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Habitat Requirements and Management Recommendations for Breeding Sites of Ferruginous Duck (*Aythya nyroca*)



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Disclaimer

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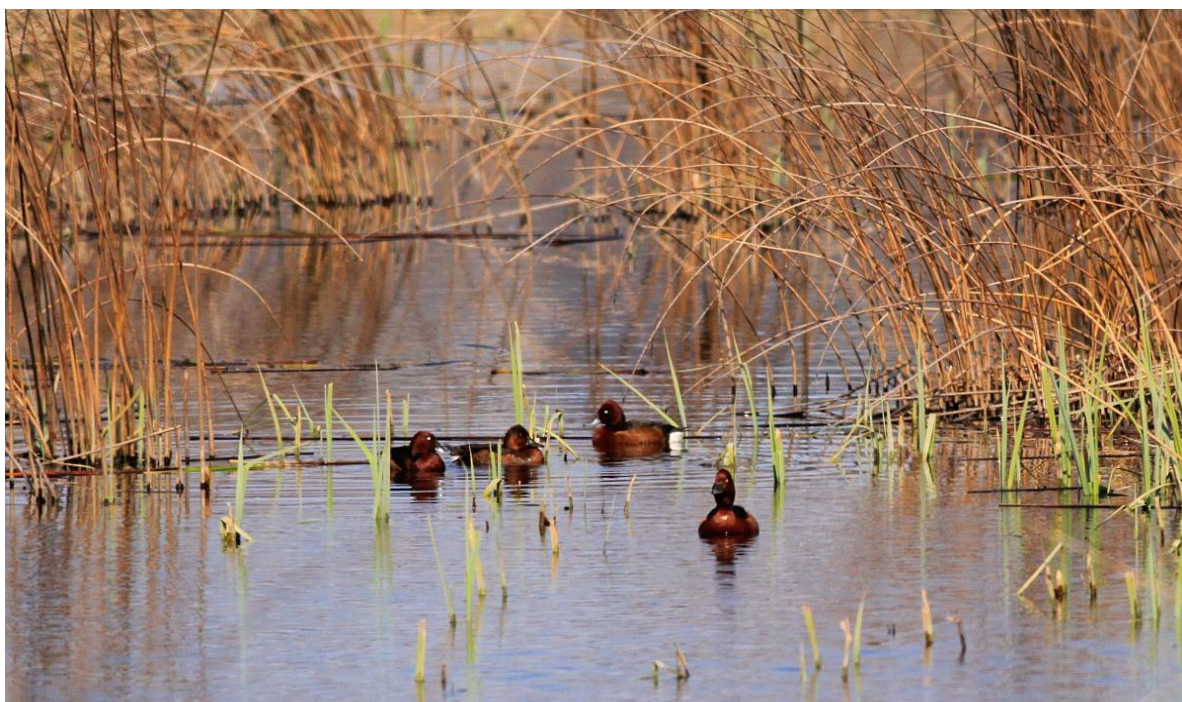


1. Executive Summary

The Ferruginous Duck (*Aythya nyroca*) is globally classified as Near Threatened by the IUCN, reflecting its vulnerability to habitat loss, hydrological alterations, environmental degradation, and human disturbance. Bulgaria holds several of the most important breeding sites for the species in southeastern Europe, making it a critical country for its conservation. This report presents a comprehensive overview of the species' habitat preferences, breeding ecology, and the current ecological state of three nationally important wetlands: Srebarna Lake, Belene Marshes, and Kalimok Fishponds. All three are designated Natura 2000 sites and Important Bird Areas (IBAs), supporting significant portions of the national breeding population.

The report is based on detailed field surveys and a synthesis of existing ecological literature, providing site-specific assessments of water quality, vegetation structure, microhabitat diversity, and threats such as eutrophication, invasive species, hydrological instability, and anthropogenic pressure. It underscores the Ferruginous Duck's strong reliance on shallow, well-vegetated freshwater wetlands, particularly those with stable water regimes and mosaic vegetation structure, which are critical for nesting success and brood rearing. Each site presents unique conservation challenges—for example, Srebarna Lake faces pressures from changing water levels, while Belene Marshes require restoration of seasonal flooding and invasive species control.

Drawing on empirical data, conservation best practices, and habitat modeling, the report proposes a set of targeted management recommendations aimed at improving breeding habitat conditions and enhancing reproductive success. These include hydrological regulation, vegetation management, control of human disturbance, and sustainable fishpond operations. The proposed measures align with the EU Birds Directive and AEWA objectives and aim to ensure the long-term viability of Ferruginous Duck population, contributing to broader regional conservation goals across the species' range.



2. Introduction

Wetlands across Europe have experienced degradation, impacting waterbird populations. Bulgaria hosts some of the strongholds for the Ferruginous Duck in southeastern Europe. This report synthesizes ecological data and proposes conservation actions necessary to ensure sustainable breeding populations.

Wetland ecosystems provide critical habitats for a wide range of avian species, particularly waterfowl, which rely on these environments for breeding, foraging, and shelter. Among the species dependent on wetland habitats is the Ferruginous Duck (*Aythya nyroca*), a medium-sized diving duck with a fragmented and declining population across its range. The species' reliance on specific habitat structures and water conditions makes it especially vulnerable to anthropogenic pressures and environmental changes.

The conservation status of the Ferruginous Duck is a cause for concern at both European and global levels. Classified as Near Threatened by the International Union for Conservation of Nature (IUCN), the species is listed on Annex I of the EU Birds Directive, indicating that it requires special conservation measures and the designation of protected areas. Bulgaria hosts important breeding populations of the species, making the country a key player in its conservation within the European context.

This report on the habitat requirements and management recommendations for the Ferruginous Duck is developed under a contract of BSPB/BirdLife Bulgaria with Notranjski regijski park, as part of the LIFE22-NAT-SI-LIFE-TRSCA project. It supports the project's broader goals by synthesizing scientific knowledge on breeding ecology and translating it into practical guidance for habitat restoration, vegetation management, and disturbance mitigation. The findings will inform on-the-ground conservation planning and adaptive management at Lake Cerknica and similar wetland systems, contributing directly to the achievement of LIFE TRSCA's conservation targets for Ferruginous Duck and associated marshland biodiversity.

The primary objective of this report is to compile the existing knowledge and evaluate the breeding habitat requirements of the Ferruginous Duck and propose site management recommendations, also drawing on the experience and data from three significant wetland areas in Bulgaria: Srebarna Lake, Belene Marshes, and Kalimok Fishponds. These sites have been selected due to their historical and present importance as breeding grounds for the species, as well as their inclusion in national and international conservation initiatives.

