# MODIS NDVI for tracking Barnacle goose spring migration

Satellite data has become a potential tool for ecologists and conservation biologists to investigate vegetation productivity and phenology. In this study, satellite-derived green wave index (GWI) which is the normalized MODIS NDVI trajectory is used to study migratory avian herbivores movements.

A total of 12 female barnacle geese were equipped with 30g solar GPS/ARGOS transmitters, and tracked from their overwintering sites in the Netherlands to their breeding sites at the Arctic coast of Russia from 2008 to 2010 (Figure 1). The MODIS 16-day composite NDVI dataset (MOD13A2) with 1-km spatial resolution (Beck et al., 2008) was used to calculate the GWI in this study:

$GWI_t=(NDVI_t-NDVI_{min})/(NDV_{max}-NDVI_{min})*100$

*(Beck et al., 2008; White et al., 1997).*

Two approaches were used to test if barnacle geese 'surf' along the green wave: visualization and statistical method.

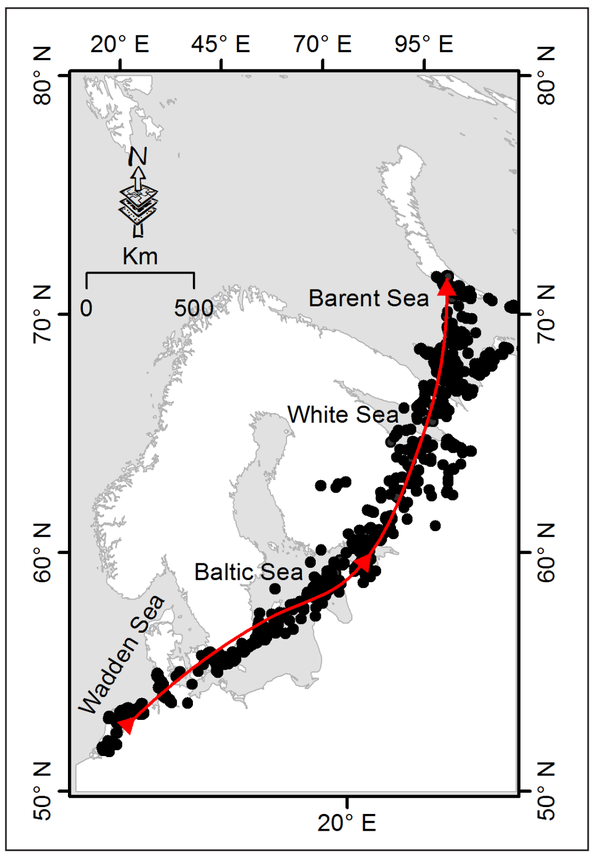


Figure 1. Spring migration route and the GPS locations of 12 barnacle geese.

