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Introduction

Bewick's Swan, a Russian nesting endemic, is a species of conservation concern. Little is known about its migration through the Eurasian steppe.

During spring migration, environmental conditions are ephemeral, making distribution modeling challenging.



Fig 1 Bewick's Swan

Goal

To assess Bewick's Swan distributions during their spring migration in the Eurasian steppe and identify what affects their distributions.

Data and methods

Study area: Steppes of North Kazakhstan and southern Russia (outlined in red).



Analysis

GPS-data for 19 swans in the springs of 2019-2020

Landsat-8+Sentinel-2+MODIS from 2018-2020

Sampling design

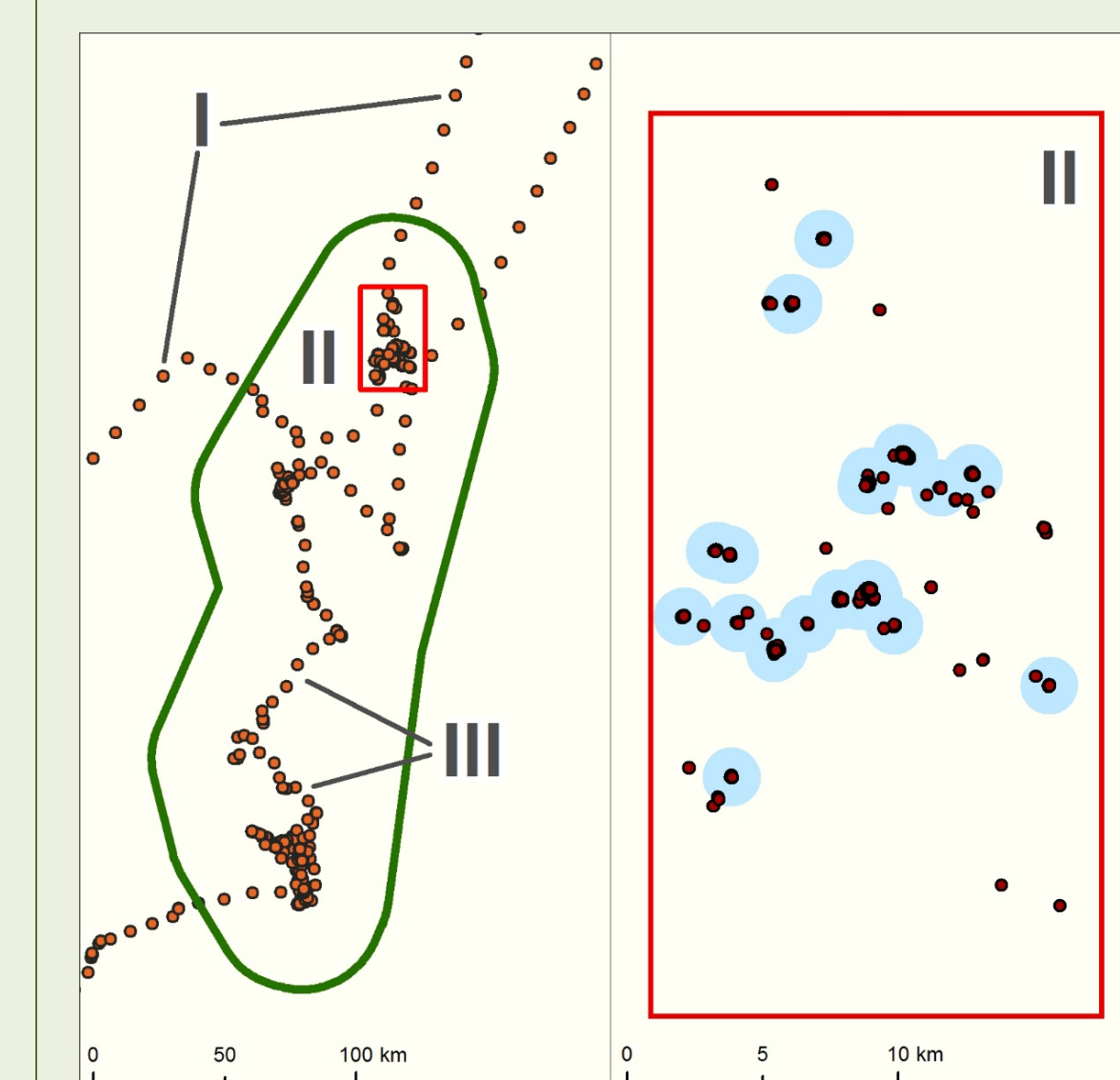


Fig 2 I: long migration paths, II: roost and feeding sites, III: short migration paths. Area for background sampling outlined in green, area for presence sampling shaded in blue

