Predicting the Effects of Removal On The English Cormorant Population

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Summary

Existing annual winter counts of cormorants from the Wetland Bird Survey (WeBS) were used to examine the potential response of the English cormorant population to different levels of licensed removal. The English winter cormorant population demonstrates significant density dependence in its growth rates between years; the population grows faster when less abundant. A simple deterministic population model incorporating the estimated density dependence was constructed.

The model predicted that the annual removal of over 25% of the cormorant population would lead to a long-term decline in their numbers. Rates of removal below 25% were predicted to suppress the size of the population to a level lower than that currently observed, but not to lead to a long-term decline. The simple WeBS counts are known to underestimate the total size of the cormorant population, and estimates of 14,260 (lowest published estimate), 17,365 (most widely accepted estimate, equivalent to 23,000 in GB) and 19,205 (highest published estimate) total wintering cormorants in England have been produced.

Comparing these estimates of the size of the English cormorant population with different numbers of licenses, suggested that a long-term policy of removing over 2,500-3,000 birds per annum would risk a long-term decline in the cormorant population. Removing fewer birds than this would suppress the population, but not lead to a long-term decline.

Models based on the range of population estimates predict that the continued annual removal of 2,000 birds would suppress the size of the English cormorant population by between 15 and 20% with this effect taking 5 years to be fully apparent. This suppression would be stable and would not lead to a further long-term decline in population size. The repeated removal of 2,000 birds per annum would have a margin of safety of 25%-40% compared to the levels that would place the population at risk of a long-term decline.

It is recommended that the effects are monitored through the existing WeBS count scheme although additional data on how WeBS data relates to actual winter population size and information on the status of the breeding population should also be collected to inform future policy. The most conservative model, applied to the annual removal of 2,000 birds predicts that the WeBS count will fall from the current stable average of 11,500 to 9,200 after five years. Should the trend in WeBS counts vary significantly from this prediction then this policy should be reviewed and the number of licenses adapted accordingly.

The model produced in this paper should be refined to include historic data from England, and should also include year to year variability in cormorant numbers. Once complete the model will be submitted to a peer-reviewed scientific journal for publication.

How Many Cormorants Are There In England?

Data on the annual trend in cormorant numbers has been collected through the WeBS scheme since 1989. This provides a count of the maximum number of cormorants observed at a wide range of sites over the winter. It provides a good method of determining year to year changes in abundance, but does not give an absolute count of the number of birds, only the maximum number seen. It is recognised that there are more cormorants than are recorded by WeBS, total numbers have been variously estimated as 1.67 (Kershaw and Hughes) and 1.24 (Kirby) times more abundant than simple WeBS counts. These correction factors suggest total English winter populations of 19,205 and 14,260 respectively. The most widely accepted figure for the total number of cormorants overwintering in GB is 23,000, this equates to 17,365 in England which is between the two other estimates. Further work is required to better assess the real relationship between WeBS counts and actual winter cormorant populations. The published WeBS counts are presented in Table 1.

WeBS provides the only consistent data on cormorant population status. However, it is important to note that these data relate to winter numbers, which include a mixture of breeding, non-breeding and migrant birds. No comparable data are available on the size or status of the breeding cormorant population

Table 1: Maximum numbers of cormorants recorded during annual Wetland Bird Surveys (WeBS) in England and throughout GB. Separate figures for England are only available since 1993. For the years 1989-1992 the English figure has been estimated as 75.5% of the GB total, the average percentage for the years 1993-2001. These are presented in italics.

YEAR	ENGLAND	GB
1989	*7323*	9700
1990	*8607*	11401
1991	*10469*	13866
1992	*9841*	13034
1993	10202	13931
1994	11076	15355
1995	10620	13769
1996	11207	15752
1997	10786	14158
1998	10343	13658
1999	12020	14475
2000	12536	16243
2001	12369	16315

Identification of Density Dependence

To assess how the population might respond to changes in the number of animals that are removed, it is necessary to examine evidence for density dependence. Density dependence measures how population growth rate is affected by population abundance, typically, populations grow slowly when abundant, and grow faster when less abundant. Such density dependence exerts a stabilising influence on, and can determine, species abundance. Reliably predicting the effects of removal depends on the presence and form of density dependence.

