	12	170
Germasogeia Dam	16	3	16	150	0	0	0	0	16	2	16	230
Larnaca wetlands	780	130	780	7100	690	1070	260	12000	690	80	690	9800
Athalassa Dam	10	2	10	90	10	16	10	470	10	1	10	140
Oroklini	91	15	50	450	48	79	39	1800	34	4	34	480
Achna Dam	77	13	60	550	37	61	37	1800	60	7	60	850
Paralimni	315	53	315	2900	253	420	253	12000	295	34	295	4200
Agia Eirini Dam	9	2	9	80	13	21	13	620	0	0	0	0
Kanli Dam	15	3	15	140	0	0	0	0	15	2	15	210
Kioneli Dam	5	1	1	10	8	13	7	332	0	0	0	0
Mia Milia	35	6	2	18	27	44	2	95	0	0	0	0
Famagusta wetlands	250	42	250	2300	120	200	40	1900	250	29	250	3500
Galateia	53	9	53	480	53	87	53	2500	0	0	0	0
Totals	**3,144**	**532**	**3,049**	**27,428**	**1,979**	**3,191**	**944**	**44,517**	**2,858**	**331**	**2,858**	**40,665**

at the site, or the CORINE maps, personal knowledge or expert advice indicated that the site may contain areas suitable or potentially suitable for its breeding under appropriate and feasible management. It is acknowledged that additional sites in Cyprus are also of potential use by one or more of these species in small numbers, but the sites considered of greatest importance are all included in the list and the present level of analysis is robust to the addition or subtraction of less important sites.

Figure 4. Wetlands in Cyprus used for the derivation of FRVs for Black-winged Stilt, Spur-winged Lapwing and Kentish Plover. Sites labelled in red are not revealed by CORINE.

Wetland habitats are highly variable from year to year depending on climatic conditions, which makes setting FRVs for wetland species particularly difficult. The suitability of some of the sites considered here may therefore vary greatly between years or may even be potential only; however, they were included in the estimation of the hypothetical maximum population sizes for these species in Cyprus, because these maxima are indicative only and should not be used as conservation targets. When setting FRVs at the national level for each of these species (below), the variability between and within sites is discussed and appropriate reductions made with respect to the hypothetical maximum population. Despite the differing nesting habitat preferences of these species, the variation in water levels in wetlands from year to year make it difficult to determine from satellite imagery which area of a wetland is suitable for each species, since this may be different in different years. For this reason, areas that were considered potentially suitable for each one of the three species for nesting in a given year were included in the habitat calculations, irrespective of the fact that maximum suitability for one species would imply sub-optimal suitability for others. Satellite imagery over a number of years, combined with improved local knowledge of the wetlands, would permit more detailed differentiation of nesting areas for the different species, while management considerations and the conflicting requirements of different species are taken into account when setting the FRVs below. Once again, as the hypothetical maximum values calculated by this method are used for guidance only and not as targets in themselves, the uncertainties inherent in these calculations are considered acceptable and are discussed in more detail when setting each FRV below the hypothetical maxima.

Connectivity between wetland sites is also important to the national-level breeding success of waterbirds, as individuals may move between sites depending on year-to-year suitability at the beginning of the breeding season (Haig *et al.* 1998). For Oroklini populations, the proximity of Larnaca Salt Lake and sewage works, and Aradippou Dam and slurry pits, may provide a compensatory mechanism for fluctuations in conditions at Oroklini (Christodoulou-Davies *et al*. 2012). However, there is little information on the extent of such movements in Cyprus, so site-level and national-level FRVs must be set without formally incorporating meta-population dynamics into the calculations.

The area within each selected wetland that was considered suitable habitat or potentially so was calculated from satellite images, while using the satellite image of Oroklini as a reference. The total areas of each wetland that were thought usable by the species for nesting and for foraging were both calculated (Table 1). Then two calculations were carried out, as described above, to determine the maximum number of breeding pairs each site might hold, i.e. using parameters that provide higher population levels: first, the total usable foraging area of each site was divided by overall (= foraging) territory size (for Spur-winged Lapwing set at 6 ha, based on the FRV value at Oroklini and close to the figure from Makrigianni *et al*. 2008), and second, the total possible nesting area at each site was divided by the estimate of nest territory size (for Spur-winged Lapwing as derived above, 0.11 ha). The two resulting figures were then compared, as for the site-level calculations described above, and the lower of the two was taken as the hypothetical maximum. For all sites tested, as expected for this species, feeding territory size was always found to be the limiting factor on the number of breeding birds (Table 1, limiting numbers highlit green).

