COAT CASE STORY

COAT has developed a foodweb-based forecasting model for improved management of willow ptarmigan

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Long-term monitoring represents a baseline approach for climate-ecological studies. Analyses and modeling of such monitoring data provide opportunities to generate explanatory predictions, used to test ecological theories, but also anticipatory predictions, suited to inform future management and policy decisions.

To improve understanding of the consequences of current rapid environmental change and how to manage it, ecologists have advocated using long-term monitoring data to generate iterative near-term forecasts. This approach allows scientific evidence to increase rapidly and management strategies to be tailored simultaneously. Iterative near-term forecasting may therefore be particularly useful for adaptive management of species and ecosystems subjected to rapid climate change.

Stakeholder involvement

COAT has developed a statistical model for the willow ptarmigan in Finnmark, which is the largest management area for this important small game species in Norway. The model development has been the result of a collaboration between COAT researchers and several stakeholders, including the landowner Finnmarkseiendommen (FeFo). We employed a Strategic Foresight Protocol (SFP) involving stakeholders to decide the purpose and structure of a dynamic state-space model of ptarmigan population dynamics. Based on local knowledge of stakeholders, it was decided that the model should include foodweb interactions and climatic drivers to provide explanatory predictions. However, several of the stakeholders also wanted the model to be used to generate anticipatory predictions (i.e. forecasts) of the ptarmigan populations a few months before the annual line-transect surveys, to be able to plan the year's hunting, quotas and management in advance. The data that feed into the model consist of ptarmigan

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Willow ptarmigan mating. Foto: Valeri Belov

Willow ptarmigan in a hunting situation. Foto: Alfred Ørjebu

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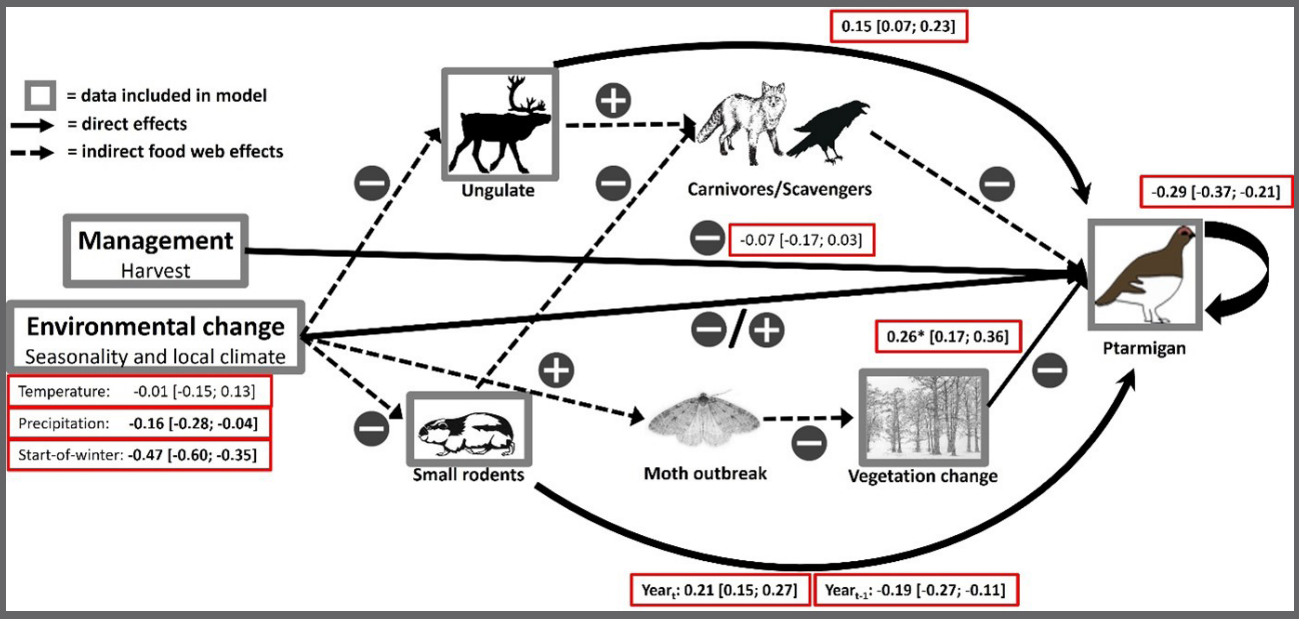

Figure 1. *A graphical presentation of the COAT food web mode. It shows the different drivers and their contribution to the population development of the willow ptarmigan populations in Finnmark during the last 22 years. In the red boxes, positive numbers indicate effects that have a positive effect on the density of the ptarmigan and negative numbers show effects that have a negative effect. The size of the numbers indicates the strength of the effect. *Note that the effect of moth outbreaks through vegetation changes is in reality a negative effect.*

Our statistical food web model, which is now based on 22 years of data, shows that the most important drivers of ptarmigan density in the autumn (Figure 1) are precipitation during the hatching period, start of the winter the autumn before (mismatch in plumage change), small rodent dynamics in summer and reindeer carcass availability in late winter (both are related to predation pressures on ptarmigan) as well as vegetation changes caused by the extensive moth outbreaks that have taken place in Finnmark during the last 10-15 years. The ptarmigan population appears to be only weakly affected by the temperature around hatching and hunting the year before.