LIFE TRSCA (LIFE22-NAT-SI-LIFE-TRSCA) is a conservation project focused on improving the ecological status of intermittent marsh habitats (turloughs) around Lake Cerknica, with particular emphasis on enhancing breeding conditions for the Ferruginous Duck (*Aythya nyroca*) and Red-necked Grebe. The project's core objectives include the restoration and management of marsh vegetation and habitat type 3180* through the implementation of revised agri-environmental and CAP measures. These involve promoting extensive mowing regimes and appropriate land use to maintain a mosaic of open water, sedge beds, and reed cover—conditions critical for the breeding success of Ferruginous Ducks. By targeting habitat structure, vegetation composition, and water dynamics, the project contributes to the conservation of sensitive wetland-dependent



bird species. As one of the major objectives of LIFE TRSCA is restore the breeding habitat of the Ferruginous duck and reduce disturbances in nesting and wintering periods, the report will serve as a basis for planning the conservation actions and direction of the site management to enhance the habitat for the target species.

A key component of LIFE TRSCA is the strategic acquisition or exchange of land to secure and manage around 50 ha of priority marshland. This will enable the creation of microhabitats with open-water patches interspersed within dense emergent vegetation—ideal breeding environments for Ferruginous Ducks, which require shallow, undisturbed wetlands with diverse aquatic vegetation. Additional measures include clearing excessive biomass and sediment buildup that impairs habitat quality, thus directly responding to the species' ecological requirements as identified in scientific studies and management guidelines from key sites across Central and Eastern Europe. These actions reflect best practices in waterbird conservation and are informed by ongoing habitat assessments and species-specific ecological research.

The report synthesizes data from field studies, conservation project reports, and peer-reviewed literature to provide a comprehensive understanding of the species' ecological needs. In addition to assessing current habitat conditions and population trends, it highlights the main threats facing the Ferruginous Duck and outlines practical actions to mitigate these pressures. The report is intended for use by conservation practitioners, land managers, policy-makers, and stakeholders involved in wetland management and biodiversity protection.

By addressing both ecological and management perspectives, this document aims to support evidence-based decision-making and foster collaborative conservation efforts to ensure the long-term viability of the Ferruginous Duck population in breeding sites.



Srebarna Lake Managed Reserved (SPA - BG0000241) – major part of the nesting grounds for many of the species are the typical for this wetland floating reedbeds



3. Species Overview

The Ferruginous Duck (*Aythya nyroca*) is a medium-sized diving duck belonging to the family Anatidae, tribe Aythini. It is distinguishable by its rich chestnut plumage, white under-tail, and distinctive pale eyes in males. The species breeds primarily in freshwater wetlands across southern and eastern Europe, western and central Asia, and North Africa. Its wintering grounds extend to the Mediterranean region, the Middle East, and parts of sub-Saharan Africa (BirdLife International, 2025).

The Ferruginous Duck has a patchy and discontinuous breeding distribution across the Palearctic, primarily concentrated in southern and eastern Europe, western and central Asia, and parts of North Africa. Its core breeding range includes countries such as Hungary, Romania, Bulgaria, Ukraine, Russia (notably in the steppe and forest-steppe zones), Kazakhstan, and extending into western China and Mongolia (BirdLife International, 2025; Wetlands International, 2017). In Europe, the species shows a preference for lowland eutrophic wetlands with dense emergent vegetation and is most commonly associated with fishponds, marshes, and shallow lakes. Conservation efforts typically focus on maintaining suitable breeding habitats, managing reedbeds and water levels, and minimizing human disturbance during the breeding season. Historically, the Ferruginous Duck was more widespread and numerous across its Palearctic range. However, over the last few decades, its numbers have declined significantly due to wetland loss, water pollution, drainage, and disturbance (Petkov et al., 2003). As a result, it is currently classified as Near Threatened by the IUCN Red List, with an estimated global population of 100,000–200,000 individuals (IUCN, 2024). The most recent population estimates as collated by Wetlands International are as follows: 5,700–6,300 individuals in the western Mediterranean and in North and West Africa; 50,000–82,000 individuals in Eastern Europe and the eastern Mediterranean and Sahelian Africa; 25,000–50,000 individuals in western and south-west Asia as well as in north-east Africa, and 100,000 individuals elsewhere in Asia (Wetlands International 2017a,b; Mundkur et al. 2017), giving a total of c.180,000–240,000 individuals.

In Hungary and Romania, conservation projects have focused on habitat restoration and protection of key breeding and migratory stopover sites including number of EU LIFE funded projects that have restored thousands of hectares of breeding and staging habitat – i.e. LIFE02 NAT/H/008634 & LIFE13/NAT/HU000388 . In Italy is a localized nesting duck, with less than 100 pairs, several breeding sites remain, while reintroduction projects and habitat restoration and enhancement have contributed to improvement of the breeding population in the country. In Russia and Ukraine, large wetland complexes in the Volga Delta and the Danube Biosphere Reserve continue to support significant breeding populations, although fluctuations occur due to hydrological variability (Bergmann et al., 2015).

In the Balkans, the species' distribution is highly fragmented. In Bulgaria, the Ferruginous Duck is considered a rare breeder, with the most important sites located in the northern floodplain zone along the Danube River. The species is listed in the Bulgarian Red Data Book and benefits from inclusion in the EU Natura 2000 network, which offers a framework for habitat protection (Petkov, 2002).



The Ferruginous Duck's ecology is closely tied to specific aquatic habitat features. Breeding success depends heavily on the presence of dense emergent vegetation for nesting, relatively stable water levels during the breeding season, and abundant aquatic invertebrates and vegetation for feeding. Its sensitivity to human disturbance and hydrological changes makes it a reliable indicator species for wetland health (Petkov, 2005; 2006).

This section provides a foundational understanding of the Ferruginous Duck's ecology, distribution, and conservation context as a precursor to examining its habitat requirements in greater detail.



Breeding habitat of the Ferruginous Duck in Bulgaria – Karst marsh of Dragoman, with typical mosaic diverse emergent vegetation and lush submerged plants

4. General Habitat Requirements

Knowledge of habitat requirements is essential for habitat management of breeding sites and, ultimately, the species' conservation. The habitat selection is often accepted as part of the theory for optimal foraging. Habitats occur as discrete units in space and the living organisms select and make choices how to distribute with in them. The preferred habitat of one species could be identified most reliably when its population grows and it starts to take suboptimal habitats.

The structure of the habitat is one of the factors determining the habitat selection by birds and in the case of wetlands the structure is much simpler compared to a deciduous forest. In the wetland the structure is impacted by the shoreline, vegetation height, water column depth and the bottom substrate. The actual selection of the habitats is a process including innate cues



and learned experience. The waterfowl species in generally select open water where courtship display and foraging take place, but also need suitable place for nesting and brooding of the youngs.

The Ferruginous Duck shows strong preferences for dense emergent vegetation in freshwater wetlands, especially those characterized by mosaic structures of open water and reedbeds. The Ferruginous Ducks prefer shallow, eutrophic water bodies with dense emergent and submerged vegetation. Optimal habitats include natural lakes, oxbows, and artificial wetlands such as fishponds and reservoirs, particularly those with a mosaic of open water and dense reedbeds. Water depth between 30–100 cm is critical for nesting and foraging. According to Petkov (1997, 2003, 2005), suitable breeding habitats in Bulgaria often consist of slow-flowing or stagnant waters with luxuriant vegetation, especially reed (*Phragmites australis*), bulrush (*Typha* spp.), and sedge (*Carex* spp.). These conditions provide both shelter and food availability during the breeding season.