We harmonized multi-year satellite images, within 3 weeks after snow melt according to MODIS snow cover product, to adjust for phenological differences among years and across the study area

Environmental variables:

- Land cover map (water, agriculture, grasslands, forest)
- Area of water bodies
- Distance to nearest water
- Indices: NDVI, SAVI, NBR, NDMI
- Elevation
- Weekly snow cover (MODIS).

Species Distribution Modeling (Maxent)

Context : Land cover map

By analyzing satellite images relative to snow melt date, we were able to map a specific landscape feature—flooded fields and grasslands (fig 3) that start to appear before snow/ice melts, but dry up within 3-5 weeks.

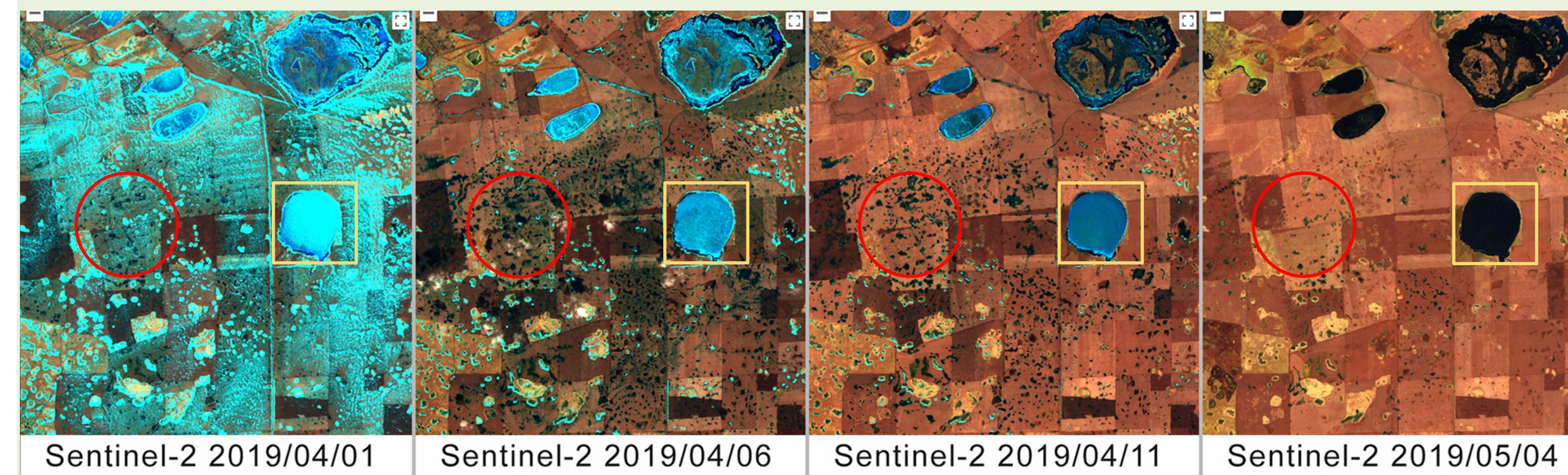


Fig 3 Changes in open water in the steppe during spring. RGB: SWIR 1, NIR, Red bands. Red circle – flooded fields, yellow square - permanent lake. Bright blue color indicates snow/ice, black color indicates open water.