These calculations were based entirely on area of apparently suitable habitat and do not take into account other factors that might prevent the achievement of the maximum population level. In some cases these factors may be significant: for example, the Spur-winged Lapwing is not known to have bred over most of the Akrotiri wetlands (only at Phassouri), despite the presence of extensive areas of suitable habitat. This may result from high levels of disturbance across the main lake and flats, with no areas being currently suitable for nesting, i.e. protected from such disturbance. Although disturbance at much of Larnaca Salt Lake is also high, protected breeding sites for the species exist there (e.g. Spyros Pool, Latsi, the airport), which may account for the difference in use of the two lakes (N. Kassinis pers. comm.). This suggests that improved management (reduced disturbance) could considerably improve the status of certain sites, such as Akrotiri and Phassouri in particular, for this species.

The figures in Table 1 indicate a hypothetical maximum population for Cyprus of 532 breeding pairs. Taking into consideration factors such as restricted management options at some sites, competition with other species, and that an FRV should be at a level regularly achievable (most years), then the FRV for this species may be set at 200 breeding pairs. The reduction from 532 pairs (Table 1) to 200 pairs is made to take account of the limited potential of the Akrotiri site in particular, where expert opinion (N.Kassinis pers comm) suggests the 250 pairs maximum based on foraging territory size is much too high, given the lack of breeding at the most of this site to date and that it is unlikely the majority of this large site would be managed for the requirements of this species alone. The 200 breeding pairs FRV is considerably more than recent population estimates of 20–65 breeding pairs (BirdLife International 2004, 2012, Charalambidou *et al.* 2008, 2012, Kassinis *et al.* 2010, Hellicar *et al.* in press, Kassinis *et al*. 2013, N. Kassinis pers. comm.), and matches the rule-of-thumb MVP guideline level of 200 individuals discussed above. If the population continues to expand, if management for this and other wetland birds can be improved at some sites, or as more high-resolution maps become available for wetlands, this figure may be revised. Regardless, this FRV represents a currently ambitious target that would see the Cyprus population increase considerably above present estimates and would only be reached through the improved management and protection of wetlands, especially the salt lakes.

FRV for Spur-winged Lapwing at Site level: 15 pairs
FRV for Spur-winged Lapwing at National level: 200 pairs

Black-winged Stilt *Himantopus himantopus*

For this species the PVA method could not be used as there was insufficient information on its key population parameters. It breeds colonially (= Scenario 3, Fig. 3), so the Habitat method must be as described above, with the limiting of the two hypothetical maxima expected to be that based on foraging area, because the breeding density of a colonial species multiplied by the available area for nesting produces a population figure likely to exceed that which can be supported by other resources (e.g. food). This was confirmed by the calculations in Table 1, using a figure for nest spacing of 0.0211 ha (area required per nest, calculated from a minimum distance between nests of 8.2 m: Cuervo 2004): the resulting hypothetical maximum numbers of nests are always unrealistic.

Site Level:

In recent years, there have been up to 140 Black-winged stilts at Oroklini at the same time (e.g. June 2010 and July 2011: BirdLife Cyprus Waterbird Counts *in* Monthly Checklists). Although these figures include non-breeding and some first-year birds, they give an indication of the number of stilts for which the site is able to provide resources. Also, the largest number of breeding pairs recorded in a given year at Oroklini was 73, in 2010 (N. Kassinis pers. comm.). In that year the foraging area theoretically available per breeding pair was 0.66 ha (habitat area 48 ha divided by 73). The smallest comparable area per pair found in the literature was in Doñana (Spain), where a colony of 164 pairs inhabited a 100-ha brackish pond, with a small island and man-made dykes. In this area, which appears closely comparable to Oroklini, the mean area per pair may be calculated as 0.61 ha (Cuervo 2004). This might not be the highest density that Black-winged Stilts could achieve in optimal conditions, but on current knowledge it may be used to calculate the maximum breeding population that a similar site may hold. By dividing the habitat area (48 ha) at Oroklini by this area (0.61 ha), the maximum number of breeding pairs is 79 (Table 1). However, Cuervo (2005) also found, in a site very similar to Oroklini, that Black-winged Stilt colonies larger than 50 breeding pairs suffered reduced breeding success due to increased predation and intraspecific aggression. Therefore, the recommended site-level FRV for this species at Oroklini is set at 60 breeding pairs. This is lower than both the hypothetical maximum number calculated above and the highest number ever recorded breeding at Oroklini in a given year, but is considered advisable because FRVs should be achievable most years, not just in exceptional conditions, and with the improved management of Oroklini that is already being implemented, this is considered a realistic target. Oroklini is currently the prime site for this species on the island and is likely to remain so for the foreseeable future, so the FRV should not be set unnecessarily low. It is not set higher however, partly because higher figures are more likely to result in increased nest losses (Cuervo 2005) and because, with improved protection, numerous other sites across the island could hold breeding colonies of this species, thereby creating a national population that would not be heavily reliant on any one site. The suggested FRV would allow for improved management at Oroklini for species with different requirements, such as lower water levels. Since the suggested FRV of 60 pairs is higher than the level at which Cuervo (2005) observed reduced breeding success, it is strongly recommended that the population's annual reproductive success and, if possible, the levels of predation and intraspecific aggression that occur, should be monitored: if advisable, the FRV could then be adjusted downwards.

National Level:

To generate a national level FRV for this species, the same method was used as described for the Spur-winged Lapwing. Although the Black-winged Stilt does not defend a feeding territory, estimates of the amount of foraging area needed per breeding pair can be used as a proxy for territory. For each site, the overall habitat area available was divided by 0.61 ha as above, and the suitable nesting area by 0.0211 ha as described above. Since the nest territory is so small in this species, even the sites with the most restricted areas of nesting habitat could provide a non-limiting area of it, so for this species, the hypothetical maximum number was always set by foraging area (Table 1).

These calculations produce a hypothetical maximum for Cyprus of 3200 breeding pairs of Black-winged Stilts (Table 1), considerably higher than recent estimates, which place the Cyprus population at 40–220 breeding pairs (BirdLife International 2004, 2012; Charalambidou *et al.* 2008, 2012, Kassinis *et al*. 2013, Tye *et al*. 2012, Hellicar *et al.* in press). This high hypothetical maximum derives in part from over-estimation of suitable habitat, owing to lack of detailed wetland habitat maps. It also presumes that all wetlands that could conceivably be managed for this species have ideal conditions, including appropriate water levels, and therefore does not take into consideration the competing requirements of other species or other management requirements at these wetlands. Since the primary function of some of the wetlands included in the calculations is water supply for human activities, it is unlikely that the management of these sites could be substantially improved for Black-winged Stilt, although for most it probably could, such as Akrotiri and Larnaca and most all sites in the occupied areas. This multiplicity of factors renders the selection of a national FRV for this species difficult, but it must evidently be substantially lower than the hypothetical maximum, although it could be significantly higher than the current population. Therefore, an initial FRV of 300 breeding pairs is suggested, which is a 36 % increase over the upper end of the current population estimate but only c. 10 % of the hypothetical maximum. The Oroklini FRV population (60 pairs) would then represent 20 % of this national level, while the national-level FRV would be well above the rule-of-thumb MVP. This is still considered an ambitious but perhaps realistic management target for the short term, since there is more potential at many key Cyprus wetlands than there is at Oroklini for improved management for this species. More detailed habitat maps of the various wetlands in Cyprus, improved estimates of the breeding parameters of this species, and better information on site suitability and (especially) the potential for improved management would all permit refinement of this figure.

FRV for Black-winged Stilt at Site level: 60 pairs

FRV for Black-winged Stilt at National level: 300 pairs

Stone-curlew *Burhinus oedicnemus*

There was sufficient information on the breeding, mortality and habitat requirements of this species to use both the PVA and Habitat approaches for this species (= Scenario 1, Fig. 3). However, the PVA approach was used to find the MVP at national level only, since Oroklini is not large enough to hold enough of this species to apply PVA at site level. The Habitat approach was used to estimate the number of breeding pairs, but for this species the habitat and density information was sufficient for these calculations to produce more realistic estimates of actual or potential numbers of breeding pairs, rather than a more hypothetical maximum.