This study also highlights that in successful breeding sites, aquatic plant diversity and coverage are essential for supporting invertebrate populations—an important food resource for ducklings. The presence of a gradient from open water to dense vegetation is necessary to accommodate different life stages of the ducks, from nesting to brood-rearing.

Species richness of the emergent vegetation is also highlighted as a major factor determining the breeding occurrence of the species (Petkov, 1997, Petkov, 1998a). Analysis based on breeding population in Bulgaria (Petkov, 2012) revealed that Ferruginous Ducks preferred well-vegetated, comparatively shallow wetlands with well-structured mosaic vegetation and a diversity of microhabitats, like shallow mudflats and floating vegetation. The Ferruginous Duck is more of a habitat specialist, which limits its distribution and makes it more susceptible to habitat changes.

Wetland parameter / Parameter mokrišča	Kendall Tau	Z	P
Vegetation cover	0.73	5.65	< 0.001
Water depth	−0.68	−5.28	< 0.001
Mosaic vegetation	0.59	4.60	< 0.005
Vegetation along the bank	−0.59	−4.60	< 0.005
Floating vegetation	0.87	6.79	< 0.001
Steep banks	−0.67	−5.16	< 0.001
Shallow banks	0.67	5.16	< 0.001
Shallow mudflats	0.93	7.26	< 0.001
Shallow vegetated area	0.58	4.48	< 0.001
Wood vegetation	−0.52	−4.05	< 0.005

based on Petkov (2012) *Acrocephalus* 32 (150/151): 127–134; doi: 10.2478/v10100-011-0005-1

The analysis of habitat use by *Aythya nyroca* across 30 breeding sites in 2002 revealed important patterns in the species' habitat selection and ecological adaptability. The Ferruginous Duck was recorded at sites representing both natural and artificial wetlands, with a slightly higher proportion of breeding pairs occupying artificial habitats (52.9%) compared to natural wetlands (47.1%). This suggests a relatively high degree of plasticity in breeding habitat selection, consistent with previous observations that the species is capable of exploiting modified landscapes such as fishponds and micro-reservoirs when key structural features are present.



The elevation range of occupied sites was broad, extending from sea level to 880 m a.s.l., with a mean altitude of 191.4 ± 175.8 m. This wide altitudinal distribution further supports the species' tolerance for varied environmental conditions during the breeding season. However, in China the species occurs up to the extreme 3,900 m a.s.l., but the major part are found between 600-1,500m a.s.l. (Xumao & Maming, 2014). This high elevation is mostly linked to the breeding population in the Tibetan plateau of Inner Tibet in China.

Habitat preference analyses revealed that the presence of breeding pairs was significantly associated with several key habitat characteristics/microhabitats (see Table above). Positive correlations were found with the extent of total vegetation cover, presence of floating vegetation, and availability of shallow mudflats—features commonly associated with low-disturbance, structurally diverse wetland systems. In contrast, negative associations were observed with deeper water, steep banks, dense woody vegetation along the shoreline, and vegetation confined solely to the margins. These findings are in line with previous studies indicating the species' preference for shallow, well-vegetated wetlands with ample emergent and floating vegetation, which offer both nesting cover and food resources.

Regression analysis identified four variables as significant predictors of Ferruginous Duck presence: water depth (negative correlation), total vegetation cover, floating vegetation, and shallow mudflats (all positively correlated). This emphasizes the importance of habitat complexity and heterogeneity in supporting breeding populations. Shallow wetlands with a mosaic of open water and vegetated patches appear to provide the optimal conditions for nesting and chick-rearing.

The microhabitat of shallow mudflats has been indicated as important in other studies as well - i.e. Zogaris & Handrinos (2003) as this is suitable habitat for development of a major protein food for the species – Chironomidae larvae (Cramps & Simmons, 1997, Dvorak et al, 1996).

The Ferruginous Ducks demonstrates a high degree of ecological flexibility in breeding habitat selection, with the capacity to utilize both natural and artificial wetlands, provided specific structural habitat features are present. The species shows a clear preference for shallow water bodies with high vegetation complexity, particularly those featuring floating vegetation and exposed mudflats. These both serve as concealment at different stages of the daily routine as well as source of food in terms of water invertebrates and aquatic plants utilized by the species. The submerged vegetation also provide structure for water invertebrates as it was observed in a case in natural wetland in Danube plain in Bulgaria where actively feeding Ferruginous Duck were picking up *Ceratophyllum demersum* from the bottom. However, when we checked on spot the exact type of plant being picked up it showed that the *Ceratophyllum* plants were heavily covered by *Chironomidae* larvae so it was difficult to conclude which was the original food resource targeted by the ducks.

The breeding success and site selection of Ferruginous Duck are closely tied to the structure and composition of aquatic vegetation. Breeding habitats typically consist of shallow freshwater wetlands characterized by a mosaic of emergent, floating-leaved, and submerged macrophytes, which provide nesting cover, foraging opportunities, and protection from predators.

Emergent Vegetation - Emergent plant species offer critical nesting substrates and concealment:



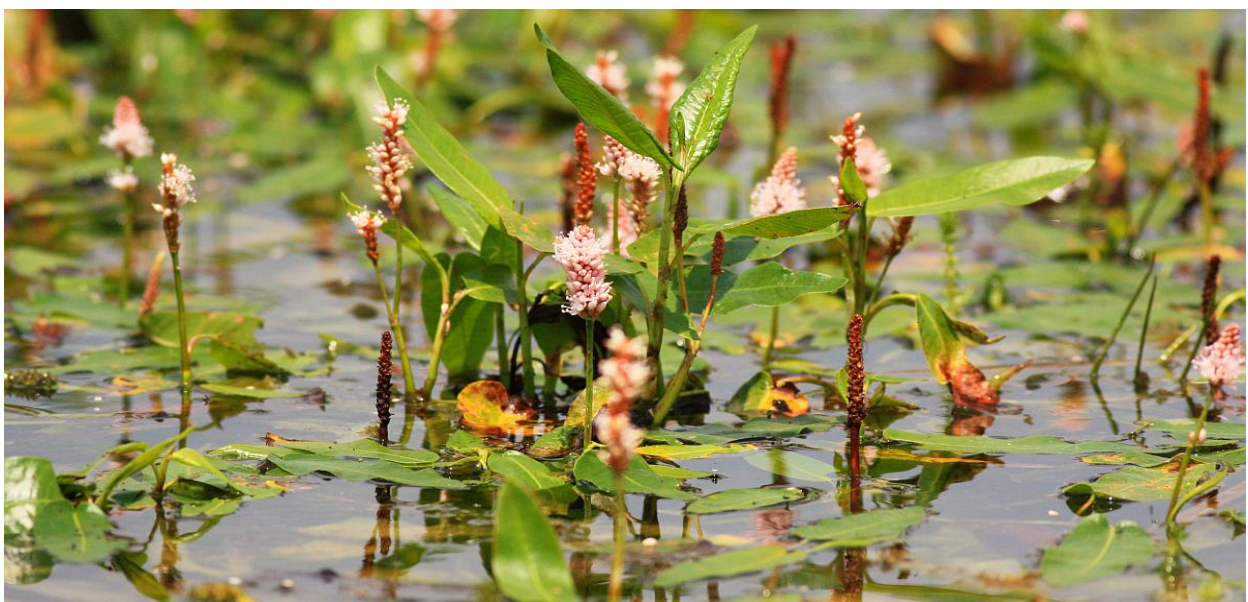
- Common Reed (*Phragmites australis*)
- Broadleaf Cattail (*Typha latifolia*)
- Narrowleaf Cattail (*Typha angustifolia*)
- Bulrushes (*Scirpus spp.*, *Schoenoplectus spp.*)
- Sedges (*Carex spp.*, *Bolboschoenus spp.*)

These species are frequently associated with nest placement, typically on dense clumps of emergent vegetation in shallow water areas (Green, 1998; BirdLife International, 2024).

