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Habitat change and population decline in breeding wigeon *Anas penelope*

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Habitat change is recognized as one of the main drivers of population declines of species worldwide. In extreme cases, habitat loss and fragmentation may result in population extinctions. On the other hand, habitat suitability may decrease more gradually, in which case species responses may manifest by decreased demographic rates and population density. Boreal wetlands are important breeding habitats for waterfowl in Europe and elsewhere [1]. While loss of wetlands per se is a major threat to waterfowl in many parts of the world [2, 3], gradual degradation of different habitat types within wetlands may also have significant negative impacts on populations. To assess the importance of such habitat changes to waterfowl and to predict their impact on population trajectories, we need a deeper understanding of habitat requirements of individual species and how habitat change affects their fitness.

Breeding numbers of Eurasian wigeon (*Anas penelope*) have declined dramatically in Finland since the early 1990s [4, 5]. In line with the alarming trends in Finland, the EU population status of wigeon has been assessed as vulnerable in 2015 [6]. We explored whether the recent population decline of Eurasian wigeon may be linked to long-term vegetation changes in their boreal breeding wetlands by using long-term data sets from six study regions in Finland and Sweden (gradient from Scania (55°N) to Lapland (66°N)). First, we assessed the importance of stands of the emergent water plants *Equisetum*, *Phragmites* and *Carex* in lake selection by pairs and in foraging habitat selection by broods. Second, in 2013-2014 we re-visited 58 lakes studied in 1990-1991, to examine if there had been any long-term change in the abundance of habitat types preferred by wigeon. Finally, using over 20 years long continuous data on breeding numbers of wigeon in 18 of the lakes studied in 1990-1991 (regions Häme and Karjala in Finland), we examined if wigeon numbers had changed at lakes where the habitat also had changed.

We found that, among the predictors considered, *Equisetum* was the best single predictor of lake occupation by wigeon (Table 1); lake occupation of nesting wigeon was positively associated with the extent of *Equisetum* stands. Similarly, *Equisetum* habitat was used more than expected by wigeon broods. When analysing the presence and abundance of this preferred habitat, we found a dramatic decline from 1990-1991 to 2013-2014 in the lakes from which the presence-absence data of wigeon emanate (Fig. 1). We also found a long-term declining trend of breeding numbers of wigeon in lakes where *Equisetum* has decreased. Our results imply that the recent population decline of wigeon in Europe may be linked to decreasing *Equisetum* habitat. However, it still remains to be resolved whether both declines reflect an overall degradation of the ecological conditions in aquatic ecosystems.

Figure 1: *Change in the extent of Equisetum habitat (length, m, of Equisetum-dominated shoreline) in 29 Finnish and Swedish lakes from 1990–1991 to 2013–2014. Lakes ranked according to extent of Equisetum habitat in 1990–1991. Figure according to Pöysä et al. 2016 in Hydrobiologia* [7].

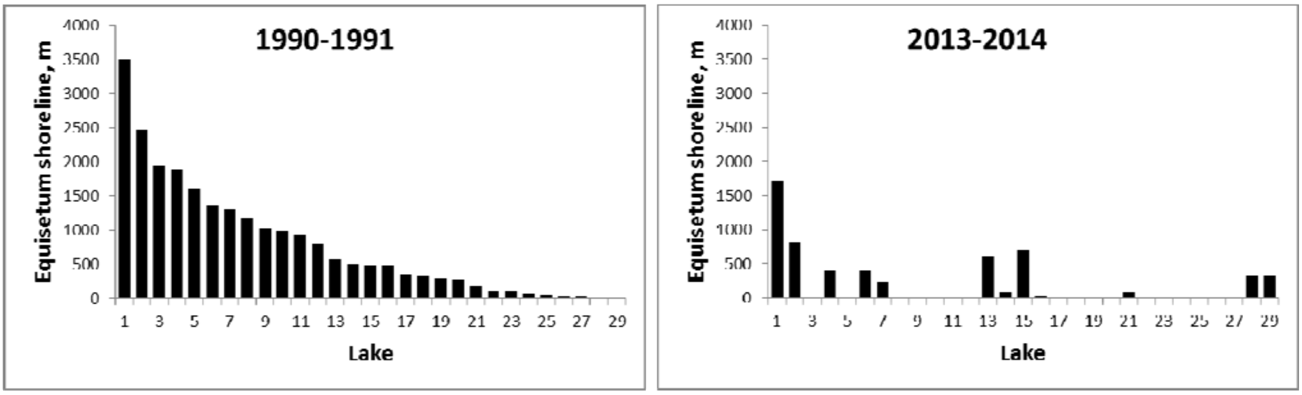

Table 1: *A priori candidate models estimating the probability of lake occupation by breeding wigeon. Table according to Pöysä et al. 2016 in Hydrobiologia* [7].

Model	AIC_c*	ΔAIC_{ci}†	w_i‡
1 *Equisetum* + Area	56.644	0	0.279
2 *Equisetum* + *Phragmites* + Area	57.205	0.561	0.211
3 *Equisetum*	57.635	0.991	0.170
4 *Equisetum* + *Phragmites*	58.693	2.049	0.100
5 *Equisetum* + *Carex* + Area	58.998	2.354	0.086
6 *Equisetum* + *Carex*	59.871	3.227	0.056
7 *Equisetum* + *Phragmites* + *Carex*	60.845	4.201	0.034
8 *Equisetum* + *Phragmites* + *Carex* + Area	61.049	4.405	0.031
9 *Phragmites* + Area	62.186	5.542	0.017
10 Area	63.902	7.258	0.007
11 *Phragmites* + *Carex* + Area	64.553	7.909	0.005
12 *Carex* + Area	65.891	9.247	0.003
13 *Phragmites*	68.115	11.471	0.001
14 *Carex*	69.920	13.276	0.000
15 *Phragmites* + *Carex*	70.406	13.762	0.000

*Second-order Akaike's information criterion.
†Difference between the current model and the minimum AICc.
‡Model weight.

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