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Further notes on the Estimation of Biodiversity and the Influence of Land use and Climate Warming on European Heath Bird Populations

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Abstract

The present commentary elaborates on the question whether interspecies and niche interactions and long-distance interactions between hibernating and breeding habitats are important for maintaining biodiversity in a changing world. The study focusses on the abundance trends of five bird species that are typical for heathland in North-Western Europe. The sympatric species Saxicola rubetra and Saxicola torquata, the Whinchat and the Stonechat respectively, receive special interest because of their very divergent conservation status and habitat preferences. An important result is that conservation practices (especially in natural reserves) should take more notice of the species-specific niche requirements and adopt the timing and precautionary requirements for biodiversity protection instead of promoting a few species at the cost of many others. In this study also an old hypothesis (formulated for tropical forest birds) is re-examined with respect the influences of seasonal migration and flexible versus stereotypical habitat selection on the long-term species survival potential, now applied to heath bird species.

Outline

Introduction: about an old question of tropical forest birds and seasonal migration

Biodiversity decline is a major issue in most environmental problems. It is also a controversial issue when regarded from the methodological viewpoint. The present paper elaborates on the question whether biodiversity estimation is basically a measurement of species abundance and diversity in one (or a few) given trophic level (s), also called a meta-community, or whether inter-trophic and niche-interactions, as well as long-distance interactions, following the effects of seasonal and other forms of migration, are equally important [1]. The former viewpoint was expressed in the well-known Unified Neutral Theory of Biodiversity and Biogeography [2]. In a previous study, we commented on this UNTB theory, based on the criticism that most support for the UNTB results from a so-called gate-keeping principle: in a nutshell, the principle states that within a given area and a specific trophic level, only a maximum of individuals can thrive and that as a result the net biodiversity over time remains constant or fluctuations remain 'neutral' [1,2]. However, the interactions between trophic levels and niche-defining characteristics point to a different paradigm [3]. Also long-distance interactions play an important role, in particular the effects of seasonal migration in birds [1].

In the present study, a case study is presented where indeed niche-defining characteristics and seasonal migration, as well as effects of climate change, may be at stake: we have chosen a number of European birds that have habitat preferences related to heath, wetlands and/or nutrient-poor grassland vegetation (species list in **2. Recent trends in Dutch bird populations: the European Nightjar and other heath birds**). The striking differences between some of these species regarding their long-term patterns of population change, has recalled an old hypothesis on the relation between bird habitat flexibility, seasonal migration and extinction risk, called **Louette's hypothesis** below [4].

In Louette's ornithological study, using a detailed analysis based on Lack's bird list, a striking discrepancy was found between 'tropical forest birds' and 'temperate forest birds'

[4,5]. Whereas the birds from (especially European) temperate forests are often found to be migratory species or species breeding in Africa (e.g. *Luscinia megarhynchos* [known as the Nigthingale], *Phoenicurus phoenicurus* [Redstart], T*ringa ochropus* [Green Sandpiper], etc.), the tropical forest birds in general are considered non-migratory [4]. Moreover, tropical forest birds were called stereotypical, meaning that they occurred in a rather limited range of possible habitats [4]. As a result, the tropical forest birds were considered more at risk for extinction due to all possible threats, climate-related or anthropogenic, to the tropical forest. However, Louette's hypothesis left out a great number of non-forest bound (European) species and also was rather rudimentary regarding the other types of vegetation (called non-forest altogether) [4]. Few studies, except for Bilcke (1984), have addressed the relation between non-forested vegetation structures and the residence of bird species, especially for other groups than the Passerines [6].

The biodiversity paradigm, has been considered one of the main and also most complex enigmas of the present state of the planet's biosphere [7,8]. A meta-analysis of multi-decadal biodiversity trends in Europe has shown an amalgam picture of the effect of changing land use and climate change upon the major biodiversity indices in the European continent [9]. For instance, these effects include decreased abundance of terrestrial invertebrates, an increased richness of birds and marine invertebrates, decreased diversity in benthic algae, but increased diversity in birds and aquatic invertebrates, an increased turnover in plants (due to the influx of new species), et cetera [9].

In the present study we will mainly focus on a small group of European birds related to heath, wetland and nutrient-poor grassland habitats, as well as on the role of land use, in particular of agricultural and foresting activities on their foraging and breeding successes. We will investigate whether or not Louette's hypothesis (see above) also applies to these so-called heath bird populations. Moreover, the effects of sampling methodology and long-distance interactions with hibernating locations is discussed for a number of well documented migratory birds, such as the European Nightjar *Caprimulgus europaeus* [10,11].