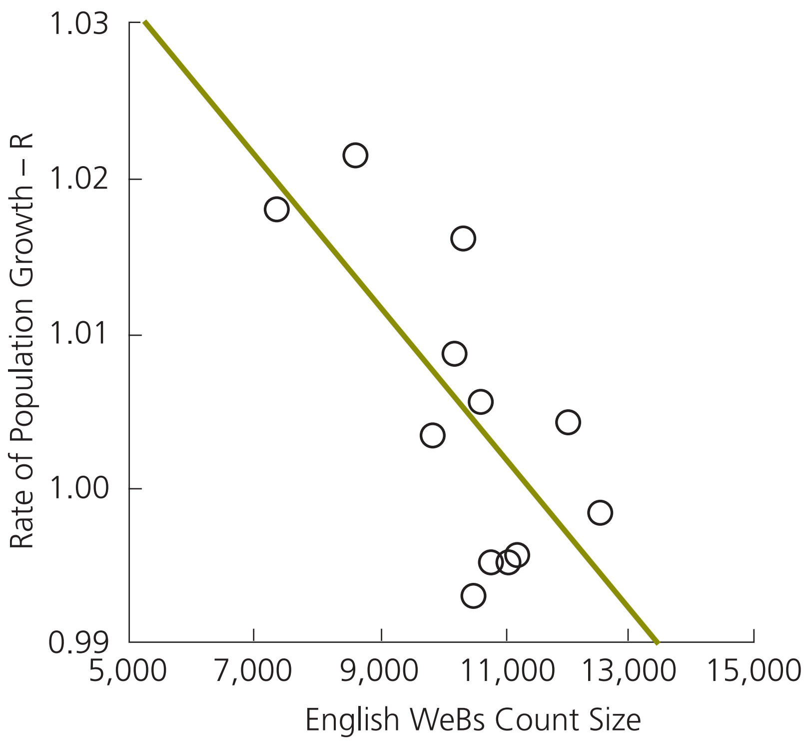
To examine the English data for density dependence, the rate of population growth rate was calculated between successive pairs of years, using the WeBS data. This used the formula:

$R=Log(x^{n+1})/Log(x^{n})$

Where R is the population growth rate, x^n is the number of cormorants in year n and x^{n+1} is the number in the following year. If density dependence is present then we would expect R to be greatest in years when the WeBS count is low, and *vice versa*.

Regression of R against x^n showed this to be the case; there was a significant negative relationship between R and the corresponding WeBS count (Fig 1) ($n=12$, $t=-3.13$, $p=0.01$, $r^2=0.49$). This indicates that the cormorant population grew faster when they were less abundant and that this would compensate to some extent for any increase in mortality caused by increased removal under licence. The relationship also suggests that the population is stable (R=1) at a figure of 11,500 birds observed during WeBS counts. Should the count exceed this level it tends to decrease in the next years; if below this level, the count tends to increase.

Fig 1: The relationship between population growth rate and cormorant population abundance as measured by the annual WeBS count.



Model Structure

A simple population model was used to examine the population consequences of different levels of licensed removal. This used the density dependent relationship to estimate cormorant population growth rate in relation to abundance. The model began with a stable cormorant population based on one of the three available estimates. This population was then reduced by a set amount (number or proportion) per year to reflect different licensing strategies. The growth rate of the reduced population was then predicted from the density dependent relationship to predict the number in the next year. This process was then repeated twenty times to simulate the effects of such a licensing strategy on long-term population status. Preliminary examination of the model outputs suggested that 20 years was sufficient time for the population to stabilise under most strategies.

Model Assumptions

At very low levels of cormorant abundance, the density dependent model extrapolates to high rates of population growth. Such high rates of growth were not observed during the period of the WeBS counts and may not be achievable. To take a conservative approach, the maximum annual growth rate was capped at 20%, a level that has been observed and exceeded in other European cormorant populations.