Floating-Leaved Vegetation - Floating vegetation contributes significantly to breeding habitat structure, providing both nesting support and cover:

- Yellow Floating Heart (*Nymphoides peltata*)
- Water Chestnut (*Trapa natans*)
- European Frogbit (*Hydrocharis morsus-ranae*)
- White Water-lily (*Nymphaea alba*)
- Duckweeds (*Lemna spp.*)
- Floating Pondweeds (*Potamogeton natans*)
- Water Smartweed (*Persicaria amphibia*)
- Common water-crowfoot (*Ranunculus aquatilis*)

Species such as *Nymphoides peltata* and *Trapa natans* have been noted in suitable breeding sites in the Danube Delta and other Central European wetlands, contributing to the structural heterogeneity favored by the species.



Floating vegetation from a breeding site of the species Persicaria amphibia



Submerged Vegetation - Submerged macrophytes support invertebrate prey and foraging activity:

- Hornwort (*Ceratophyllum demersum*)
- Pondweeds (*Potamogeton spp.*)
- Stoneworts (*Chara spp.*)
- Spiny Water Nymph (*Najas marina*)

These species are prevalent in eutrophic and mesotrophic wetlands that provide high-quality foraging opportunities for adults and broods.

Conservation strategies for Ferruginous Duck should prioritize the maintenance and restoration of structurally diverse wetland habitats. In particular, artificial wetlands such as fishponds can serve as suitable breeding sites if managed to maintain shallow zones and heterogeneous vegetation. Ensuring the availability of these habitat features may enhance breeding success and contribute to stabilizing or increasing local populations of this globally Near Threatened species.

Furthermore, in Bulgaria, habitat suitability is closely tied to water management practices. Sites with regulated water levels that mimic natural hydrological cycles tend to support more stable breeding populations. Conversely, wetlands affected by drainage, drought, or unpredictable flooding show reduced nesting success. Late flooding and droughts can significantly contribute to nest failure.

These observations underscore the importance of integrated wetland management that combines vegetation maintenance, water level control, and minimal human disturbance to meet the ecological needs of the Ferruginous Duck during its breeding period.

At the microhabitat scale, Ferruginous Ducks demonstrate selective nesting behaviors that maximize concealment and minimize predation risk. Preferred nest locations are typically within dense stands of emergent vegetation such as *Phragmites australis* or *Typha angustifolia* and associated emergent vegetation species, with nests often situated at the interface between open water and vegetation margins. This transitional zone allows easy access to feeding areas while providing sufficient cover from terrestrial and avian predators Petkov, 2004.

Microhabitat selection is also influenced by vegetation height and density, with optimal conditions involving stems tall and rigid enough to support nests above fluctuating water levels. In field observations at Srebarna and Belene, Nests were often found in vegetation patches with high stem density, ensuring both structural support and camouflage.

Additionally, nest site fidelity has been observed, with females often returning to the same microhabitat type across seasons, especially in undisturbed areas. Ferruginous Ducks tend to avoid sites with recent vegetation cutting or where livestock grazing has reduced vegetation cover (Petkov, 2004).

These preferences indicate the importance of managing wetland vegetation not only at the macrohabitat scale but also in fine-scale patterns to ensure that structurally diverse and undisturbed microhabitats remain available throughout the breeding season.



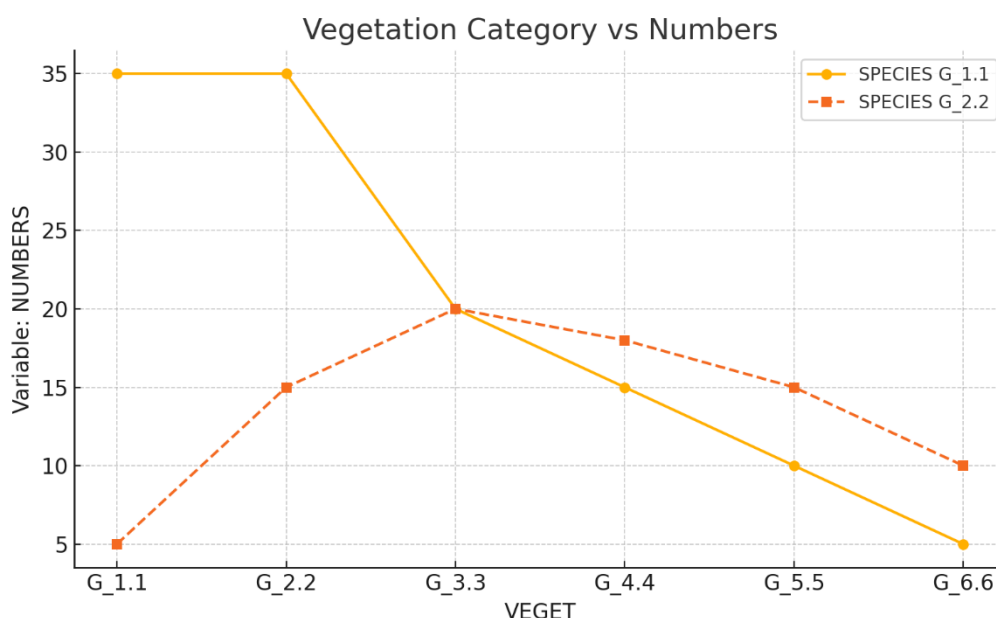
Petkov et al. (2017b) conducted comparative habitat assessments for Ferruginous Duck and Common Pochard in Bulgaria. They found that Ferruginous Ducks “preferred more secluded and denser reedbeds with adjacent shallow waters,” whereas Pochards used slightly more open areas. This suggests subtle niche differentiation.

The best habitats included:

- Around at least 40% emergent vegetation cover
- High interspersed index (vegetation-open water mix) – high mosaic diversity of the wetland habitat interspersed with open water and reedbeds, floating vegetation mats.
- Reed canopy height >1.5 m though lower reed canopy (around 1-1.5m) is also occurs.

These conditions maximize concealment and predator avoidance and foraging areas availability.