Recent trends in Dutch bird populations: the European Nightjar and other heath birds

In the present paragraph we focus on the following species, all related to heath, open forest space, wetlands or nutrient-poor grasslands. The chosen species reflect all a different conservation status:

(a). The European Nightjar (*Caprimulgus europaeus*): Red list species with iconic value in the ornithological community. Dutch national records of breading couples (Figure. 1) show full recovery at 100 % of the conservation aims of the Natura 2000 directive [12];

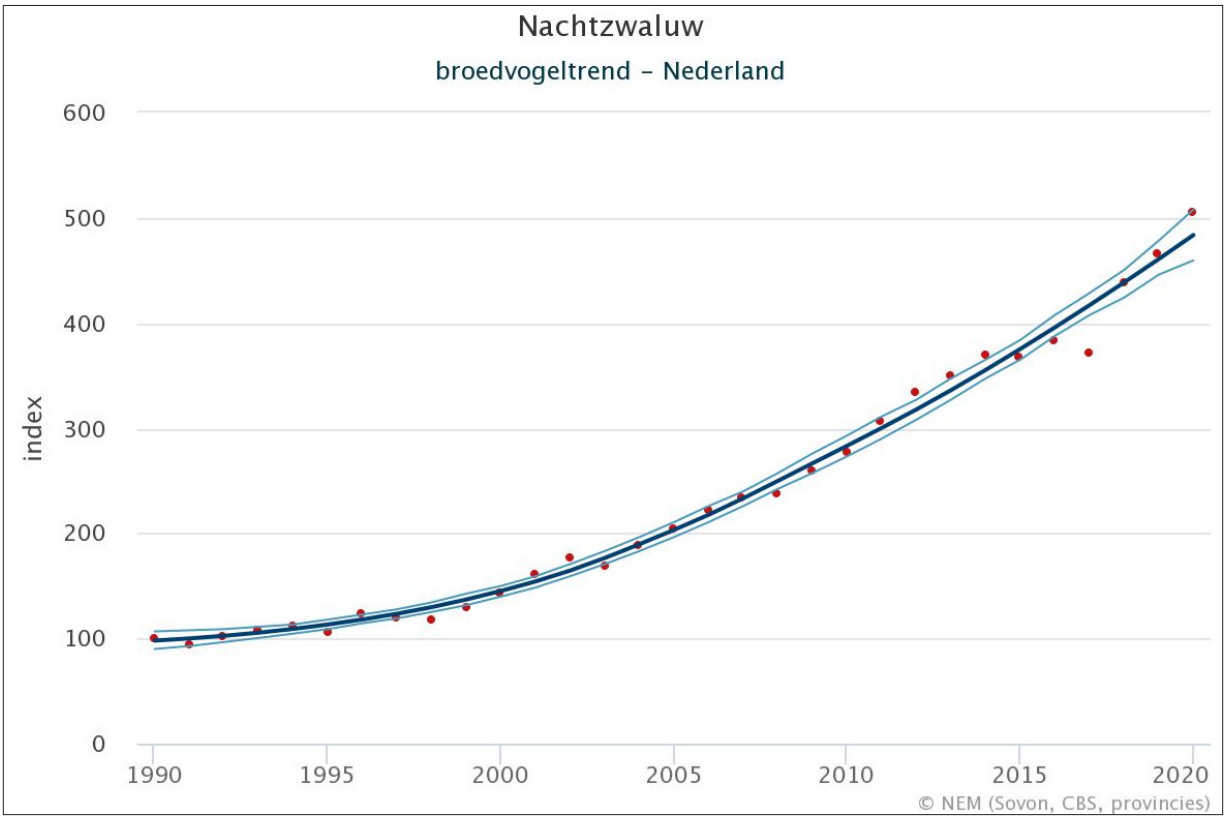

Figure 1: Trend in Dutch breeding couples of the European Nightjar (*Caprimulgus europeus*) between 1990 and 2020 (Data obtained through *NEM* [Nationale Gegevensautoriteit Natuur, The Netherlands] with data compliled from *Stichting Vogelonderzoek Nederland* [SOVON], *Central Bureau of Statistics* [CBS] and Provinces).

(b). The Whinchat (*Saxicola rubetra*): Red list species with threatened status; the trend of breading birds shows a steady decline since the 1990s, with only a pause between 2005 and 2020 (Figure 2). The hope for recovery in the northern provinces of the Netherlands (harboring 88 % of the population) is mainly based on the population in the Drenthe province (49 %) where the marginal woodland around peat-moorland may form a safe buffer zone [13];