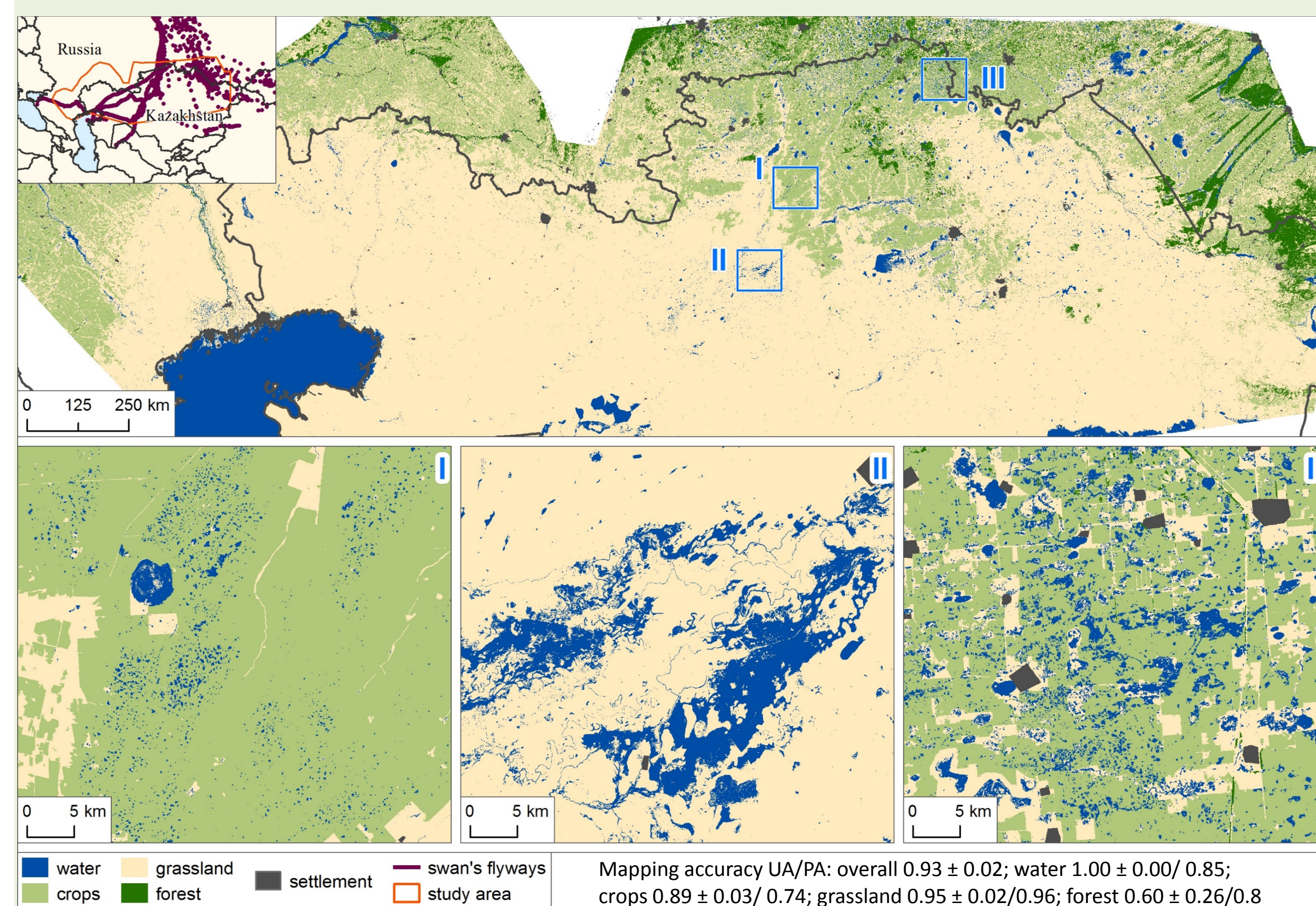


Fig 4 Land and water cover in spring. Inset shows study area and swan migratory paths

Results: Species Distribution Model

The most important variables accounting for 72% of the model's predictive power were distance to nearest water and water area (fig. 5). The land cover map itself had lower importance; but was essential to map water.

