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Looking for rooks: better surveillance and detection tools for rooks

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Contents

# Summary

Project and Client

- Horizons Regional Council (HRC) is optimising its control strategy for invasive rooks (*Corvus frugilegus*) and sought advice from Landcare Research (Envirolink Project HZLC84) on the efficacy of current methods for identifying rook populations and ways in which any deficiencies in detection of rookeries could be addressed.

Objectives

- Review current surveillance methods for locating rookeries.
- Suggest options for improving these methods.

Methods

- Pest managers at five regional councils (Horizons, Hawke's Bay, Greater Wellington, Waikato and Bay of Plenty) were emailed a list of questions about the rook data they collected. We assessed the suitability of the rook data collected by regional councils for statistical analysis that would provide quantitative estimation of the probability of detecting a rookery.
- We used rookery location data provided by the Hawke's Bay Regional Council to build a predictive model of rookery distribution across the region. Data on rookery presence and simulated absence were regressed against landscape predictor variables such as altitude and landcover, with the year the rookery was first recorded included as a random effect.

Results

- The data collected by the regional councils could not be used to estimate the relationship between probability of detection and effort expended since the discovery of a rookery could usually not be unequivocally assigned to data about search effort. Most rookery detections were opportunistic – reported by members of the public or spotted by council staff while out on other jobs. Where helicopters were employed for survey purposes, this was often secondary to the main use of the helicopter, which was to access known nests for toxin application. In such operations, rookery searches were made en route to or around the location of the known rookery, if time permitted.
- The best logistic regression model to explain rookery presence (taking into account predictive power and the number of included variables) incorporated: significant negative effects of altitude, soil water deficit and distance to the nearest shelterbelt; a significant positive effect of percent cover of improved grassland; and a significant negative effect of percent cover of short-rotation crops. The baseline probability of rookery presence varied between years, possibly due to the cumulative effects of control since more recent years (2009–2011) had a negative effect on the baseline probability of rookery presence whereas those pre-2009 (with the exception of 2005) had a positive effect. Including distance to water bodies, distance to nearest neighbours

or the number of neighbouring rookeries did not improve model fit. The fitted model had reasonable predictive ability. Based on the model predications, a map was produced of probability or rookery occurrence for the Hawke's Bay region.

Conclusions

- Improving detection of rookeries requires more searching (which is costly), a more sensitive searching method, or a more targeted search. The first two options represent a trade-off as use of a less sensitive but cheaper method would allow more searching and thus achieve a higher overall sensitivity. Unfortunately we could not assess this trade-off with the available rookery location data, but we did use these data to map the predicted distribution of rookeries across a landscape. The use of this map to plan future surveys would enable optimal allocation of search effort.
- The overall aim of the rook management programme (control or eradication) will dictate what metric to measure progress against and thus the data collection required. For example, if identifying the most cost effective search method is the aim then councils would need to collect data on the number of new rookeries detected for each dollar spent on search effort, perhaps using some sort of mark–recapture framework. If the aim is eradication and there is a need to validate eradication, then some measure of search efficiency is required to quantify the overall searching sensitivity. If the aim is sustained control to suppress rook populations and councils need to track the distribution and abundance of rookeries over time, then a probabilistic sampling scheme is required.

Recommendations

- To improve surveillance methods for detecting rookeries we recommend councils should:
    - Record spatial coverage and area searched when conducting rookery searches – this could be done, for example, using grid coordinates, roads travelled, helicopter GPS tracks.
    - Redo the regression model analysis using true rather than pseudo-absence locations then use this model to predict rookery locations in another region and assess its performance. If the model has a high predictive value, it could then be used for targeting search effort or designing a probabilistic sampling survey.
    - Specify desired metrics to measure progress towards rook management objectives (control versus eradication) and then design appropriate protocols for operational data collection to measure these metrics.

1 Introduction

Horizons Regional Council (HRC) is optimising its control strategy for invasive rooks (*Corvus frugilegus*) and sought advice from Landcare Research (Envirolink Project HZLC84) on how to improve detection of rookeries.