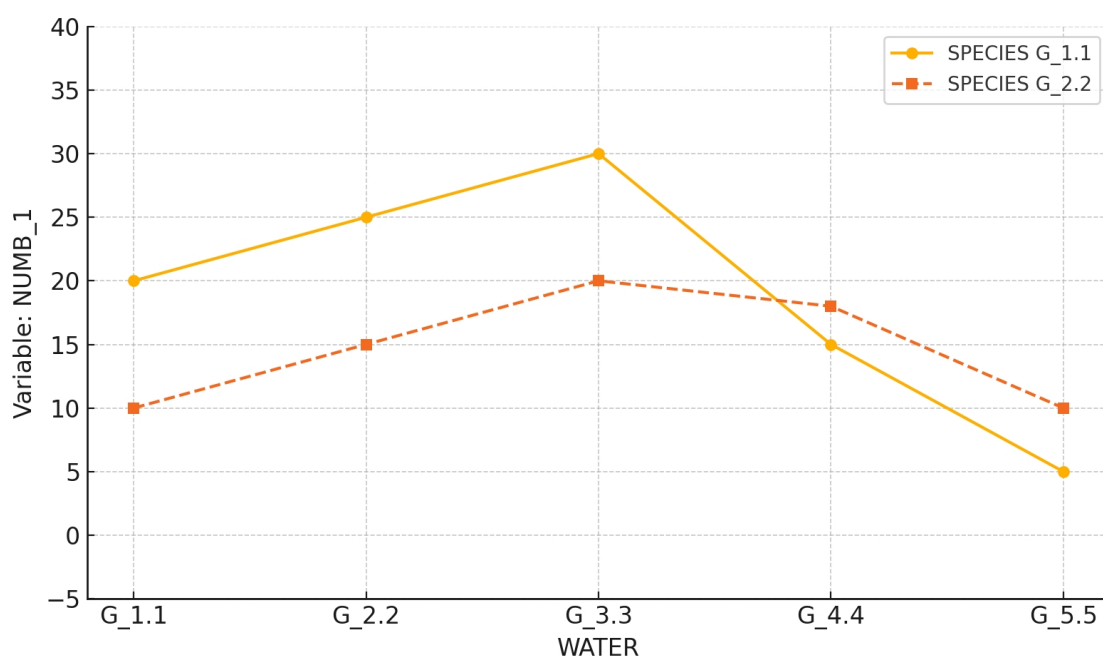
Factor analysis of the microhabitat selection by Ferruginous Duck across a dynamic ecological gradient of dynamic wetland conditions over two years of study in Srebarna Lake managed reserve showed quite special segregation along several factors and microhabitats (Petkov, 2004). Dispersal analysis according the space selection compared to the distance to emergent vegetation show that there is a strong influence of this parameter and the species selects microhabitats within the close vicinity of the emergents. The distance is separated in six classes (0m; 1m; 2-5m; 6-10m; 11-50m; >50m). The number of birds go down the further they are from the emergent vegetation (on the Graph bellow the solid line of Species G1.1). The highest numbers were up to 2m from the vegetation. This reconfirms other observations and findings that the species dwells in the more vegetated areas of the wetlands and in close proximity of the vergation. In this case the species is compared with its conspecific – the Common Pochard, which tends to stay further from the vegetation.



Graph 1

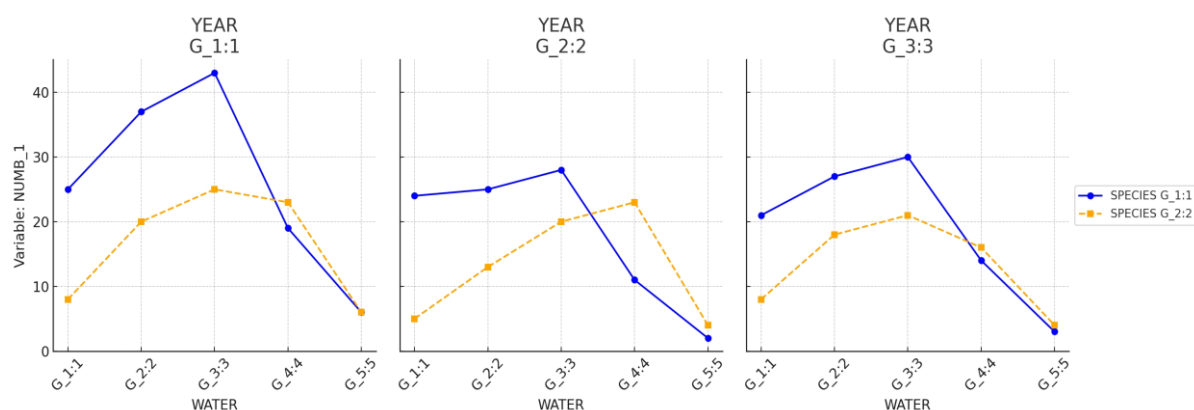


When analysing the influence of the water depth for the distribution of the species in Srebarna Lake we found that the factor is strongly influencing the distributioun ($F=11.562$, $p < 0,0001$). Water depth is given in 5 classes (0,5m; 1m; 1,5m; 2m; >2m).



Graph 2

Much higher numbers of Ferruginous Ducks are found in the shallower areas of the lake, with numbers dropping down steeply in the deepest central parts of the lake. The shallower areas are also those that are more vegetated and also the food resources could be reached more easily by dabbling and skimming on the surface rather than diving which is more energetically demanding. The number of Ferruginous Ducks dropped down significantly after the depth of 1,5m (G-3.3 on the graphs). The distribution varied between years (*Graph3*) mainly due to the dynamic of the wetland conditions linked to the variation in the water level (see graph bellow – blue line is Ferruginous Duck).