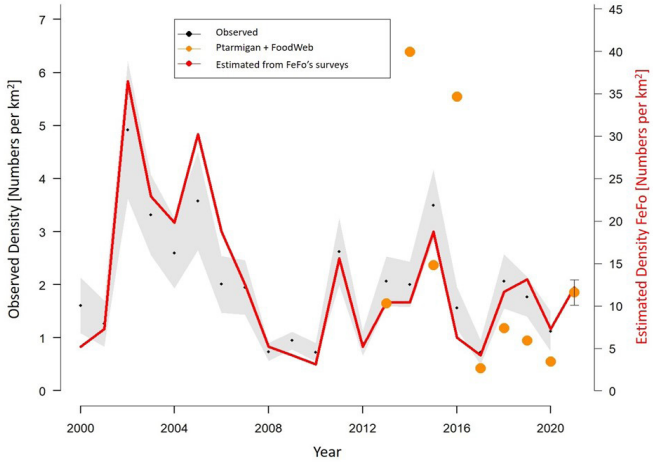

Figure 2: *Estimated density of the willow ptarmigan population in Finnmark in the period 2000 - 2020 (red line, estimates from Hønsefuglportalen) compared with the predictions from COAT's food web model in the last 9 years (orange dots). Hence, the last orange dot (i.e., for 2021) is our prediction for that year's average ptarmigan density on the Finnmark estate (FeFo), almost 2 months prior to the ptarmigan surveys in the end of august. Note that our model predicts the average observed number of ptarmigan per km2, while the assessment result (red line) is given as the estimated number of ptarmigan per km2 from a model that corrects for detectability (i.e., a distance model).*

population series from the last 22 years obtained from FeFo's and "Hønsefugl portalen's" line-transect surveys with pointing dogs in late August, meteorological data from MET and food web variables obtained from COAT's ecosystem-based monitoring.

Alternative models

To account for the potential different views of stakeholders, we developed three different models that differed in the set of environmental drivers thought to be most important in explaining the dynamics of willow ptarmigan. The three models consisted of one with only density dependence and harvest as drivers of ptarmigan dynamics, one with the addition of local climate drivers (i.e. climate) and one also including food web data (i.e. food web model). We used iterative short-time predictions to assess model fit and assess the best model for population forecast. We did this by fitting the models

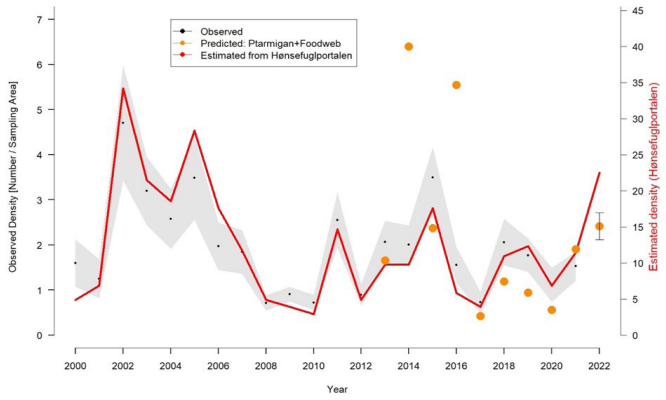

Figure 3: *Same as figure 2, but with one extra year of data for the model (2000-2021) and consequently a model forecast for 2022.*

to the first 10 years of data, then predicted the next year's density, updated the model with a new year of data and predicted the next year's density and so on. Predictions was iteratively compared to the observed densities and the estimates provided by "Hønsefuglportalen". These iterative near-time forecasts showed that the foodweb model performed better than the two simpler models that did not include COAT's monitoring data. Moreover, the forecasts become increasingly better with increasing length (i.e. years) of the monitoring series.

Model-based forecasts

In the last two years, we have for the first time used the models to perform forecasts of the current year's ptarmigan density in Finnmark, almost two months prior to the line transect surveys in late August. Thus, we have had to anxiously wait almost two months to be able to assess the quality and accuracy of our forecasts. In 2021, predictions (Figure 2) showed that we expected a slight increase in ptarmigan density. This was because it was a relatively normal start to the winter in the autumn of 2020, in addition to a hot and dry period in June/July when the chicks were newly hatched. In addition, a couple of years with low small rodent densities, as well as relatively few carcasses of reindeer in the winter of 2021, likely resulted in fewer predators in the system. It was therefore gratifying to see that our forecasts were spot on the survey estimates in 2021 (Figure 2), but also that the model prediction corresponds quite well overall, especially for the last 5-6 years.

In 2022, we predicted a further increase in the ptarmigan density in Finnmark. This was because it was a relatively normal start to the winter last autumn in addition to a quite hot period in July, when the chicks were newly hatched and a late winter with slightly more carcasses than normal. In addition, an increase in small rodent densities (increase phase) has likely resulted in reduced predation on ground breeding birds in the system. Gladly, we can see that we correctly predicted an increase in willow ptarmigan density (Figure 3), for the second year in a row. However, it appeared that our model forecasted a lower density than the actual survey results (see figure 3). However, the difference is not large. Also, the survey-based density estimates show quite large heterogeneity in space across Finnmark (FeFo home page).

State-of-the-art applied ecology

Both actively involving stakeholders in research and applying models for near-term iterative forecasting is currently considered state-of-the-art in applied ecology. However, there are still few cases of successful implications of this approach. For this reason, COAT's ptarmigan model was recently highlighted by means of a newsletter from the EU commission, distributed to more than twenty thousand subscribers (facsimile below). COAT's ambition is to build similar models for other COAT modules for which near-term forecasting is deemed useful by stakeholders in a rapidly warming Arctic. Such models are now under construction for the forest-tundra ecotone and the ungulate module.

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