2 Background

Current management of rooks in New Zealand relies largely on identification and lethal control of rookeries, using toxic (DRC-1339) gel applied to nests (NPCA 2006). To prevent further population increase or to eradicate rook populations, the number of rookeries removed must be equal to or greater than the number of new rookeries establishing each year. Obviously, location of rookery sites is pivotal to such an approach but the discovery of a few large rookeries each year (Martyn & Dodd 2011) suggests a proportion of active rookeries are undetected from one year to the next, thus confounding control measures. To address these concerns, the current study aims to: (1) assess the effectiveness of current detection methods for rookeries and (2) provide advice on how detection could be improved.

Assessing or comparing methods for detecting rooks depends on quantifying the sampling sensitivity, which is the probability of detecting a rookery given it is present in the area sampled. Statistical methods available to estimate the probability of detection include occupancy modelling, which uses repeated visits to sites and the resulting detection histories to estimate the probability of detection (MacKenzie et al. 2006); catch per unit of effort (CPUE) methods, which use data from successive removals/catches to fit a relationship between catch (detection) and some measure of effort such as the number of traps set out (Seber 1982); and classical search theory, which predicts the overall probability of detection given information about coverage or the area effectively searched, which is derived from the distance traversed and the (known) effective search width of the searcher (Cacho et al. 2006).

When it became apparent that most of the data collected by regional councils would not be suitable for assessing probabilities of detection, a method of analysis was identified that enabled use of the data collected frequently, namely the coordinates of rookery locations. Search theory predicts that if the search target is unevenly distributed across the landscape then concentrating your search in the areas where the target is most likely to be present will increase the overall probability of detection (Koopman 1980). Therefore understanding and predicting where rookeries are most likely to be across a landscape will aid optimisation of a search strategy.

For this project we assessed whether the data collected by five regional councils doing rook control were amenable to statistical analysis to derive estimates of the probability of detection for comparison among methods. Then, using the Hawke’s Bay as a case study, we identified landscape-scale predictors of rookery locations.

3 Objectives

- Review current surveillance methods for locating rookeries.
- Suggest options for improving these methods.

4 Methods

4.1 Estimating the probability of detecting a rookery

Pest managers at five regional councils (Horizons, Hawke's Bay, Greater Wellington, Waikato and Bay of Plenty) were emailed a list of questions regarding the rook data they collected. The survey included questions about data the councils had on rookery locations, how it was collected and stored, and if data on searching effort was recorded (see Appendix 1 for the full list of questions). We assessed the characteristics of the rook data collected by regional councils against criteria that, if met, would enable statistical analysis and thus quantitative estimation of the probability of detecting a rookery. These criteria were:

- Repeated surveys of the same sampling units/sites (occupancy and CPUE models)
- The population can be assumed not to change (e.g. from breeding, emigration or immigation) during the time taken to complete each survey (occupancy and CPUE models)
- Measurement of some unit of effort (e.g. distance travelled, time spent searching, area covered, dollars spent) associated with success or failure in detection (CPUE and search theory models)
- Probabilistic selection of sampling units/sites (occupancy models)
- Number of data are greater than the number of model parameters to be estimated (all models)

4.2 Landscape predictors of rookery locations

For this part of the project we used the rookery location data provided by Hawke's Bay Regional Council. The data were 10 years (2002–2011) of rookery locations comprising geographic coordinates of the rookery, the year it was first recorded, if the rookery was active (had evidence of breeding occuring) in a particular year, and if the rookery was controlled that year. Before 2006 the region was split into two zones for management purposes, a control zone and an eradication zone, but the data from both zones were combined here. Rookery locations (*x*,*y* coordinates) were converted to a points layer in a GIS (ArcMap version 10.0). First, the density of rookeries across the region was plotted and compared to that expected if rookeries were uniformly distributed, using a Kolmogorov–Smirnov test from the 'spatstat' package in R (version 2.14.2; R Development Core Team 2012). As this test indicated rookery density was not uniform, we then sought landscape variables that might explain this distribution. These potential predictor variables and their sources are listed in Table 1. The landscape predictor layers were overlain with the rookery locations, using ArcMap software, and values for each predictor at each rookery location were extracted usingthe inbuilt ArcMap tools or tools in the Geospatial Modelling Environment (GME, version 0.6.0.0; Beyer 2012).