Site Level:

Very little of Oroklini is suitable breeding habitat for this species: *c.* 12 ha on the west side, including the restored market site, and a small area of farmland (Non-irrigated arable land: cover type 211) which is outside the SPA but within the IBA. However, these areas could be managed in such a way as to maximise the chance of success of any Stone-curlews that breed there. This could be done in numerous ways including choice of crop type, means of harvesting, timing of harvesting or ploughing etc. A brief review of farming and other management methods beneficial to this species (Firbank *et al.* 1993) could be used as a guide. An FRV for the site is not particularly informative since no more than one or two pairs could breed there. While the contribution of the Oroklini population to the national FRV (below) is tiny, the implementation of farming practices favourable to Stone-curlew at this site could provide an important example for other areas that are more suited to the species. A suitable conservation target for this species would simply be to try to maintain it as a regularly breeding bird at Oroklini.

National Level:

Most available breeding and mortality data for Stone-curlew were from outside Cyprus, mostly from the UK (Green *et al.* 1997, Bealey *et al.* 1999, Green *et al.* 2000). PVA using Vortex, with the parameters set as in Table 2, indicates that it would be necessary to have an initial population of 1500 birds in Cyprus to produce a probability of extinction of < 0.01 in 100 years: this is the MVP. Although this number of birds (1500) produces a slowly declining population that would not be viable over periods exceeding 100 years, it is thought that the current Cyprus population is actually above this level (N. Kassinis pers. comm., Hellicar *et al.* in press).

Table 2. The values used in the PVA software Vortex for calculating MVPs for Stone-curlew and Kentish Plover, and their sources. For parameters not shown here (which are less species-specific and/or for which no information was available for these species), such as inbreeding depression, catastrophe frequency and impact, values were taken from Brambilla *et al*. (2011).

	Stone-curlew		Kentish Plover	
Age at first breeding	1	Green et al. 1997	1	Cramp & Simmons 1983
Maximum breeding age	15	Green et al. 1997	10	Cramp & Simmons 1983
Mean progeny per pair	0.645	Bealey et al. 1999	1.83	Pineau 1993
Juvenile mortality	39%	Green et al. 1997	47%	Cramp & Simmons 1983, Sandercock et al. 2005
Adult mortality	17%	Green et al. 1997	40%	

Most information on habitat requirements and breeding density also came from outside Cyprus, with the most detailed studies in England, where there were breeding densities of 0.6–6.4 pairs/km^2 depending on the habitat, soil type and slope (Green *et al*. 2000). The home range of the species in Emilia-Romagna (Italy) was 16–190 ha (Gustin *et al*. 2009), equivalent to 0.53–6.25 pairs/km^2, a very similar range to that from the UK study. No data suitable for calculating breeding densities were found from elsewhere in the species' range. The habitat suitable for breeding (Solis & Lope 1995, Thompson *et al.* 2004, Green *et al.* 2000) corresponds in Cyprus to CORINE land-cover types 211 Non-irrigated Arable land, 241 Annual and Permanent Crops, 243 Farmland and related formations, 321 Natural Grassland, 323 Scrub (which includes Phrygana), 333 Sparsely Vegetated and 421 Saltmarsh. All of this area in Cyprus is at suitable altitude, but some of it was considered unsuitable for the species due to disturbance within 3.6 km of major roads (Green *et al*. 2000): while this research was also carried out in the UK there is no reason to believe that the response to disturbance will differ greatly between countries. However, removal of such buffers around all surfaced roads in Cyprus would result in virtually no habitat being left for the species, and Green *et* al. (2000) did not provide information on road use intensity, which might enable refinement of this factor. It was therefore decided to use GIS software to remove the area of habitat within 3.6 km buffers around urban centres and the main and busiest highways for which GIS data were available. This will inevitably result in the exclusion of small areas suitable for the species, but other unsuitable areas will have been included. The resulting map (Fig. 5) shows the remaining habitat area. Of this, some habitats were considered optimal for the species and the rest sub-optimal: 321 Natural Grassland was classed as optimal, while the remaining habitats listed above were considered either suboptimal, or optimal in parts and suboptimal or unsuitable in other parts (for example, Phrygana is optimal but its proportion of CORINE class 323 is unclear). The optimal habitat type (321 Natural Grassland, 91 km^2) was then multiplied by a breeding density of 6.4 (pairs/km^2: the highest breeding density found in the UK, see above), and the remaining suboptimal habitats (211 Non-irrigated Arable Land 1973 km^2, 241 Annual and Permanent Crops 123 km^2, 243 Farmland and related formations 99 km^2, 323 Scrub 541 km^2, 333