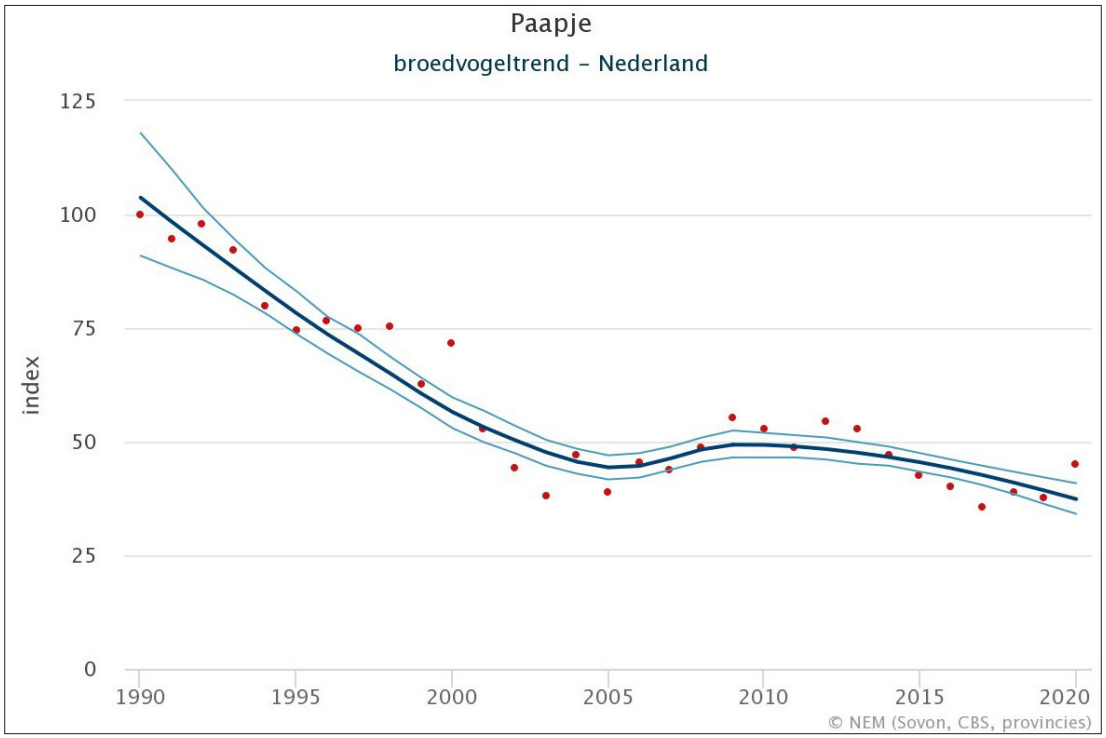

Figure 2: Trend in breeding couples of the Whinchat (*Saxicola rubetra*) in The Netherlands between 1990 and 2020 (see Figure. 1 for data source).

(c). The European Stonechat (*Saxicola torquata*, previously *S. rubicola*): Red list species with stable, increasing population of breeding pairs (Figure 3);

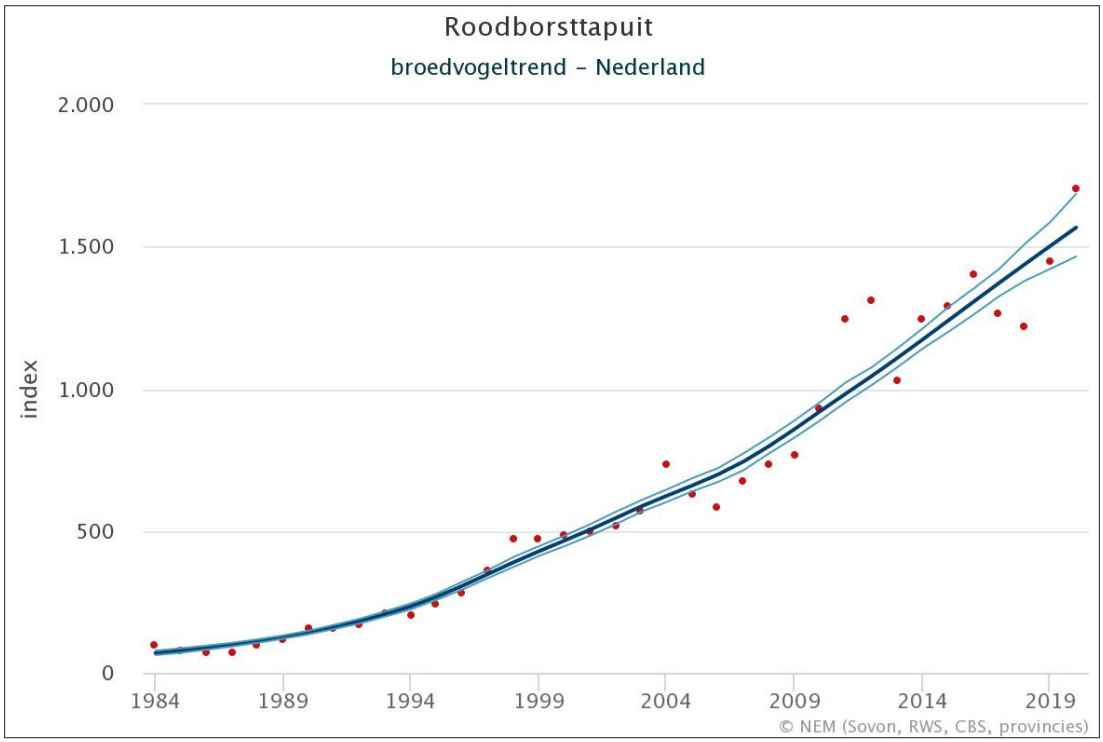

Figure 3: Trend in breeding couples of the Stonechat (*Saxicola torquata*, previously *S. rubicola*) in The Netherlands between 1984 and 2019 (see Figure. 1 for data source).