The model also assumes a direct and predictable link between abundance and growth rate. In real life this relationship is more uncertain and varies from year to year, for instance as birth rate varies in relation to the weather. The model did not include this annual variability in its predictions although such factors could be included in the future. The absence of this variation in the model could lead to its predictions becoming uncertain following, for example, a run of years with poor weather which might suppress cormorant numbers. Measures to protect against such effects are discussed later.

Model Results

The model was first used to estimate the effect of removing a constant percentage of the cormorant population on the size of the remaining population (Fig 2). This predicted that annually removing over 25% of the population would put the population into a long-term decline. Removing smaller percentages would cause a short-term decline in the population after which numbers would stabilise at a new, lower level. Table 2 presents the expected level by which the population would be reduced following 20 years of removing a set proportion of the population.

Figure 2 The predicted effects of removing a constant percentage of the population on an annual basis on the size of the cormorant population.

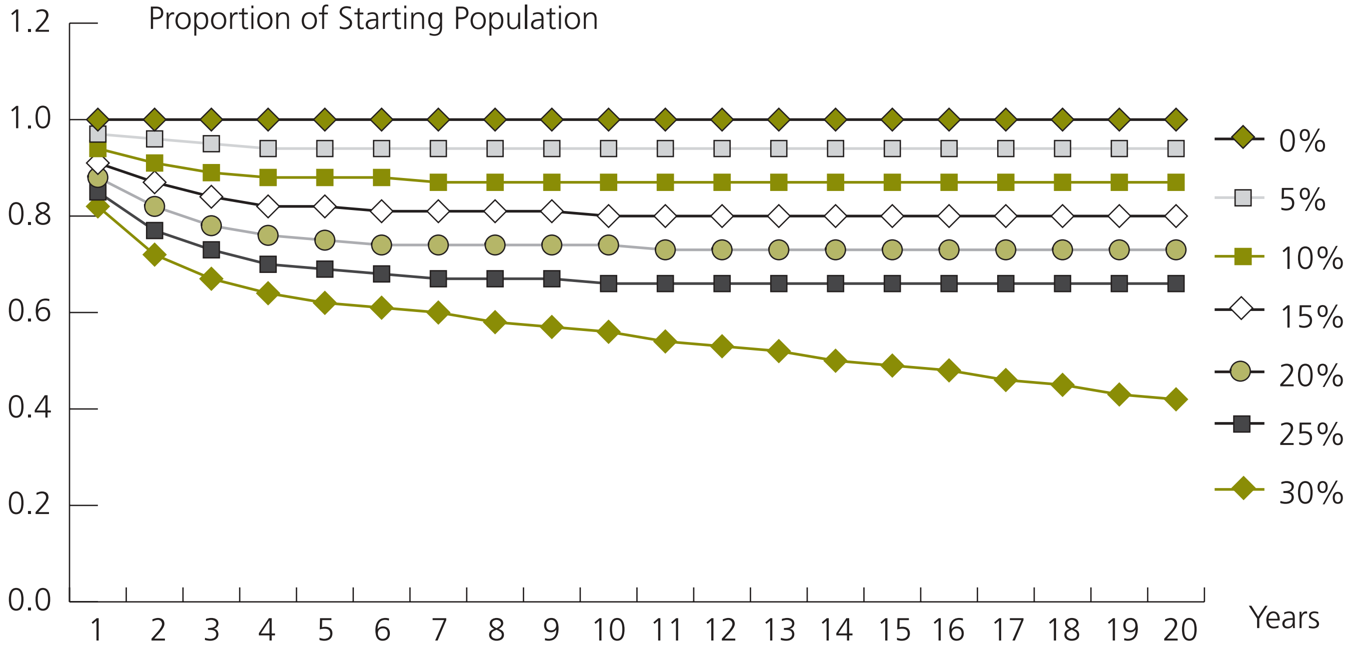


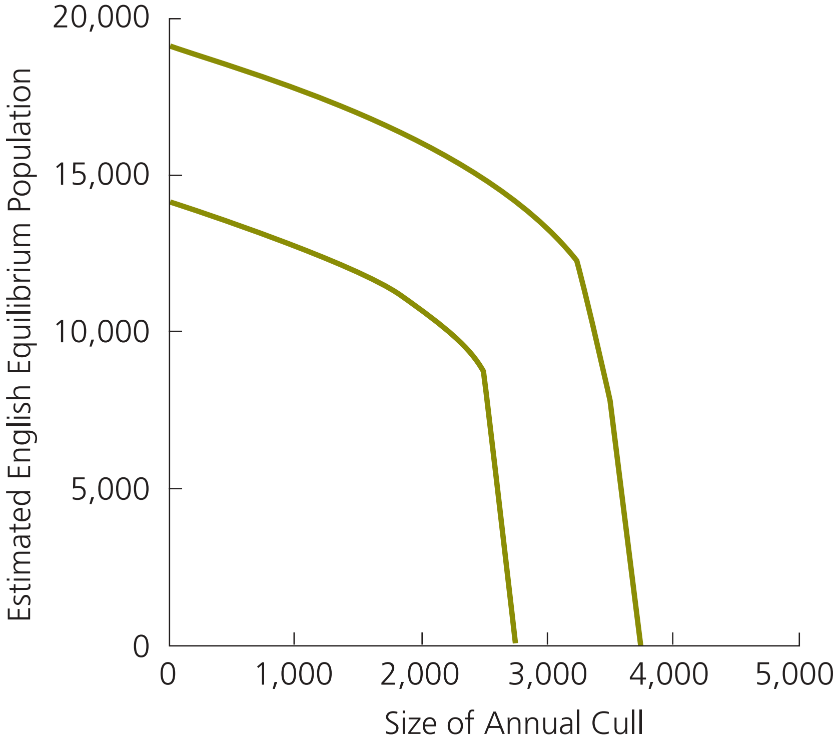
Table 2: Predicted effects of removing a constant percentage of the cormorant population on the proportion of the original population remaining after 20 years

Percentage Annual Removal	**Proportion of Original Population Remaining After 20 Years**
0%	Stable at 1.00
5%	Stable at 0.94
10%	Stable at 0.87
15%	Stable at 0.80
20%	Stable at 0.73
25%	Stable at 0.66
30%	Long-term decline