Sparsely Vegetated Areas 33 km^2, 421 Saltmarsh 8 km^2) by 0.6, in line with the respective breeding densities given by Green *et al.* (2000). This produced an estimate of 2250 breeding pairs as the maximum that Cyprus might hold. This value masks unmapped variation in habitat quality, as discussed above, and in particular does not take into account slope and soil type, both of which strongly influence breeding site preferences (Green *et al*. 2000). This may be considered to have been taken into account for the suboptimal habitats by having used the lowest density of the range as multiplier but, in order to take into account the reducing effects of slope, soil type and disturbance (particularly from unmapped roads) for the optimal habitat, a mid-value for breeding density (3.4 pairs/km^2) may be used as its multiplier instead of 6.4: this reduces the population estimate to a value of 1980 breeding pairs. Both of these estimates are well above the MVP calculated from PVA modelling (1500 individuals or *c*. 700 breeding pairs), and are also above recent population estimates for the species (200–1000 pairs: N. Kassinis pers. comm., Hellicar *et al*. in press). However, for this species they are considered realistic estimates of populations that Cyprus could hold under reasonably achievable management regimes. An FRV of 2000 pairs is therefore adopted for this species in Cyprus.

FRV for Stone-curlew at Site level: Maintain it as regular breeding bird at Oroklini Lake (1-2 pairs)
FRV for Stone-curlew at National level: 2000 pairs