(d). The Northern Wheatear (*Oenanthe oenanthe*): Red list species with threatened status; in the Netherlands, the species is mainly present in the coastal dune region, because of the species' niche association with rabbit holes (*Oryctolagus cuniculus*) for breeding. The disappearance of the rabbit population following the subsequent myxomatosis outbreaks - rabbits were added to the list of endangered mammals in 2020 - has resulted in a strong decline in the Wheatear population too (Figure. 4). In the Central-European Alps, the Northern Wheater is found in association with holes of the Alpine Marmot (*Marmota marmota*). The Wheatear however does also occur in the alpine zones of the Sierra Nevada (Spain) above the timber-line (personal observations);

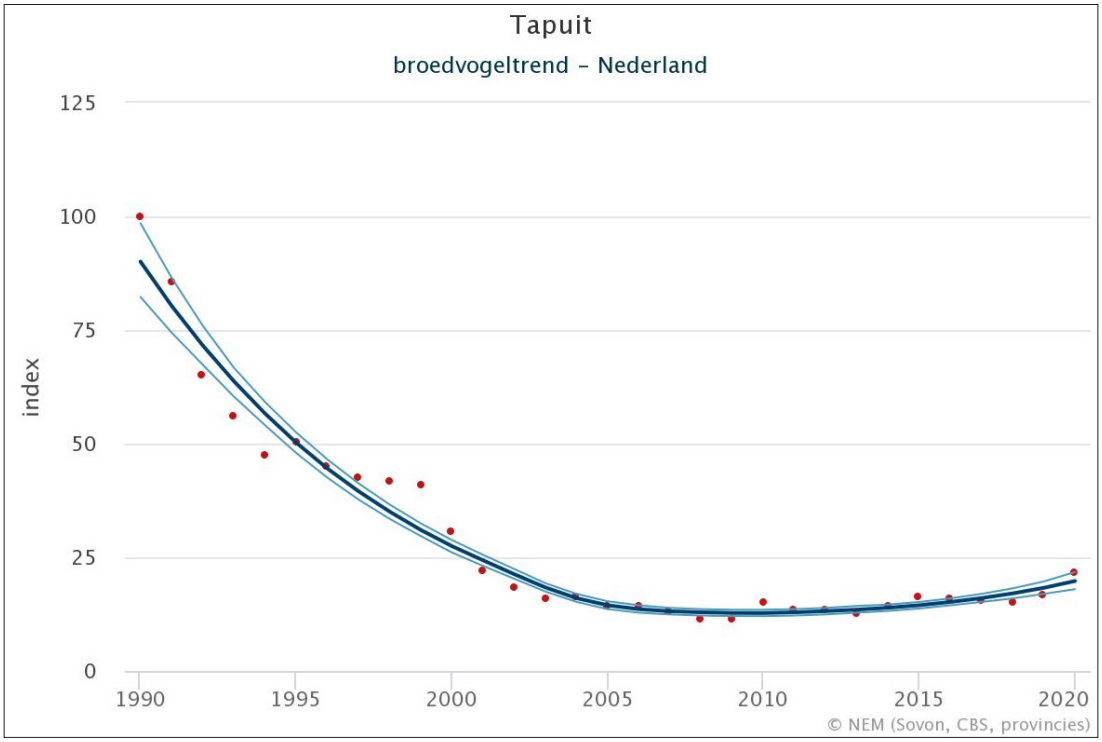

Figure 4: Trend in breeding couples of the Northern Wheatear (*Oenanthe oenanthe*) in The Netherlands between 1990-2020 (see Figure. 1 for data source).

(e). The Woodlark (*Lullula arborea*): Red list species showing a modest but significant recovery of breeding pairs (< 5%) (Figure. 5(a)). The long term trends of migration numbers show no trend (Figure. 5(b)).

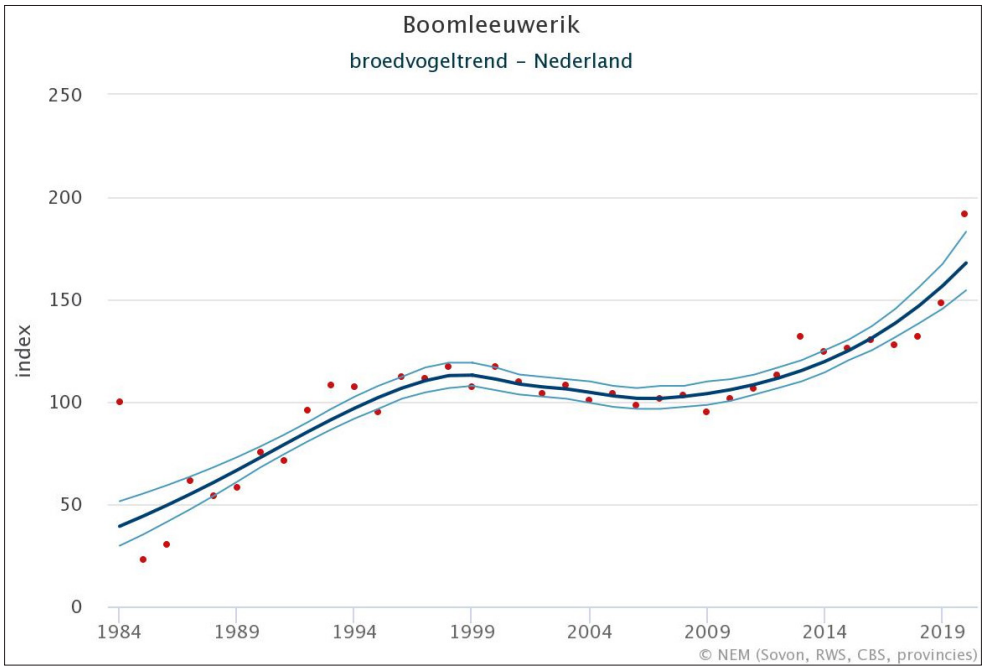

Figure 5(a)