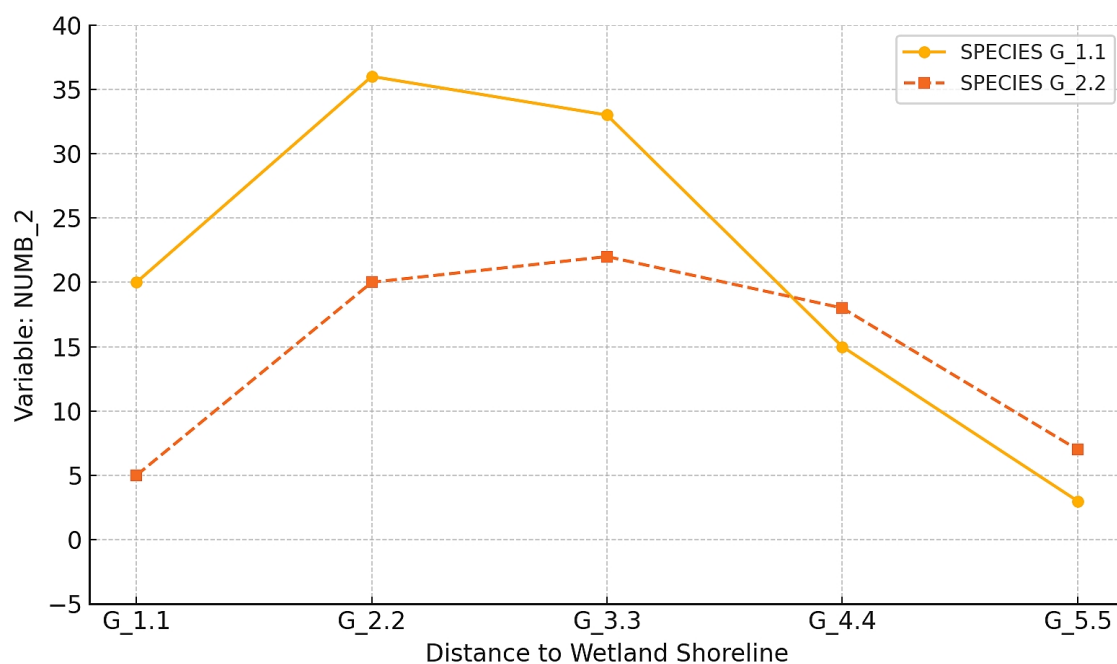


Graph 3

The graph clearly reveals the prevailing preference of the species towards shallow water areas. Further another factor that influences the species special distribution is the distance from the shoreline/edge of the wetland (*Graph 4*). The species shows clear preference to keep closer to



the shoreline (see the graph below, $F=78,108$, $p<0,0001$), which is in line with the other microhabitat preferences of the species towards the shallow mudflats and vegetated shallow areas of the wetland where it finds more abundant food resources and more easily accessible compared to the deeper areas. The selection is species specific ($F=39,113$, $p<0,0001$) and also influenced by the year ($F=3,739$, $p<0,01$). The distance is given in five bands (0-5m; 6-10m; 11-50m; 51-100m; >100m)



Graph 4

These factors are important in respect to potential habitat management measures that could influence the distribution and numbers of the species in the wetland. However, it is important to keep in mind that they are part of the complex ecological factors that influence the habitat and microhabitat selection in the species. In cases of momentum assessment of the species distribution during active feeding and zoobenthic biomass it has been revealed that the species does select

We can conclude that the Ferruginous Duck is a habitat specialist whose breeding success and distribution are closely tied to a combination of macrohabitat and microhabitat features within shallow freshwater wetlands. Key determinants of suitable breeding habitat include shallow water depths (typically <1.5/2 m), complex vegetation structure, and a mosaic of emergent, floating, and submerged plant communities. Emergent vegetation such as *Phragmites australis* and *Typha* spp. provides critical nesting substrate and concealment, while floating-leaved and submerged plants enhance food availability and shelter.

This species exhibits a marked preference for structurally diverse and low-disturbance wetland environments, especially where open water is interspersed with vegetated patches. Microhabitats like shallow mudflats and floating vegetation support rich invertebrate communities—particularly Chironomid larvae—vital for duckling development.



Importantly, the Ferruginous Duck demonstrates a moderate degree of ecological flexibility by utilizing both natural and artificial wetlands, such as fishponds and reservoirs, provided they mimic natural conditions and maintain appropriate vegetation structure. Regression and factorial analyses further confirm that total vegetation cover, water depth, presence of floating vegetation, and proximity to the shoreline are significant predictors of species presence and abundance.

Overall, conservation strategies should emphasize the preservation and restoration of wetlands with heterogeneous vegetation, controlled water levels, and minimal human disturbance during the breeding season. Fine-scale habitat management—including maintaining vegetated shallow zones, limiting grazing and reed cutting, and enhancing emergent vegetation near open water—can significantly improve habitat suitability and support the persistence of Ferruginous Duck populations.



Breeding site of former fishpond Orsoya on Danube River was a typical diverse mosaic wetland habitat.

5. Breeding Ecology

The Ferruginous Duck breeds primarily in late spring and early summer, with nesting activities generally commencing from April to June depending on the region (BirdLife International, 2023). Preferred nesting habitats consist of dense emergent vegetation such as *Phragmites australis* (common reed), bulrushes (*Typha* spp.), and other aquatic plants that provide essential cover and concealment for nests. The Nests are typically described in older literature to be constructed near or just above the waterline on floating or semi-floating platforms made from plant material, offering protection from terrestrial predators and environmental fluctuations (Cramp & Simmons, 1977; Székely et al., 2006). However, this varies with the conditions in the wetland and usually solid structure is required as a base even if it is part of floating reedbed or alike.

The species initiates breeding between late April and June, depending on latitude and water availability. In NE Algeria, Samraoui & Samraoui (2007) report an average clutch size of 10.1 ± 2.3 eggs, with incubation periods of 25–28 days. Eggs hatch after 25–28 days. Only one brood is



reared per year. Brood size varies from 3-12 ducklings. Fledging takes 55-60 days (Robinson & Hughes, 2006). Other publications from Algeria report Females with broods and chicks make their apparitions in the 2nd week of June (Rizi et al., 2016) and also stating that egg-laying by Ferruginous Ducks starts in mid-April and ended in the second half of June, with mean egg-laying date around the end of May (Djelailia et al., 2017). Petkov (1997) observed families ranging from 6 to 14 ducklings, with fledging success strongly correlated with water depth and disturbance levels. The breeding period in Bulgaria is roughly similar to that reported for Algeria (Petkov, 1997), but it is likely that some of the birds in mid and late April are still migrants as the species breeds further North as well. However, the second decade of May is full breeding season, while in June you notice the first lone males and male gatherings that will flock together for the moulting. In China breeding period is reported as May -June with females laying 6-11 eggs in early June (Xumao & Maming, 2014).

Some publications from North Africa region (Rihane & Abdeslam, 2012) report earlier dates for initiating clutches - late March/early April and nesting site located in stand of bushy vegetation including Tamarisk stands. In the same publication it is reported that four pairs altogether produced 30 ducklings as broods, but no subsequent data on survival to fledging.



Nest location is a key factor influencing reproductive success in birds, and habitat choice is considered the main way in which birds select nest sites. According to Samraoui et al. (2017), at Lake Tonga (NE Algeria), “nests were mainly located in the dense stands of *Typha angustifolia*, *Phragmites australis*, and occasionally *Scirpus lacustris*, providing optimal cover from predators and climatic exposure.” Similarly, Samraoui et al. (2006) found that 86% of nests in NE Algeria were placed within 2 m of the water’s edge and in stands of emergent vegetation, often elevated on platforms of broken reeds and plant material. Floating nests or those placed in flooded reedbeds were more successful, particularly in dense, undisturbed reed stands.

The study at Durankulak Lake, Bulgaria (Petkov & Mitev, 2003), supports these findings: “The species was predominantly found breeding in transitional areas between open water and



reedbeds, where fragmented strips and patches of *Phragmites australis* and *Typha* spp. provided shelter and quick access to feeding areas.”

It tends to select nest sites near vegetation edges, within close proximity to the shoreline, and avoids deeper open-water areas and steep banks. The nest site selection in Srebarna Lake managed reserve (Natura 2000 SPA site - BG0000241) is linked again to immediate access to water on the floating reedbeds (N. Petkov - unpublished data) within reed stands and thick vegetation including emergent hygrophytes and fern that develops on these floating reedbeds.