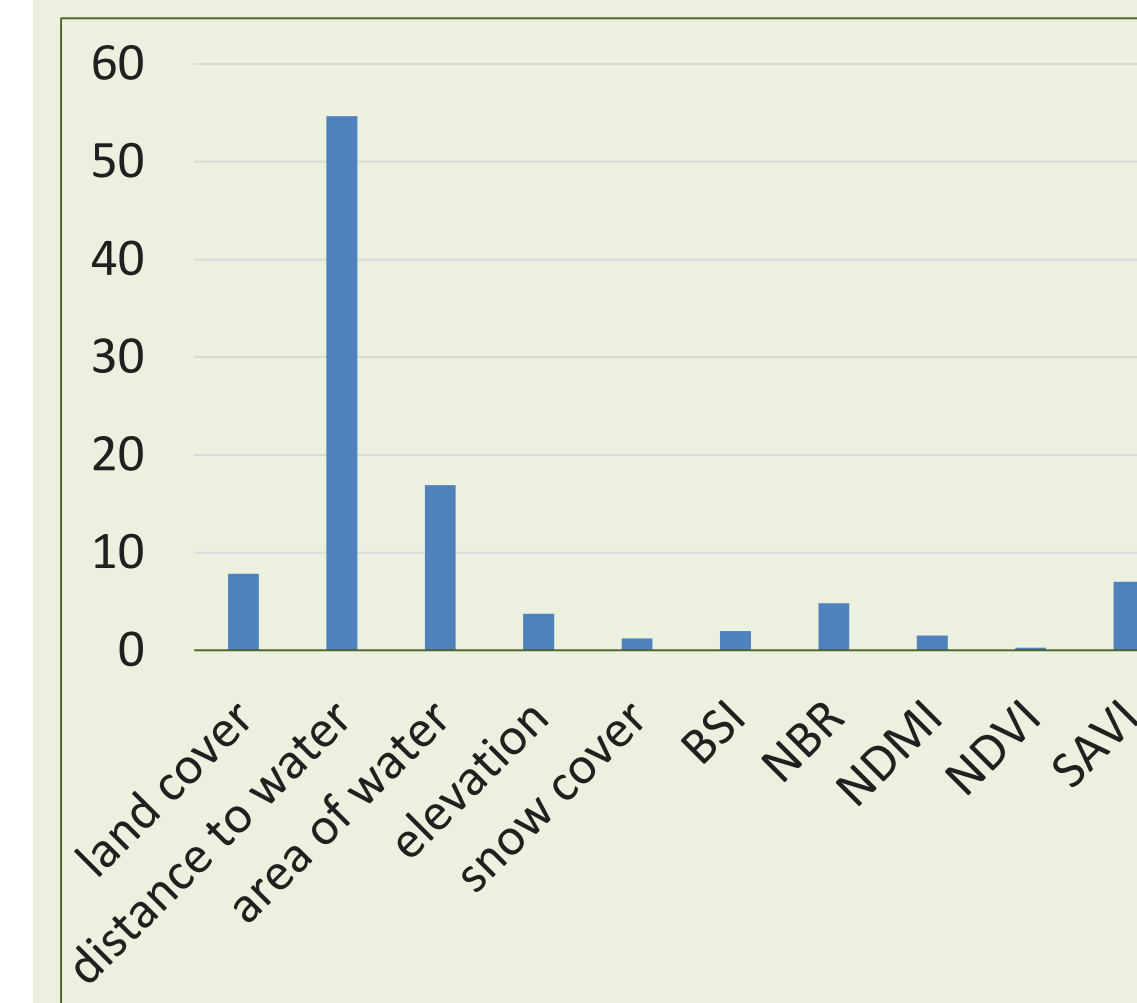


Fig 5 Variable contributions in the SDM.

Among the indices, SAVI was the most important and performed better than NDVI, most likely because it is optimized for sparse vegetation.

Area of water bodies was negatively related, and that is likely due to the speed of ice melt (smaller lakes melt faster), so that area is a proxy for available water.