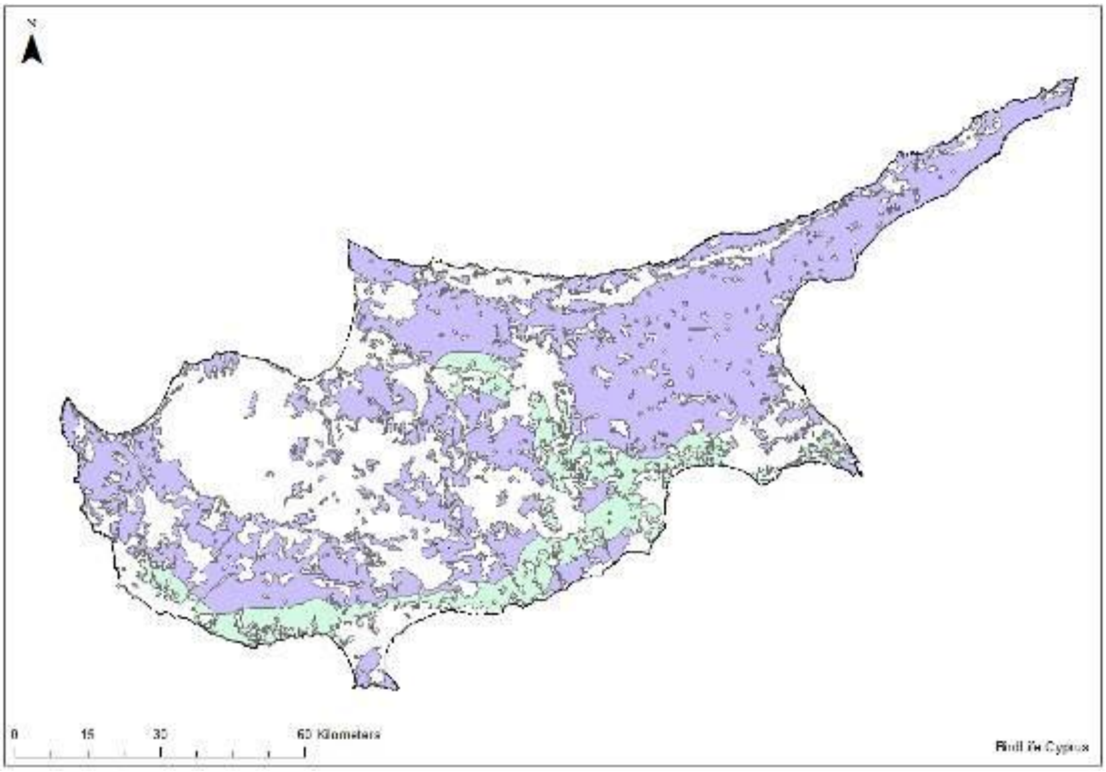


Figure 5. Habitat map for the Stone-curlew showing the presence of suitable habitat types (purple), with urban centres and major highways and buffers around them (green) removed.

Kentish Plover *Charadrius alexandrinus*

For this species there was adequate information to use both the PVA and Habitat approaches for the national level calculations (= Scenario 1, Fig. 3). However, for the site level, PVA is not appropriate as any MVP would be larger than the population which could be held by a site as small as Oroklini; in other words, the site-level FRV is necessarily smaller than the MVP. Therefore, only the Habitat approach was used for the site-level calculations. For this species, the use of "pairs" for population estimates and other purposes requires caution, because it is known that, for 98 % of nests, one parent, usually the female, deserts after hatching and re-nests with another mate (Amat *et al*. 1999). The concept of "breeding pair" therefore applies only to incubating and pre-incubating birds. Some implications of this are discussed below. Studies on nesting Kentish Plovers have shown them to nest within 15 m of conspecifics, which produces an area required per nest of 0.0707 ha. Since this is so much smaller than the foraging area for this species (see below), it was always foraging area which limited the hypothetical maximum population size (Table 1), and values based on nest territory size are not discussed further.

Site Level:

The closely related Snowy Plover *Charadrius nivosus* defends a territory surrounding the nest, but does not defend a foraging area (Page *et al.* 1983) and the Kentish Plover is thought to show similar behaviour (Cramp & Simmons 1983). Therefore, the amount of area needed per breeding bird for foraging was estimated by analysing the numbers of birds recorded on wetlands in Cyprus and elsewhere, and the size of the wetlands' suitable habitat areas. For example, BirdLife Cyprus unpublished records show 35 "pairs" of Kentish Plovers breeding at the Larnaca wetlands in 2006, and analysis of satellite images of this site shows c. 690 ha as appearing suitable for this species as foraging (including breeding) habitat; this would allow each breeding pair 19.7 ha. In the Akrotiri wetlands, c. 1470 ha appear to consist of potentially suitable habitat, while c. 125 "pairs" may have bred there in 2012 (the upper end of the range estimate for breeding birds and the lower end of that for the resident population given by Tye *et al*. 2012), allowing each pair 11.8 ha. Similar calculations on Kentish Plover populations in Spain gave an overall value of 8.6 ha per breeding pair (Fraga & Amat 1996). As the habitat approach aims to create a theoretical maximum, and assuming that there is potential for the better management of Akrotiri and Larnaca for this species, it was decided to use the smallest of these three values, i.e. 8.6 ha per pair. Dividing the potentially suitable area of Oroklini (34 ha, if managed for this species) by 8.6 gives a maximum of four breeding pairs for the site. Most of Oroklini is currently composed of wetland habitat types that are not suitable for Kentish Plover, and the previous maximum number of breeding pairs recorded in a given year at Oroklini was one pair (in 2007 and 2008: BirdLife Cyprus 2008, 2009). Given that little of the site could be managed primarily for Kentish Plover without compromising its other conservation interest, as this would require the creation of wide areas of open flat as foraging areas, an initial site-level FRV for this species may be set at four breeding pairs, to represent an increase on the current value but taking into consideration the limited potential for managing Oroklini for this species: achieving this FRV would mainly require reduction of disturbance in the west and southwestern parts of the site. This figure may be revised in the light of the outcomes of planned management improvements at Oroklini. At such a small FRV, the main conservation objective is simply to ensure that the species continues to be present at Oroklini as a regularly breeding bird, and the effect of pair members re-nesting with other mates may be ignored.