Table 1 List of variables and their sources for predicting rookery locations

Variable name	Source	Summary value	Transformation used for analysis
Altitude (m)	http://koordinates.com/layer/3737-10-napier-15m-dem-nzsosdem-v10/	Point value	Mean-centred
LENZ[#] annual soil water deficit (mm)	http://lris.scinfo.org.nz/layer/97-lenz-annual-water-deficit/	Mean value of 3-km-radius circle around point	Mean-centred
LENZ[#] mean annual temperature (°C)	http://lris.scinfo.org.nz/layer/94-lenz-mean-annual-temperature/	Mean value of 3-km-radius circle around point	Mean-centred
Land cover/use classification	http://koordinates.com/layer/1072-land-cover-database-version-2-lcdb2/	Percentage of area covered by each class in 3-km-radius circle around point	Arcsin
LENZ[#] soil particle classification	http://lris.scinfo.org.nz/layer/82-lenz-soil-particle-size/	Percentage of area covered by each soil type in 3-km-radius circle around point	Arcsin
Distance to closest shelterbelt (m)	http://koordinates.com/layer/1010-land-cover-database-version-2-shelter-belts/ http://koordinates.com/layer/1072-land-cover-database-version-2-lcdb2/	Distance from point to feature	Mean-centred
Distance to source of fresh water (m)	http://koordinates.com/layer/1072-land-cover-database-version-2-lcdb2/	Distance from point to feature	Mean-centred
Distance to nearest neighbouring rookery (m)*	20101216 Rooks Eradication Zone 2011-2012.xls 20101216 Rooks Control Zone 2011-2012.xls	Distance from point to point	Mean-centred
Number of neighbouring rookeries*	20101216 Rooks Eradication Zone 2011-2012.xls 20101216 Rooks Control Zone 2011-2012.xls	Number of rookeries within 3-km-radius circle around point	None

*Neighbouring rookeries were only measured or counted if present and active in the year before the focal rookery was first recorded.

[#]LENZ: Land Environments of New Zealand classification.

In order to make inference using a logistic-regression approach on what explains the presence of rookeries we also needed information on where rookeries were absent. Because these data were not available we generated randomly-located ‘pseudo-absence’ points across the landscape using the ‘genrandompnts’ function in GME. Because we observed that most rookeries were located near a road (80% within 300 m, 99% within 1500 m) the pseudo-absences were also generated close to roads, using distance to road to determine the probability of a random point being generated at that location. This approach was taken instead of using distance to road as a predictor of rookery location as we considered the closeness of rookeries to roads was more likely to be a result of increased visibility/ detectability along roads rather than a preference of rooks to locate their nests near roads. Alternatively this association with roads could be simply an artefact of the high road coverage across the region. In either case, locating the pseudo-absences at similar distances from roads as the true locations removes the influence of roads in the final analysis. Landscape predictors for the pseudo-absence points were derived in the same way as for the point locations of actual rookeries.The rookery presence and absence data were regressed against the landscape predictor variables listed in Table 1, using the lme4 package in ‘R’ with a binomial error structure. The year the rookery was first recorded was included as a random effect since often the area searched varied with year. Predictor variables that were highly correlated with each other were removed from the model and the best performing model was chosen using Akaike’s Information Criterion (AIC). The model residuals were examined to identify any model mis-specification, and a variogram was produced of the residuals in relation to distance between locations. The area under the Receiver Operating Curve (ROC) was calculated to assess the predictive capability of the best model. Predictions from the best model were calculated across the region at a 15-m-pixel resolution, using the ArcMap raster calculator, and the resulting probabilities of rookery presence were plotted.

5 Results

5.1 Estimating the probability of detecting a rookery

The data collected by the regional councils could not be used to estimate the relationship between probability of detection and effort expended since the discovery of a rookery could usually not be unequivocally assigned to some measure of effort. For example, many rookery detections were opportunistic, i.e. reported by members of the public or spotted by council staff while out on other jobs. Where helicopters were employed for survey purposes, this was often secondary to the main use of the helicopter, which was to access known nests for toxin application. In such operations, rookery searches were made en-route to or around the location of the known rookery, if time permitted.

Occupancy models require repeated visits to sampling sites within a season to determine the probability of detection but only a few councils made more than one visit to a site in a year and these repeat visits were usually to sites previously identified as being occupied rather than revisiting all sites visited on the first search. This meant there was no information on non-detections, which is required to fit the detection function. Likewise, catch-effort models rely on repeated visits, and also removals of individuals from a site, to estimate the detection function, so this approach could not be used either.