These results relate to percentage removal and proportions of the original population. How do these relate to actual numbers of licenses and cormorants? Three estimates of the number of cormorants in England are available. WeBS provides the minimum, while two correction factor estimates are available (WeBS times 1.24 or 1.67) that estimate the English cormorant population from WeBS. Given that the model predicts an equilibrium WeBS count of 11,500 birds, these correction factors suggest total English winter populations of 14,260 and 19,205. The most widely accepted figure for the total number of cormorants overwintering in GB is 23,000, this equates to 17,365 in England which is between the two other estimates.

A range of scenarios of annual licenses were examined. These were based on the higher and lower estimates of total cormorant numbers to give a range of possible impacts on total cormorant numbers (Fig 3).

*Fig 3: The predicted response of the English cormorant population to different levels of annual culling. The estimated equilibrium population relates to the numbers predicted to occur after 20 years of annual removal. The two lines relate to the higher and lower estimates of the size of the English population. The lower line represents WeBS*1.24 (starting at 14,260), the upper line is WeBS*1.67 (starting at 19,205). The most widely accepted figure for the total number of cormorants overwintering in GB is 23,000, this equates to 17,365 in England which is between the two other estimates.*



These predict that the population would be at risk of long-term decline should the number of birds removed under license exceed 2,500-3,000 birds per year depending on the population estimate used. An annual cull of 2,000 birds would reduce the winter population by between 15% and 20% after 5 years, but this reduction would be stable and would be unlikely to place the long-term conservation status of the species at risk.

Issues of Confidence

Modelling is only as good as the data on which it is based and the assumptions used. Wherever possible the data has been treated in a conservative manner to produce the most pessimistic scenarios. However, there remain other considerations.