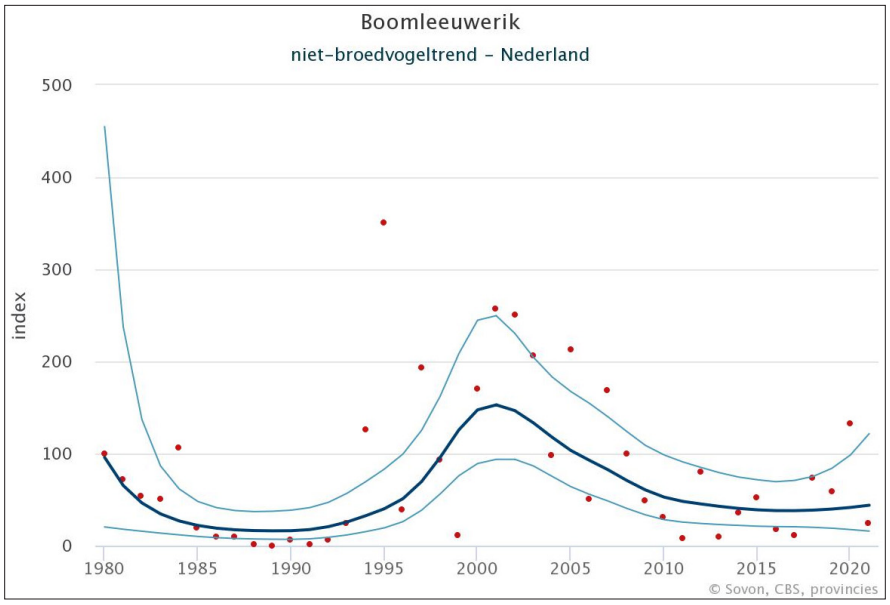

Figure 5(b)

Figure 5: Trend in breeding couples of the Woodlark (*Lullula arborea*) (a) and long-term numbers of migrating Woodlark (b) in The Netherlands (between 1980-2020) (see Figure. 1 for data source).

Figure 6(a)

Figure 6(b)

Figure 6: a,b. Two sympatric species of the same genus and divergent conservation status in Europe: the Stonechat (*Saxicola torquata*) (a) with stable status, and the Whinchat (*Saxicola rubetra*) (b) with threatened status. Both species frequently use perches for surveying the surrounding area, but show significantly different breeding success in several biotopes (Photographs by Biological Publishing, A&O).

These five species show remarkable analogies and contrasts in abundance trends (and in case of the Nightjar, the Stonechat and the Woodlark also of breeding recovery). A very interesting contrast is found between two closely related, sympatric species, namely the Whinchat and the Stonechat. The trends described for both species in the Netherlands (see Fig. 2 and 3) are very similar to trends described in Great Britain and in Germany [14-16]. In the following paragraph, we will mainly focus on the differences between these two sympatric bird species, concerning their long-term patterns of population change. Also the trends for the Northern Wheatear is remarkably different from that of the Stonechat. In case of the Wheatear, other reasons play a significant role like the association with Rabbit holes for breeding, which may become replaced by Marmot holes or other forms of shelter in high mountainous areas of Central- and Southern Europe.

Comparison with European trends for two sympatric species: the Whinchat and Stonechat

In several European countries, the contrasting patterns of population change, an alarming decline in the Whinchat (*Saxicola rubetra*) and a steady increase for the Stonechat (*Saxicola torquata*), has urged for a revision of the species conservation status, at least for the Whinchat in Britain and in Germany. In Central Europe, the Whinchat has experienced a dramatic population decrease over the past decades. According to the European Bird Census Council, the Whinchat population has been declined with 67 % between 1980 and 2012.