Petkov & Mitev (2003) emphasizes the importance of reed-water edge heterogeneity: “The abundance of the Ferruginous Duck increased with the length of contact zones between reedbeds and open water, suggesting that this interface plays a critical role in habitat selection.” The authors also report that shallow wetlands with diverse plant communities, moderate eutrophication, and limited disturbance were preferred.

Clutch sizes usually range from 7 to 10 eggs, with an incubation period of approximately 24 to 26 days, entirely undertaken by the female (Cramp & Simmons, 1977). The eggs are incubated carefully to maintain stable temperature and moisture conditions critical for embryo development. Upon hatching, the ducklings are precocial, fully feathered, and capable of leaving the nest within hours. They immediately begin to feed on aquatic invertebrates, including insect larvae, mollusks, and crustaceans, which are vital for their rapid growth and development. As they mature, their diet becomes increasingly omnivorous, incorporating a higher proportion of seeds and aquatic vegetation (Alonso et al., 2012).

Breeding success in Ferruginous Ducks is closely tied to the stability of water levels in their wetland habitats during the nesting season. Flooding can submerge nests, causing egg loss, while drought can lead to desiccation and increased predation risk if vegetation cover is reduced (BirdLife International, 2023). Human disturbances such as water regulation for agriculture or fish farming, reed harvesting, and recreational activities pose significant threats by degrading nesting habitats or directly disturbing breeding pairs (Székely et al., 2006; Alonso et al., 2012).

Water level is a key driver of nesting success. In Algeria, Samraoui et al. (2006) noted that “fluctuating water levels caused by seasonal droughts or human interference led to significant nest losses through flooding or desiccation.” Nesting densities were higher during years with stable water levels, allowing safe incubation throughout the breeding season. This is easy to explain as the species nests in areas close to water and around the water level and variation of the water column could flood or leave the nest on dry ground and this leads to abandoning of the nest by the female.

Predation by mammals (e.g., foxes, minks, otters) and birds (e.g., gulls, raptors) is a natural risk; however, habitat degradation and fragmentation often increase vulnerability by limiting safe nesting sites (Cramp & Simmons, 1977). Conservation measures that maintain stable hydrology, protect dense reedbeds, and minimize disturbance have been shown to improve breeding success.

Nest predation is a major factor affecting breeding success. Samraoui & Samraoui (2007) noted: “Predators such as snakes (*Natrix maura*), rodents, and corvids (e.g., *Corvus corone*) accounted



for up to 30% of nest failures.” The study emphasized the role of vegetation density and remoteness in mitigating predation pressure.

In Bulgaria, while specific predators were not always identified, Petkov & Mitev (2003) cited similar challenges, noting that “predation and human disturbance, especially reed cutting during the breeding season, contributed significantly to breeding failure.”

Compared to closely related diving ducks such as the Tufted Duck (*Aythya fuligula*), the Ferruginous Duck’s preference for dense reedbed nesting and smaller, more localized populations makes it more sensitive to habitat changes (Alonso et al., 2012). This specificity underscores the importance of targeted conservation actions tailored to their unique breeding ecology.

Studies in the Mediterranean region suggest that nest cover provided by vegetation can be a major determinant of breeding success. The likelihood of a successful nesting outcome of Ferruginous Ducks significantly increased with vegetation height. In the hot Mediterranean summer, tall vegetation may provide relief against heat stress for eggs, chicks and adults, whose survival is enhanced by better cover against sun exposure (Amat and Masero 2004; Touati et al. (2017). Heat stress is a common cause of breeding failure for exposed nests. Cherkaoui et al. (2016) show that the breeding of the Ferruginous Duck is highly associated with emergent vegetation species richness, which is consistent with Green (1998), who has stated that the Ferruginous Duck made extensive use of the mixture of emergent vegetation. Floating leaved vegetation like *Nymphaea alba* could serve as hiding space for newly hatched ducklings (Zogaris & Handrinos, 2003).

The Ferruginous Duck being a habitat specialist relies on shallow, well-vegetated freshwater wetlands for successful reproduction. Optimal breeding habitats feature a mosaic of emergent, floating, and submerged vegetation, offering a combination of nesting substrate, concealment, and foraging resources. Nest site selection is influenced by proximity to water, vegetation density, and edge complexity between reedbeds and open water. Reproductive success is strongly affected by hydrological stability and low disturbance levels. Conservation efforts should prioritize maintaining structurally diverse wetland habitats, regulating water levels to mimic natural hydrological cycles, and limiting human disturbances during the breeding season.





6. Threats to Breeding Sites

The key threats to breeding habitats of the Ferruginous Duck include:

➤ *Hydrological alterations*

Water limitations due to seasonal droughts pose another potential threat to breeding waterfowl. Spatial and temporal disparities in environmental resources may provide clearer indications of ultimate habitat selection. Hydrological regime is a primary determinant of habitat suitability for breeding diving ducks. Fluctuations in water levels—whether due to natural variability or anthropogenic interventions such as dam operations, irrigation, and drainage—can significantly affect nest site availability, breeding success, and duckling survival (Green et al., 1996; Kloskowski, 2006).

Diving ducks such as the Ferruginous Duck typically nest in shallow, vegetated wetlands with stable water levels during the breeding season. Sudden water level increases may flood nests, while declines can expose them to predators or desiccation (Samraoui & Samraoui, 2007; Petkov et al., 2017b). In Srebarna Lake (Bulgaria), for instance, Petkov (2006) observed significant reduction in breeding densities in years with extreme water level fluctuations. Water level fluctuations at Srebarna Lake were found to be a key factor influencing the breeding success and population trends of the Ferruginous Duck. Statistical analysis revealed a strong positive correlation between spring water levels and the number of breeding individuals ($r = 0.87$, $p < 0.001$), underscoring the species' dependence on stable hydrological conditions. Low water levels during the breeding season expose nests to predation and desiccation, while late and excessive flooding may drown active nests. Nesting typically occurs on floating reedbeds or in pools within reed-dominated areas, both of which become inaccessible or degraded under fluctuating conditions. Additionally, the loss of shallow, vegetated microhabitats due to water level changes reduces the availability of foraging and brood-rearing sites. Years with reduced water levels at Srebarna coincided with sharp declines in breeding numbers, while habitat restoration via reconnection to the Danube in the mid-1990s facilitated a gradual recovery of the population. These findings highlight the species' sensitivity to hydrological disturbance and reinforce its value



as a bioindicator of wetland health. Similarly, in Algeria, Samraoui et al. (2006) reported up to 40% nest loss due to seasonal drought and water drawdown.

Hydrological instability can also reduce aquatic vegetation cover and invertebrate biomass, critical for feeding ducklings during early development stages (Kloskowski, 2005). Moreover, altered flooding regimes can limit the formation of optimal breeding microhabitats, such as emergent reedbeds or floating mats, further restricting suitable nesting sites (Cherkaoui et al., 2016).