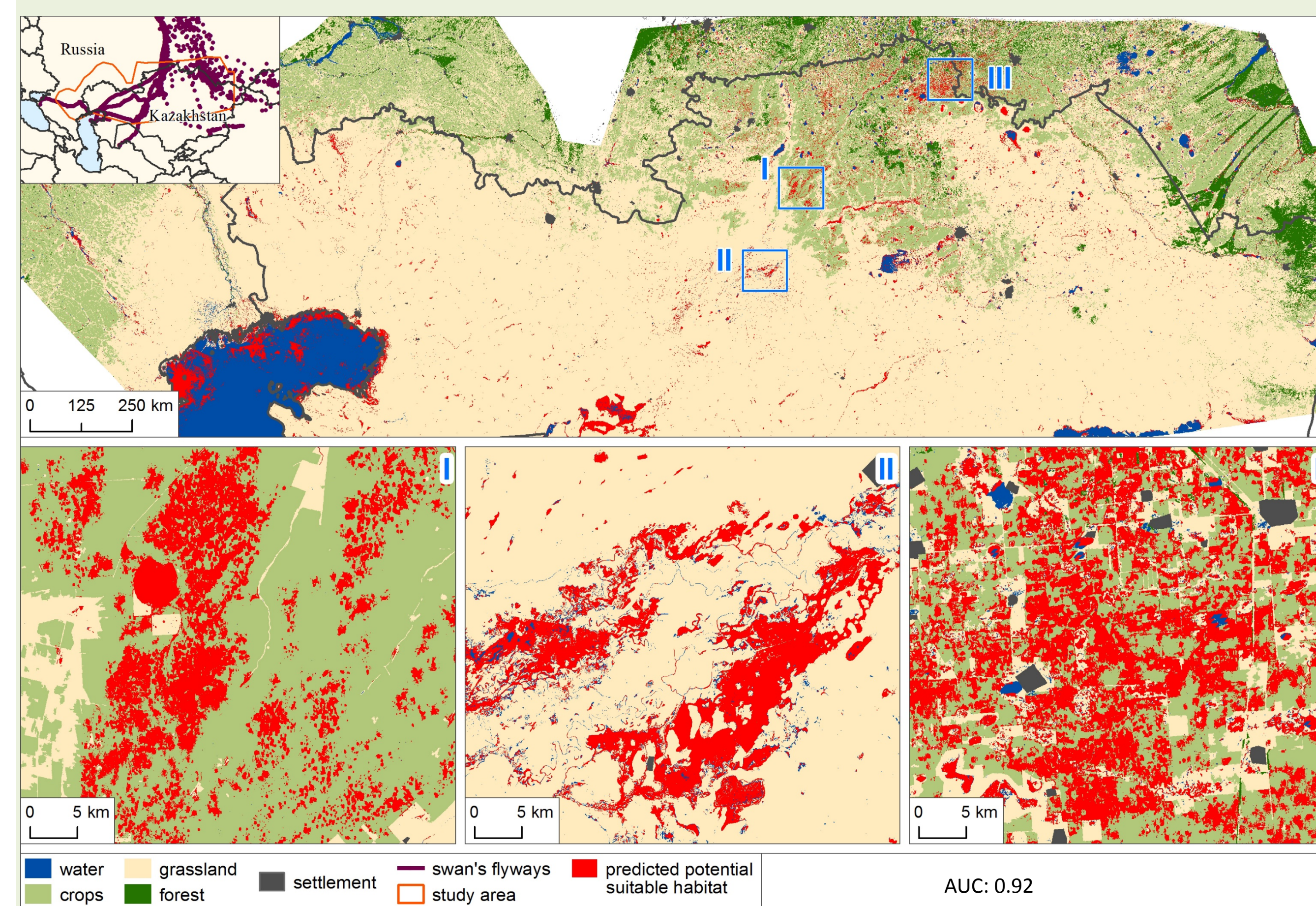


Fig 6 Predicted potential suitable spring migration habitat for Bewick's Swan.

Discussion and conclusions

We mapped potential distribution of Bewick's Swan during spring migration across the Eurasian steppe and identified what affected the distribution.

Flooded fields and grasslands are an essential resource for migratory swans:

- Found within crops and grasslands, they provide both refuge and food concomitantly, so swans do not need to move from roost to feeding sites.
- They are available 10-15 days before ice-out on lakes allows birds to migrate earlier, and potentially reach breeding grounds earlier.

Grasslands or mixed cropland-grassland landscapes seem to accumulate more water than pure row-crop areas, thus keeping at least some steppe patches within agriculture is beneficial for both migratory waterfowl, and agricultural productivity.

Our map of potential distribution of Bewick's swan is important for conservation efforts such as the creation of protected areas in natural landscapes and establishing hunting-free zones in agricultural lands, because different landscapes require varying conservation approaches.

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