Search-theory models require some estimate of coverage to estimate the probability of detection. To apply this approach the components of coverage can be estimated separately, such as distance travelled, the effective search radius and the type of search path (e.g. random or parallel paths). This approach could probably be applied to the helicopter search for rookeries if some measure of the effective search width of an observer in a helicopter was made. Estimating coverage would also have the advantage of identifying areas that were searched but did not appear to contain rookeries, i.e. ‘known absences’, which would be useful in understanding where rooks are located across the landscape for using the logistic regression approach described in Section 4.2.

We could not compare the relative effectiveness of the different search methods (public and council staff awareness, ground searching, helicopter searching) for detecting rookeries because we could not reliably ascribe the cause of a rookery being detected to one method and thus associate it with some measure of effort, let alone make a quantitative assessment of the sensitivity of each method.

5.2 Landscape predictors of rookery locations

Rookery locations in Hawke’s Bay during 2002–2011 were distributed unevenly across the landscape with a significant South to North trend of decreasing rookery density (KS test: D = 0.2859, $p < 0.001$). The best performing logistic regression model to explain rookery presence included: significant negative effects of altitude, soil water deficit and distance to the nearest shelterbelt; a significant positive effect of percent cover in improved grassland; a significant negative effect of percent cover in short-rotation crops. Including a random effect for year the rookery was first recorded improved the model fit (ΔAIC = 39.6), suggesting that the baseline probability of rookery presence varies between years for some unknown reason, possibly due to the cumulative effects of control since more recent years (2009–2011) had a negative effect on the baseline probability of rookery presence whereas those pre-2009 (with the exception of 2005) had a positive effect. Mean annual temperature was highly negatively correlated with altitude so including just one of these variables in the model was sufficient. Including distance to water bodies or distance to nearest neighbours or the number of neighbouring rookeries did not improve model fit. The fitted model had an area under the ROC curve of $A' = 0.78$ indicating reasonable predictive ability (where $A' = 0.5$ is random guessing and $A' = 1.0$ is perfect predictability). The model captured the South to North gradient in rookery locations across the Hawke’s Bay region (Figure 1). The highest model residuals (i.e. the worst predictions) were predictions of a low probability of rookery occurrence in the urban areas of Napier and Hastings and the orchards surrounding Hastings when, in fact, a few rookeries have been found in these locations.