National Level:

The Habitat approach similarly follows closely that used for the Spur-winged Lapwing, whereby individual wetlands were assessed for their suitability for the species and then the number of foraging "territories" that they could theoretically hold was calculated, with a value of 8.6 ha per pair adopted, as described above (Table 1). The sum of the hypothetical maximum populations in the wetlands in Table 1 is 331 breeding "pairs". However, this should be reduced somewhat because of the propensity of one parent to desert after hatching and re-nest, so that 331 pairings will include fewer than 662 adults. There is no firm basis for calculating a reduction factor, but reducing 662 adults by 20 % produces an estimate of 530 adults. Based on demographic data indicating that a population comprises 59 % adults and 41 % immatures (Sandercock *et al.* 2005), 530 adults equates to a total population of 900 birds (530 ÷ 0.59). This may seem low as a maximum population that Cyprus might hold, and more detailed evaluation of the suitability of wetland sites for this species might result in an upward adjustment of this estimate.

There are few data available on the number of chicks successfully fledged per Kentish Plover nest, in part due to the difficulty of monitoring broods of this species. Kentish Plover chicks are nidifugous and highly mobile, being found up to 4 km from the nest just one day after hatching (Fraga & Amat 1996). This, combined with the cryptic coloration of the chicks and the complex structure of wetlands causes considerable obstacles to collecting accurate data on fledging success and mortality. However, estimates of the mean number of fledged chicks per Kentish Plover nesting attempt include 1.83 (Nile Valley), 1.84 (southern France), 1.64 (California) and 1.5–2.0 (northwest Europe) (Pineau 1993). The only figure available for Cyprus was 1.1 fledged chicks per breeding attempt, based on seven late nests in 2012 (Tye *et al*. 2012), which was probably an under-estimate of the seasonal average. PVA sensitivity testing showed that values of fledged chicks per pair below 1.5 require an initial population of at least 800 breeding "pairs" (more accurately, nest attempts that reach hatching) in order to reduce the probability of extinction below 1% in 100 years. Since the Cyprus population of Kentish Plover does not appear to be declining (breeding-season counts, 2006–2012: BirdLife Cyprus Monthly Checklists), relatively high values for breeding and low values for mortality parameters were therefore adopted for the PVA method (Table 2), in line with the recommendations of Brambilla *et al.* (2011). The number of fledged chicks per nest was taken as 1.83 (from the closest studied site to Cyprus and towards the higher end of the ranges reported by Pineau 1993), while juvenile mortality was taken to be 47% and adult mortality 40% per year (Cramp & Simmons 1983, Sandercock *et al*. 2005). There were no data available on mortality rates of the Kentish Plover in Cyprus. Values for other population parameters such as age of first and last breeding, were taken from Cramp & Simmons (1993) and Sandercock *et al*. (2005), while other factors modelled by the software, such as the effects of catastrophe frequency and severity on a population, were taken from Brambilla *et al.* (2011). Using these values, it was found that a population of 300 individuals (approximately 90 breeding pairs) would have a probability of going extinct of < 1% in the next 100 years; this may therefore be taken as the MVP. However, sensitivity testing showed that small increases in the mortality rate or reductions in breeding success led to a declining population with an unacceptably high risk of extinction. Therefore, it was considered safer to place the FRV a little closer to the hypothetical maximum value as generated by the Habitat method (900 birds), rather than using a figure closer to the MVP. The FRV for the Kentish Plover is therefore set at 800 individuals. This equates to approximately 250 pairs, so would represent an increase on the recent population estimates for Cyprus (up to c. 160 breeding pairs: BirdLife International 2004, 2012, Charalambidou *et al*. 2008, 2012, Kassinis *et al*. 2013, Kassinis *et al.* 2010, Tye *et al*. 2012, Hellicar *et al.* in press). This FRV is considered achievable by the implementation of realistic improved management, especially reductions in disturbance, at key wetlands.