Several reasons have been suggested to explain the different population dynamics of the two sympatric species, that moreover belong to the same genus and are quite difficult to discriminate in the field (see also Fig. 6 a,b). Some of the main reasons are found in the habitat preferences, both in Europe and in the regions for hibernation: in Europe, the Whinchat occupies

open, invertebrate-rich grasslands, sometimes in the presence of light scrub or perches (such as in a vegetation of Bracken *Pteridium aquilinum*) [14]. Compared with the Stonechat, the Whinchat prefers habitats with a cooler temperature range (for instance in moist alluvial grassland habitats, meadows , bogs or in lush upland landscapes) [14]. During winter, the species hibernates in Africa, where it also uses open grassy steppes, wetlands and crops such as maize [17]. Although the African habitats for hibernation, in particular for the Whinchats, were suggested not to affect the breeding success of the species in Europe, the Whinchat was nevertheless considered to have a disadvantage of the seasonal migration, due to the warming in Europe and consequently the early start of spring and the food availability during the spring breeding [14,17]. It was suggested that this might explain the differences in breeding success with the Stonechat [14]. In Britain, in the period between 1994 and 2011, the Whinchat has shown a drastic reduction in density but no significant change in neither latitude and elevation above sea level [14]. On the contrary, in the same period the Stonechat in Britain occupied habitats at higher density especially at a higher elevation and more northern latitudes. These findings may corroborate the conclusion that the Stonechat, in contrast to the Whinchat, may benefit from the increased temperatures due to climate change. Possibly, this rise in abundance of the one species may negatively affect the other.

Also in Germany, a close investigation of habitat preferences and breeding success of the Whinchat (*S. rubetra*) has been carried out in the Westerwald region [16]. The breeding success was found to be significantly different across several biotope types. The most favorite habitats corresponded with the nutrient-poor wet grassland, followed by nutrient-poor dry grassland, fallow land, and, finally – the least favorites, the nutrient-rich grassland [16]. Whinchats preferentially forage in structurally diverse grasslands, with also a high abundance and diversity of invertebrate prey animals as well as a high abundance of perches from which they survey the surrounding area and catch their prey [16]. The type of grassland management also severely affected the Whinchat's breeding success. In the Westerwald region, studied over the period 2005 - 2011, the population declined from 48 to 5 singing males in the intensively managed sites, but only from 51 to 31 singing males in the traditionally managed sites [16]. Moreover, it was recommended that both grazing (by large herbivores, such as semi-wild horses, cattle and sheep) as well as mowing should not start before 1 July, and preferentially not before 15 July [16].

Impact of agriculture and grassland management in the Netherlands

The impact of agricultural activities on the emission of ammonia-derived nitrogen and resulting biodiversity issues, has been a serious challenge for the political and social-economic stability in several low-land countries of Europe, such as in the Netherlands, Denmark and Belgium [8]. Also the abundant use of pesticides, herbicides, nematicides and other chemical substances have seriously affected the farmland ecosystems (see 5. Ecological networks of flowering plants, insects and birds). Less well-known are the impact on biodiversity indices of management practices executed by conservation agencies and local governments.

In the Netherlands, water-management forms an important cornerstone in natural conservation. During the winter season, high altitudes of subsoil-water are maintained, whereas during the summer months, the water-table is significantly lowered. The main reason is to allow the farmers or conservators to get access to their pastures, farmlands and grasslands, using the heavy equipment that is found necessary for either management or cultivation (Figure. 7 a,b).

Figure 7(a)

Figure 7(b)

Another aspect of grassland and heath management in the Netherlands, is the common practice of mowing and removing shrubs and especially the many small Birch (*Betula* sp.) trees. In many natural reserves in the Eastern and Northern provinces of the Netherlands, trees and shrubs have been completely removed following extensive land restructuring, whereby only strictly conserved tree species are spared, like the Sweetgale or Bog Myrtle (*Myrica gale*) in wet moorlands (Figure. 7 c), and *Juniperus communis* in dry heathlands (Figure. 7 d). A vast number of (*Sphagnum acid*) bog landscapes, Juniper matorral or evergreen and scrub heathlands, respectively, are protected under the *Annex 1* (and *Resolution 4*) of the *European Habitat Directive(s)* [18,19]. Obviously, from the interpretation of these legal documents it is clear that herein the conservation of vegetation types, plant communities or specific plant species are dominant. The presence of tree perches, enabling certain endangered species to forage, such as the Whinchat and others, are not envisaged in these regulations (see 3. Comparison with

European trends for two sympatric species: the Whinchat and Stonechat). The aims of conservation is often related to the ambition to prevent successive plant communities to develop, with woodland being the undesired end stage of succession [20,21].

Figure 7(c)

Figure 7(d)

Figure 7: a,b,c,d. Representative images of landscape conservation in The Netherlands: (a) removal of Salix scrubwood (one year later on same location as Fig. 6b); (b) heavy material heavily affects the soil structure and requires hardening and broadening of the access paths; (c) Blossoming Sweetgale or Bog Myrtle (*Myrica gale*) in early Spring; (d) High stands of *Juniperus communis*, giving view to a Linnet (*Carduelis cannabina*) (Photographs by Biological Publishing, A&O).