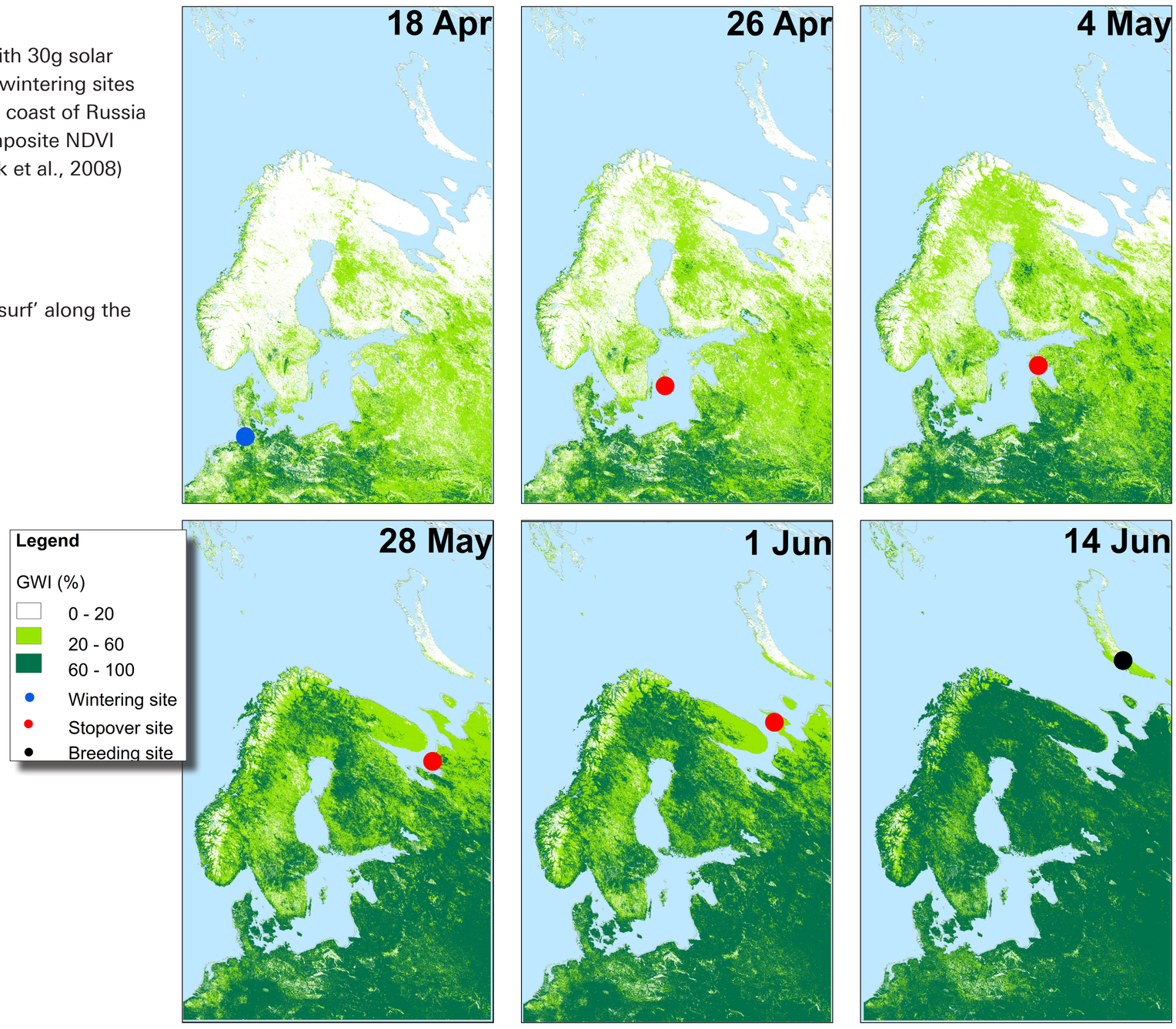


Figure 2. The northward movement of one individual barnacle goose in relation to the "green wave".

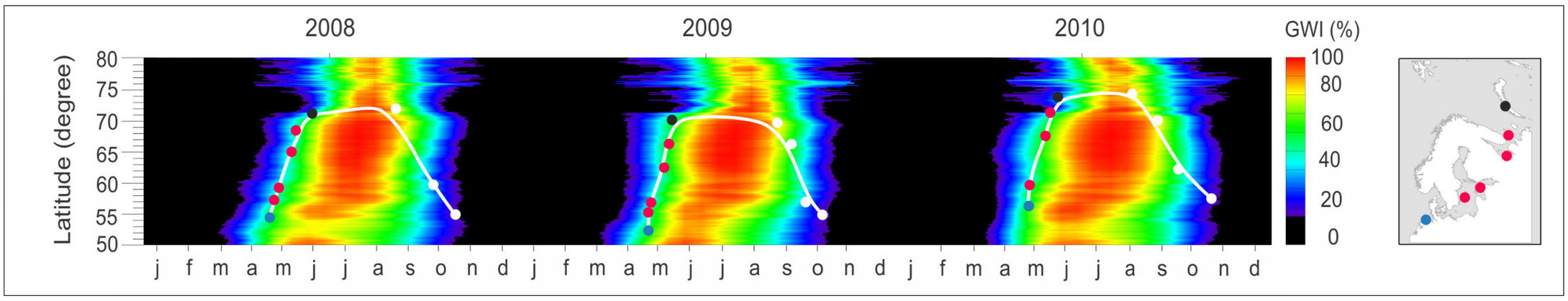


Figure 3. The GWI summary plots showing plant phenology over three years (2008-2010). The site locations include breeding, overwintering, and stopover sites which have been shown with black, blue, and red dots respectively.

The northward migration of barnacle geese correlated well with plant phenology (Figure 2). For a one-month period (late-April to late-May), the geese migrated to higher latitudes following a mid-range of GWI values (GWI 40-60%). However, in 2010, the geese tracked the higher range of GWI (60–80%) during their northward migration (Figure 3). Furthermore, A significant relationship was found between the arrival date at stopover sites and the date of 50% GWI, i.e. the supposed date of peak nitrogen concentration (Doiron et al., 2013), at that specific stopover ($R^2$=0.73, $p$<0.001, n=22) (Figure 4).

Using satellite-derived GWI (the normalized MODIS NDVI), this study has shown how strongly the spring migration of barnacle geese is correlated to the "green wave" of vegetation phenology.

The results also indicated that that the arrival time of the GPS-tracked barnacle geese at their stopover sites during spring migration over a three-year period coincided well with a specific range of GWI, which is referred to as the "green wave". The GWI values selected at the habitat scale indicate that barnacle geese select areas with an intermediate range of plant productivity, thereby making a trade-off between forage quality and quantity.

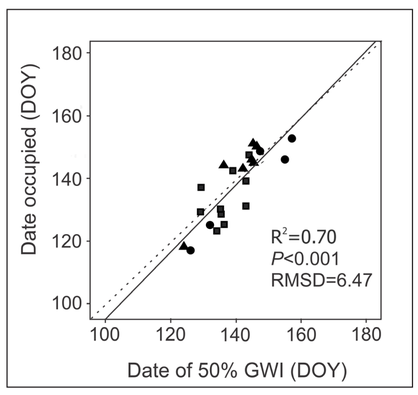


Figure 4. The relationship between date of 50% GWI and arrival date at stopover sites. Different years are shown with different symbols: 2008 circle, 2009 triangle, and 2010 square. The solid line shows the OLS regression line, while the dotted line is the 1:1 line. GWI = green wave index, DOY = day of the year from 1 January.


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**References**

Beck PSA, Wang TJ, Skidmore AK,Liu XH (2008) Displaying remotely sensed vegetation dynamics along natural gradients for ecological studies. International Journal of Remote Sensing 29: 4277-4283.

Doiron M, Legagneux P, Gauthier G,Levesque E (2013) Broad-scale satellite Normalized Difference Vegetation Index data predict plant biomass and peak date of nitrogen concentration in Arctic tundra vegetation. Applied Vegetation Science 16: 343-351.

White MA, Thornton PE,Running SW (1997) A continental phenology model for monitoring vegetation responses to interannual climatic variability. Global Biogeochemical Cycles 11: 217-234.


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