WeBS is an incomplete winter count of breeding, non-breeding and migratory birds. How this relates to actual winter numbers, or breeding numbers, remains uncertain and the model predictions only relate to winter numbers. However, the effect of removal on breeding numbers would be expected to be less pronounced than on winter numbers, as a proportion of cormorants are known to be non-breeders and these provide further scope for compensation for losses to breeding birds.

The model assumes future population responses can be predicted from past trends. Should the carrying capacity of the environment change, for example the amount of food available to this species increase, or other factors impinge on cormorant population dynamics then the model predictions will be less reliable. The model predictions should be regularly compared to the actual counts to assess this risk.

The model is based on England and treats the population as a whole. Local concentration of removal could lead to greater local declines, and the model cannot accommodate such regional effects in its current form.

Current licensing already removes a proportion of the population (225 birds shot in 2001/2002) although this effect is not included in the current predictions. The model predicts that such culling is already suppressing the size of the English population by around 2-3% and that this is reflected in the WeBS data used in this analysis. This is an example where the model is conservative.

Cormorant removal can be used to assist scaring. It is possible that an increase in licenses would increase the scaring effect of other measures and reduce the availability of suitable foraging sites for this species. If they are therefore unable to feed effectively this could have implications for their survival and breeding success. It is possible that increased licensed removal could impact on the survival and breeding success of remaining birds, but this is not supported by any existing evidence.

A strategy should not rely on a model alone. This should also include independent data to compare actual status against the predictions. Should the cormorant population follow a trend significantly different from that predicted here, then the number of licenses could be adapted as appropriate, or even stopped. This provides an extra margin of safety. This can be obtained through the existing WeBS data and could be further improved by a better assessment of how WeBS counts relate to real winter cormorant numbers and data on breeding numbers and thereby reduce the margin of error.

Implications for a Licensing Strategy

This model was used to predict the level of cormorant removal that placed the population at risk of long-term decline. This predicts the annual removal of 25% of the population or 2500-3000 birds would be the level at which the population would be placed at risk. Levels of removal below these figures are predicted to suppress the size of the cormorant population, but are not expected to result in long-term or irreversible declines. A licensing strategy based on the annual removal of 2,000 birds would provide a safety margin of 25-40% (the difference between the amount the population is predicted to be suppressed, compared to the amount necessary to risk a long-term decline)

During the first years of a new strategy it is possible that the number of licenses received will exceed 2,000. Removing over 2,000 birds per annum for a short period would increase the speed with which the population is suppressed, but could not be sustained at that level in the long-term without the risk of significant detrimental effects on the population. However using WeBS counts and the model predictions, licenses in subsequent years could be reduced to maintain the population at an acceptable and sustainable level without risking long-term declines. Should this appear likely, then further modelling should be conducted to assess the effects of varying the number of licenses issued in the early years of a new strategy.

There is a need to monitor the effects of any change in licensing policy. The most conservative model predicts that an annual removal of 2,000 would reduce the average number observed during WeBS counts from the current equilibrium of 11,500 to 9,200, with this taking around 5 years to settle at this new level. The annual WeBS count should be used to monitor the changes in cormorant numbers and if numbers diverge significantly from this expected result, then the policy should be reviewed and the number of licenses adjusted accordingly. The precise definitions and confidence limits of these predictions should await the inclusion of annual variation into the model. However, the principle of model predictions compared to the WeBS counts, with a threshold level that triggers review, provides a safety mechanism to protect against unexpected long-term changes in cormorant numbers.

Future Modelling and Publication

This model is based on the available WeBS data and has taken a conservative approach to the issues to minimise the likelihood of predicting a strategy that could detrimentally impact on the long-term conservation status of the species. However, the model could be improved in a number of ways. Firstly, early data for England is currently extrapolated from the GB count, the true WeBS data could be extracted from the original records although time did not allow this for this exercise. Secondly, the current model is purely deterministic, it does not take account of annual variability. A further model incorporating these stochastic elements will be produced although time did not allow their inclusion in this exercise. With these two additions it is intended that this work should be submitted for publication in a peer-reviewed scientific journal, with a planned submission date of early 2005.

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