FRV for Kentish Plover at Site level: 4 pairs

FRV for Kentish Plover at National level: 800 individuals

Common Tern *Sterna hirundo* and Little Tern *Sternula albifrons*

Both of these species have been recorded breeding or attempting to breed at Oroklini in the past and are Annex I species. There is also some evidence of occasional breeding by one or both of them at other wetlands in Cyprus, including Larnaca, Akrotiri and Achna Dam (BirdLife Cyprus 2008, 2010, Charalambidou *et al.* 2008, Kassinis *et al*. 2010). Since both species breed colonially (= Scenario 3, Fig. 3) and there is little evidence of established breeding colonies at any site, it is not yet possible to set FRVs for these species at site or national levels. Colonies of these species are often transient, and move depending on food or nest site availability, while breeding individuals may forage outside the wetland in which they are breeding. These factors, which cannot easily be controlled, mean that the availability of suitable nesting habitat may not necessarily result in birds nesting at a particular site. The average foraging distance of Common Tern is 5.1 km (Fasola & Bogliani 1990), so offshore feeding is easily accessible to terns breeding at Oroklini, but management of inland water bodies within a corresponding distance of a given site might also increase the probability of the species nesting successfully. Although there are no significant wetlands within this mean distance from Oroklini, the Larnaca wetlands are c. 7.5 km away and therefore within a conceivable foraging radius for the species.

Despite these caveats, the habitat at Oroklini and possibly other sites could be managed to encourage these two species to nest. Both are highly sensitive to disturbance, so suitable nesting habitat should be created in the least disturbed part of a site if possible, such as a mud island surrounded by water, or an artificial nesting raft (Dunlop *et al.* 1991). In the Mediterranean, both species show a strong preference for nesting on mud and sand substrate, with sparse *Salicornia* and *Salsola* vegetation (Fasola & Canola 1992). This shared preference in nesting habitat should simplify any site management intended to favour both species. Further tactics to encourage successful breeding at Oroklini and other sites, such as managing the ditches at Oroklini to provide improved feeding habitat for Little Tern, the use of decoys, and management of disturbance and predation, could also be implemented (Kress 1983).

FRV for Common Tern and Little Tern on Site level and on National level: It is not yet possible to set FRVs for these species at site or national levels.

The table below summarises the Favourable Reference Values (FRVs) for all the species described in this report, on site and national level.

	FRVs	
SPECIES	**Site level, Oroklini Lake (pairs)**	**National level, Cyprus (pairs)**
Spur-winged Lapwing ***Vanellus spinosus***	15	200
Black-winged Stilt ***Himantopus himantopus***	60	300
Stone-curlew ***Burhinus oedicnemus***	Maintain it as regular breeding bird at Oroklini Lake (1-2 pairs)	2000
Kentish Plover ***Charadrius alexandrinus***	4	250 (800 individuals)
Common Tern ***Sterna hirundo***	It is not yet possible to set FRVs for these species at site or national levels	
Little Tern ***Sternula albifrons***	It is not yet possible to set FRVs for these species at site or national levels	

Conclusions

The Favourable Reference Values (FRVs) for key bird species detailed above provide a baseline and point-of-reference for all actions aimed at bringing Oroklini Lake Special Protection Area (CY6000010) to favourable conservation status, which is the goal of the EU LIFE project "Restoration and Management of Oroklini Lake SPA in Larnaca, Cyprus". A vital pre-requisite for the Lake to attain favourable status is that its qualifying species reach such status. The site level FRV values determined for populations of European Union Birds Directive Annex I bird species regularly breeding at Oroklini Lake can be used to evaluate current population levels and form conservation targets. The FRVs arrived at for the two Oroklini Lake Annex I SPA qualifying species are: Spur-winged Lapwing *Vanellus spinosus*, 15 breeding pairs at site level (200 breeding pairs at national level); Black-winged Stilt *Himantopus himantopus*, 60 breeding pairs at site level (300 breeding pairs at national level). Comparison of current and future populations of these two qualifying Annex I bird species against their FRV targets values makes it possible to establish whether or not their populations are at favourable conservation status, informing and guiding conservation actions.

Acknowledgments

We thank Claudio Celada for advice on the LIPU approach and how to adapt it, and Martin Hellicar, and Nikos Kassinis for expert advice and opinion on site suitability and bird populations, species needs and current distribution. Christos Mammides kindly provided training on the use of population viability analysis software, and Vasiliki Anastasi created the GIS-based habitat maps.

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