In combination with the subsoil-water management and the use of heavy equipment for mowing and other management operations, it is clear that the maintenance of diverse grasslands or heathlands may become or already is in conflict with the optimal conservation strategy for the vulnerable bird species listed above (see 2. Recent trends in Dutch bird populations: the European Nightjar and other heath birds). Also with respect to other wet marshland-inhabiting song birds, like the Long-tailed Tit (*Aegithalos caudatus*), in several locations we found occupied nests of this species in small Birch and Goat Willow (*Salix capraea*) brushwood, that were removed few days later during an extensive deforestation procedure (Figure. 8 a,b). Extensive stands of Juniper trees (*Juniperus communis*) on the other hand are spared, because they are believed to attract several bird species during the winter season (Figure. 9 a,b). An often heard criticism, especially in the Netherlands, is that the role of centralized planning offices such as the Dutch *Centraal Planbureau voor de Leefomgeving* (PBL, also known as *Bij12*) don't sufficiently take notice of the local landscape characteristics and local needs for nesting, breeding or foraging (birds and other) species. It is called too much management 'at the drawing-table', with the additional accountancy drawbacks that field management tasks are given out to contract, and therefore, have to be executed and invoiced as a whole (C. Zoon-ecology, pers. comm., 2023). Phasing of the activities in accordance with the natural and seasonal phases in the development of the ecosystems, would undo some of the disadvantages. Finally, when the work of the contractor is done, its monotony is often reflected in a monotonous restructuring of the landscape, like we have witnessed in several tens of *Natura 2000* reserves (additional photographic material available at Biological Publishing A&O).

Figure 8(a)

Figure 8(b)

Figure 8 a,b: Also other birds depend on the presence of brushwood for foraging and breeding, like the Long-tailed Tit (*Aegithalos caudatus*)(a), showing its nest in a small Birch tree fork (b) (Photographs by Biological Publishing, A&O).

Figure 9(a)

Figure 9(b)

Figure 9 a,b: Berries of the Juniper-tree (a) are famous and useful to various ends: e.g. they are believed to attract the hibernating Fieldfares (*Turdus pilares*), which are often seen in large numbers in the Netherlands during winter; (b) Woodlark (*Lullula arborea*), a species showing a modest but significant recovery in heathland in the Netherlands (see Figure. 5) (Photographs by Biological Publishing, A&O).

On the other hand, with respect to the shortlist of species given above, the increasing numbers of breeding Wheatears in the high Alp meadows, compensating the eventual loss of Rabbit holes in the Dutch dunes, suggest that Nature may sometimes come up with creative solutions not thought of by the legislation and administrative forces (Figure. 10 a,b). Otherwise, the Wheatear may appear a demonstration of Louette's hypothesis (see 1. Introduction: about an old question of tropical forest birds and seasonal migration), namely that species with a flexible habitat occupancy (Figure. 11 a) are presumably better adaptors to climate change than the more stereotypical species.

Figure 10(a)

Figure 10(b)

Figure. 10 a,b: Adult (a) and juvenile (b) specimen of the Northern Wheatear (*Oenanthe oenanthe*), a ground-breeding species that uses holes of Rabbits or Alpine Marmots for shelter. In the Netherlands, the species is almost confined to the North Sea dune region. The juvenile on (b) is found in the coastal area of the Isle of Skye (Scotland) (Photographs by Biological Publishing, A&O).

Figure 11(a)

Ecological networks of flowering plants, insects and birds

It is a commonly heard discourse, especially in the public debate on agricultural load on natural ecosystems and their biodiversity, that all organisms in an ecosystem are interrelated. We call this the 'holistic' view on biodiversity. This aspect was not so prominent when influential ecological theories on biodiversity and biogeography had been propagated,

only a few decades ago (see Hubbell's *UNTB theory* in 1. Introduction) [2]. Although nowadays we might call the UNTB theory outdated, there is still a problem with the 'holistic' view, when it comes to the quantification of biodiversity and biodiversity resilience. Moreover, when the holistic approach is used to cover the impact of real management practices and forge the discussion into an ideological polarization scheme, its usefulness becomes very shortsighted.

The biodiversity estimates of flowering plants, insects and birds, which in itself are related to the rather 'invisible' worlds of soil inhabitants like worms, fungi and bacteria, et cetera, have the advantage of creating much more empathy and basic support from the voting members of society. Moreover, they are hard to ignore and therefore, these biodiversity estimates have an important signaling function too.

Recent studies have documented the detrimental effects of the use of insecticides, fungicides, herbicides, on the abundance numbers of populations of European insect, bird and flowering plant species, and, not to forget the dramatic impact of these products on the insects that are necessary for crop pollination and food production [23-25]. Less well known are the effects of the use of fumigantia, chemicals that are used to kill eelworms and potato (cyst) nematodes (like *Meloidogyne chitwoodi*, *M. fallax, Globodera spp.* and others of the *Nematoda* phylum), which create an economic burden for the cultivation of crops such as potato (*Solanum tuberosum*), maize and other cultivated plants and especially the flowers and bulbs (of *Tulipa, Gladiolus*, et cetera) [26]. Although real alternatives exist for the use of these fumigantia, they are very commonly used in the Dutch clay soil regions. Unfortunate for their abatement is that eelworms also have a beneficiary effect on the decimation of plague insect species, like Box Tree Moths (*Cydalima perspectalis*), the larvae of the Common European Cockchafer (*Melolontha melolontha*), the Oak (and other) Processionary Caterpillar(s) (*Thaumetapoea processionea*), and many other plague species. It would go far beyond the scope of the present paper to give an extensive list of ecosystem distortions in farmland, also because these enriched clay soils are less suited for the preferred habitats of the selected group of bird species (see 2. Recent trends in Dutch bird populations). But, as mentioned before, the complex seasonal traveling and foraging behavior of certain bird species, makes it necessary to observe the relations with habitat and prey preferences more closely.