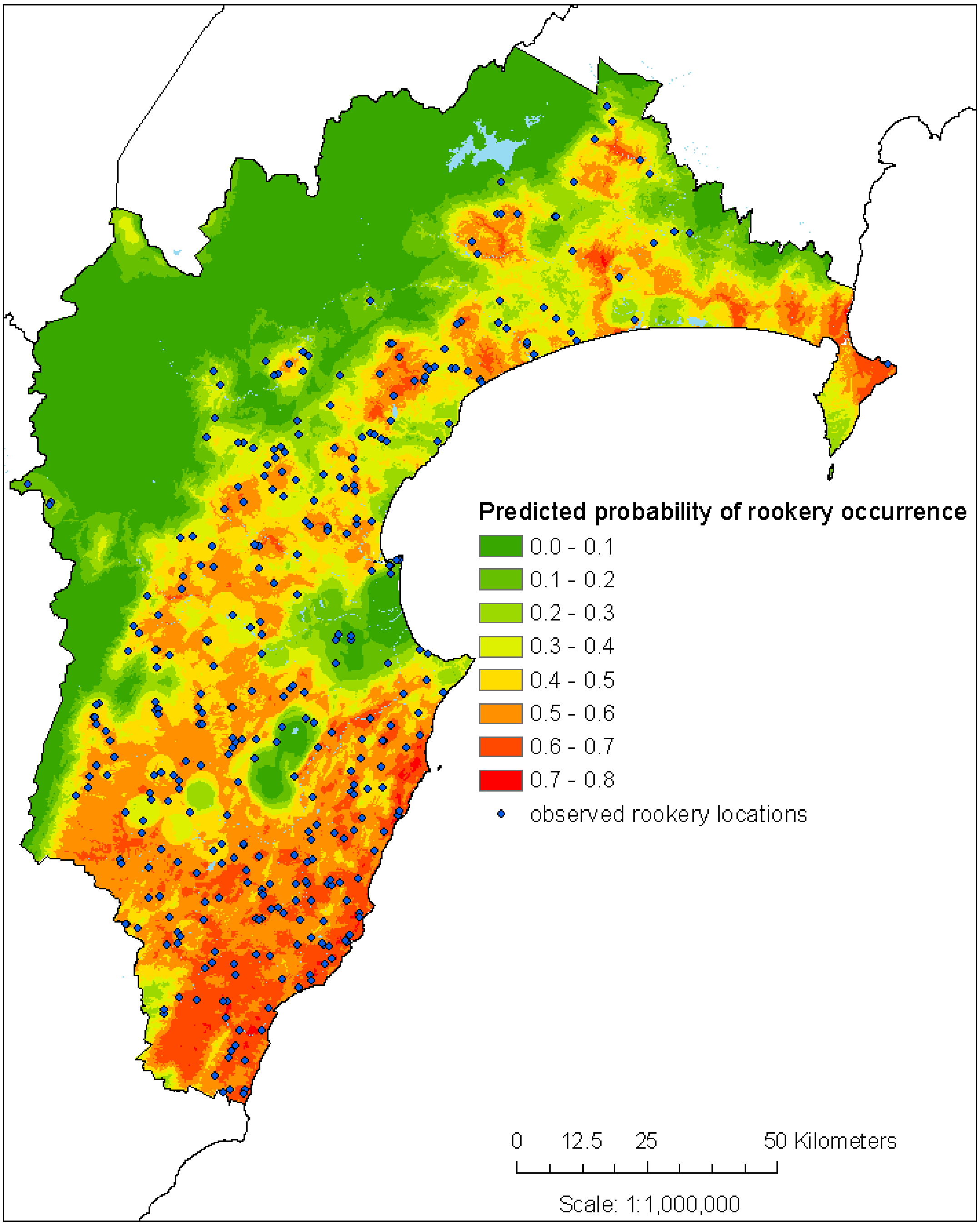

Figure 1 Predicted probability of rookery occurrence across the Hawke's Bay Region based on a logistic regression model with percentage land cover, altitude, soil water deficits and distance to the nearest shelterbelt.

6 Conclusions

We were unable to make any inference about the sensitivity of rook detection methods using the available data, primarily because units of search effort could not be unequivocally associated with detection of a rookery. Helicopter searches alone could be amenable to quantitative analysis if search coverage and the effective search width were measured. Coverage could be measured by GPS tracking of helicopter flight paths and search efficacy could be measured by using independent double observers or by flying observers over an area where the actual number of rookeries was known to determine how many are found and at what maximum distance from the helicopter they are sighted. Quantification of search sensitivity is of little use for the current primary objective of detecting each and every rookery (or for comparing between detection methods) but if the ultimate goal is regional eradication of rooks it is necessary to have some estimate of sensitivity to assess progress towards that goal. This is because as rook numbers are reduced more searches will be negative (i.e. they will not detect a rookery). To be able to say whether these negative outcomes are due to rooks being eradicated ('true negatives') rather than just due to non-detections of remaining rookeries ('false negatives'), the search sensitivity needs to be known, i.e. the probability of detecting a rookery given it is present and given a certain level of search effort.

Due to the problems in assessing sensitivity we focused instead on optimal allocation of search effort by deriving landscape predictors of rookery presence for the Hawke's Bay Region. This same approach could be applied to all regions with rooks. The next step would be to make predictions for a different region and evaluate the model's performance using known presence and absence locations. The presence of tall trees for the rooks to roost in is a prerequisite for a rookery site. Although individual trees could not be identified directly from the land cover maps this could explain the positive effect of close proximity to shelterbelts on rookery presence. In terms of other factors shown to be linked with rookery distribution, the positive effect of improved grasslands on rookery presence was unsurprising given rooks obtain much of their food from pasture and a positive effect of pasture on rookery presence and rookery size has also been found in several studies in the UK (Gimona & Brewer 2006; Griffin & Thomas 2000; Mason & MacDonald 2004). The negative effect of short-rotation cropland was unexpected given rooks' reported fondness for cereal and pea crops (NPCA 2006) although these foraging opportunities are likely to be ephemeral, varying with the life cycle of the crop, whereas grassland is a more permanent and reliable source of food (Mason & MacDonald 2004). The location of rookeries might have more to do with the management of different land-types rather than the foraging opportunities per se; e.g. mixed cropping farmers might be more proactive in controlling pest birds than dry stock farmers. Also the analysis assumed static conditions, i.e. that rooks have had opportunity to spread to all suitable areas of the Hawke's Bay, and that the land cover maps used (LCDB2) reflect land cover at the time the nests were established. The distribution and size of rookeries in the Hawke's Bay has changed over time, however, largely driven by ongoing population control (Porter et al. 2008), so current rookery locations may reflect not just habitat preference but also the intensity of control. In particular, the South-to-North gradient observed may be a result of the pre-2006 focus on eradication in the northern part of the region. Perhaps the biggest flaw with this analysis was that locations where rookeries were absent were not known so we had to generate and use pseudo-absences. This could be easily remedied by staff noting which areas, perhaps grid cells, had been searched but where no rookeries were found, in order to distinguish such areas from those that had simply not been searched.

Rather than asking what sort of analysis can be done with the current rook data, councils should decide what metrics to use with respect to the overall aim of the rook management programme (control or eradication) and collect the right data to estimate that metric. For example, if identifying the most cost effective search method is the aim then councils would need to collect data on the number of new rookeries detected for each dollar spent on search effort, perhaps using some sort of mark–recapture framework where the number of re-reportings of rookeries is analogous to the recapture rate. If the aim is eradication and there is a need to identify searching sensitivity to be able to validate eradication, then some measure of search efficiency is required, as discussed above for helicopter searching. If the aim is sustained control to suppress rook populations and councils need to track the distribution and abundance of rookeries over time, then a probabilistic sampling scheme is required using some form of adaptive, unequal probability sampling whereby sampling is concentrated in areas where rookeries are most likely to be found. This will be similar to what council staff or contractors already do intuitively but, by deciding the rules for whether an area is included in the sample or not before sampling is undertaken (probabilistic design), valid statistical inference can be made. Generalised Random Tessellation Stratified (GRTS) survey design is one way of creating a spatially balanced survey design (e.g. Milne & Williams 2008) that could be useful for rookery surveys. This type of design is already in use by the Southland Regional Council for weed monitoring and is also being considered for a rabbit monitoring programme in Southland (Warburton & Williams 2012). The area to be sampled can be stratified according to likelihood of rookery occurrence, allowing more sampling effort in areas with a higher probability of occurrence. In all of these examples, identifying spatial coverage of the region of interest and thus areas where rooks are known to be absent is key and is the most immediate recommendation we make.

In summary, improving detection of rookeries requires more searching (which is costly), a more sensitive searching method, or a more targeted search. The first two options represent a trade-off as use a less sensitive but cheaper method would allow more searching and thus achieve a higher overall sensitivity. Unfortunately we could not assess this trade-off with the rookery location data provided but we did use these data to map the predicted distribution of rookeries across a landscape. The use of this map to plan future surveys would enable optimal allocation of search effort.

7 Recommendations

To improve surveillance methods for detecting rookeries we recommend councils should:

- Record spatial coverage and area searched when conducting rookery searches – this could be done, for example, using grid coordinates, roads travelled, helicopter GPS tracks.
- Redo the regression model analysis using true rather than pseudo-absence locations then use this model to predict rookery locations in another region and assess its performance. If the model has a high predictive value, it could then be used for targeting search effort or designing a probabilistic sampling survey.
- Specify desired metrics to measure progress towards rook management objectives (control versus eradication) and then design appropriate protocols for operational data collection to measure these metrics.

8 Acknowledgements

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Appendix 1 – Rook data survey

1. What information do you have about rook distribution and numbers in your region?
2. How is that information collected (e.g. aerial surveys, staff searches, notifications from the public, farmers)?
3. Do you have data about searching effort (e.g. amount of time spent searching, helicopter time, staff time)?
4. How is that information stored (e.g. Excel spreadsheets)?
5. How many years' data do you have?
6. Did survey methodology change at any time – if so how and when?

Rookery in spring