In case of the European Nightjar, detailed tracking analysis using telemetry has shown that habitat degradation during the migratory pathways on the Southern hemisphere may have a deleterious effect on the population numbers [10,11]. Also the use of sub-optimal breeding areas and the dispersal of foraging areas used in the breeding season, may have a negative impact, because of the decreased food quality, the increased foraging duration and concomitant stress levels [27]. Also the decline in their favorite prey species, in particular the crepuscular Lepidopterans, would cause a dramatic reduction in population size, which is in contrast with the Dutch population data (Figure. 1). However, although Lepidopterans comprise 65 % of the European Nightjar's food source, the species tends to select larger species of Lepidoptera (> 19 mm), which suggest they may optimize the efficiency of their foraging trips and, doing so, they anticipate on the decreased food availability and increased foraging costs [28]. Nevertheless, the increasing population numbers of the species in the recent years (see Figure. 1) are not free of doubt (about their scientific accuracy), because the density of breeding couples is estimated using acoustic means during crepuscular hours. Also, the extrapolation of local density numbers to the scope of vast areas that are difficult to access at night, may cast some suspicion about the trustworthiness of these optimistic numbers of the European Nightjar restoration in *Natura 2000* areas.

Conclusions and recommendations

The amalgam picture of bird abundance and biodiversity in heathland species reflects the amalgam picture of vertebrate and invertebrate species at an European scale [9]. A closer, detailed examination of the present selected list of heath birds, brought forward that each of them revealed a distinct pattern, some species are doing well, or show a modest recovery while others are at risk of extinction. A most remarkable difference is seen when the Whinchat (*Saxicola rubetra*) and Stonechat (*S. torquata*), two sympatric species of the same genus, are compared (see 3. Comparison with European trends for two sympatric species). The examination of the different habitat preferences, foraging behavior, and their relation with landscape elements is in favor of a more nuanced view of natura conservation. Moreover, the limited selection of these five species also shows the intricate interrelationship with other elements of the ecosystem, which is much in contrast with the previously discussed UNTB theory [1]. Some species, like for instance the Woodlark, show good recovery in the Netherlands, whereas for other Red list species, their status is more critical, like for the Wheatear and the Whinchat. The poor outcome of the abundance data in the Netherlands, does however not mean that the European status is following the same trend. For the Whinchat, the threatened status is confirmed and documented for a broader region, from the British Islands to Germany. For the Wheatear, a species that probably may at best reflect the flexible kind of species in Louette's hypothesis, further European research will be necessary, not only to confirm or reject the hypothesis, but also to monitor the influence of climate warming and increased dryness in Southern European mountainous regions.

The foremost important recommendation for the situation specific to the Netherlands, therefore is to give a higher priority to small landscape elements that are beneficial to the breeding and foraging successes of these species. For instance, the recommendation to protect the Whinchat in natural grasslands by avoiding both grazing (by large herbivores, such as semi-wild horses, cattle and sheep) as well as mowing before 1 July, and preferentially not before 15 July (see 3 above). Of course, the conservation practices should take the multitude of vulnerable species in check, or, rather leave more space to the self-regulating capacity of (strong) ecosystems. In this respect,

it is interesting to cite the word of a Dutch pioneer in natural conservation, Victor Westhoff (1916-2001): "*the most valuable natural areas (and ecosystems) in the Netherlands are those where farmland and nature reserves meet*", an observation that is often confirmed in vertebrate inventory studies. Westhoff and A.J. den Held were the first biologists in the Netherlands to study the plant communities, being the fourth, ecological cornerstone of biodiversity [29,30].

Similar to the suggested ranking of freshwater quality by a ten-point system (giving the highest rank to the freshwater habitat with the most vulnerable water [insect] species, such as Stonefly larvae, Plecoptera, etc.), it would be interesting to establish a similar ten-point ranking system, based on the occurrence of foraging, nesting or presence of breeding couples of the heath birds listed above [31]. Additional points could also be given for the (occasional) presence of vulnerable birds of prey (such as the Harriers of the *Circus* genus (Figure 11. b), Short-toed Eagles [*Circaëtus gallicus*], etc.) and other red list species. In any case, a valorization system of the quality of biodiversity shouldn't focus on an inflexible fixation on the presence of certain isolated 'flagship species' alone. In particular this approach should be avoided, when the fixation is at the cost of the ecosystem as a balanced ensemble of animal species, fungi, soil communities, and structured plant vegetation, like some interpretations of the *Nature 2000* conservation program have entailed.

Figure 11(b)

Figure 11: (a). Northern Wheatears in the alpine zone (above timber-line) in the Spanisch Sierra Nevada; (b). Male Marsh Harrier (*Circus aeruginosus*), known for hunting several marsh inhabiting bird species (Photographs by Biological Publishing, A&O).

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