Stable hydrological conditions, particularly during May–July, are thus essential for supporting viable breeding populations. Wetlands with managed water regimes that mimic natural seasonal cycles—gradual spring inundation followed by summer stability—tend to support higher occupancy and reproductive success among diving duck species (Gibbs et al., 1991; Kostecke et al., 2004).

➤ *Wetland drainage and land reclamation*

Any wetland conservation and management must consider proximity to land uses that may present threats to breeding waterfowl. Wetlands near farmland must be monitored carefully to address threats to nest and brood survival. Determination of conservation areas for waterfowl broods should include an assessment of current and future adjacent land use particularly as shifting climate conditions affect water usage.

The direct impacts of drainage and agricultural reclamation change regional water balance, and the wetlands hydrology and water cycle could be greatly changed, especially influencing the surface water and runoff of wetlands. Wetlands are biologically diverse transition zones between terrestrial and aquatic environments that are inundated or saturated by water all or part of the year, such that they support vegetation adapted to those conditions. Neither land nor sea, humans have intimately interacted with wetlands over at least the last 6000 years, exploiting them for their stocks of waterfowl, fish, marsh grass, reeds, and peat. Human perception and modes of exploitation of wetlands have evolved over time from periods of coexistence to reclamation (drainage and transformation to a terrestrial environment) in correlation with changing demographic, economic, environmental, and technological conditions. Wetland loss is concentrated in Europe, China, and the United States, where wetland loss has exceeded 75% in some regions (Fluet-Chouinard *et al.*, 2023). The loss of lakes and wetlands in Europe is a major environmental problem with far-reaching impacts on ecosystems, biodiversity, water resources and humans. Over the years, the condition of many lakes and wetlands in Europe has deteriorated and many have disappeared due to urbanization, agriculture, drainage, pollution and, more recently, climate change. Between 75 % (Netherlands) and 90 % (e.g. Ireland) of the wetlands in the EU Member States have been lost.

➤ *Pollution from agriculture and industry*

Pollution from agriculture and industry poses a significant threat to the quality and ecological integrity of wetlands used by diving ducks for breeding. Nutrient runoff from fertilizers (particularly nitrogen and phosphorus) leads to eutrophication, causing dense algal blooms that reduce water oxygen levels and alter aquatic plant and invertebrate communities, which are essential food sources for ducklings (Gibbs et al., 1991; Green et al., 2002).



Turbidity and elevated chlorophyll-a concentrations are widely recognized as key indicators of eutrophication in freshwater wetlands, often resulting from nutrient enrichment due to agricultural runoff and industrial discharges. These conditions have substantial ecological consequences for aquatic habitats, particularly those used by breeding diving ducks such as the Ferruginous Duck.

In the case of Srebarna Lake (NE Bulgaria), long-term monitoring revealed a strong negative correlation between chlorophyll-a concentration and Ferruginous Duck numbers ($r = -0.79$ to -0.89), alongside a positive correlation with water transparency ($r = 0.83$ to 0.91), emphasizing the species' sensitivity to eutrophic conditions (Petkov, 2006). Increased turbidity from algal blooms reduces water clarity, disrupting submerged macrophyte growth and leading to a decline in invertebrate populations, especially benthic organisms such as Chironomidae larvae that are essential food for ducklings (Green et al., 2002; Kloskowski, 2005).

Chlorophyll-a serves as a proxy for phytoplankton biomass and is directly influenced by nutrient loading—particularly nitrogen and phosphorus—originating from fertilizers, livestock effluent, and sewage (Carpenter et al., 1998). Excessive algal growth reduces oxygen levels during decomposition (hypoxia), alters food webs, and can create conditions inhospitable to both aquatic vegetation and invertebrates. These changes affect not only food availability for waterfowl but also nesting success, as dense floating algal mats can interfere with nest stability and brood mobility.

Multiple studies have highlighted how eutrophication leads to habitat degradation in key breeding wetlands across Europe and North Africa. In Morocco, Cherkaoui *et al.* (2016) found that high chlorophyll-a levels were linked to reduced nesting density and breeding success of Ferruginous Ducks. Similarly, in Central Europe, eutrophic wetlands with excessive nutrient inputs showed a decline in submerged vegetation and reduced occupancy by diving duck species (Zhmud, 2003; Robinson & Hughes, 2003). These findings suggest that eutrophication thresholds—once crossed—can result in rapid declines of specialist wetland bird populations.

To mitigate these impacts, wetland conservation efforts must address nutrient input reduction through buffer zones, sustainable farming practices, and improved wastewater treatment. Regular monitoring of turbidity and chlorophyll-a levels, combined with bird-based indicators such as Ferruginous Duck, can provide early warning signals of ecosystem degradation and guide adaptive management strategies.

Excessive eutrophication also degrades emergent and submerged vegetation used for nesting and concealment. In severe cases, cyanobacterial blooms can become toxic, impacting chick survival and reducing wetland attractiveness for breeding ducks (Cherkaoui *et al.*, 2016). Pesticides and herbicides applied to nearby agricultural lands can accumulate in wetland sediments and aquatic organisms, affecting reproduction through eggshell thinning, embryo mortality, and disruption of endocrine function (Mineau & Whiteside, 2013).

Industrial effluents containing heavy metals, oil residues, and organic pollutants contribute further to wetland degradation. Contaminants such as lead, cadmium, and mercury have been detected in waterfowl tissues and can reduce hatchability, impair behavior, and cause mortality (Scheuhammer et al., 2007). These pollutants also diminish macroinvertebrate diversity and



biomass, directly affecting the food supply of diving duck broods during critical early development stages (Kloskowski, 2005).

Sustained exposure to agrochemical and industrial pollutants reduces the carrying capacity of breeding wetlands and contributes to long-term population declines in sensitive diving duck species, such as the Ferruginous Duck and Common Pochard. Conservation of these species depends on improved land-use practices, pollution control, and restoration of water quality in key breeding habitats.

➤ *Disturbance from fishing and recreation*

Human activity causes wintering waterfowl to expend energy to avoid humans at a time in their annual cycle when energy conservation is important to survival, migration, and breeding reserves. Boating, heavy machinery, and construction near breeding wetlands significantly reduce nesting success. In an urban UK setting, disturbance from redevelopment activity forced wintering *Aythya* ducks to abandon feeding areas on 75% of days, with particularly severe impacts during cold spells. Similar pressures likely apply during breeding: habituation is limited, especially in high-disturbance areas. Animals balance costs of antipredator behaviors with resource acquisition to minimize hunting and other mortality risks and maximize their physiological condition. This inherent trade-off between forage abundance, its quality, and mortality risk is intensified in human-dominated landscapes because fragmentation, habitat loss, and degradation of natural vegetation communities is often coupled with artificially enhanced vegetation (i.e., food plots), creating high-risk, high-reward resource selection decisions.

One of the significant yet often under-addressed threats to Ferruginous Ducks during the breeding season is human disturbance, particularly in the form of poaching and uncontrolled access to breeding habitats. Long-term observations at Durankulak Lake (Petkov, 2003) demonstrate that despite the availability of high-quality wetland habitat, breeding success is severely compromised in years with elevated disturbance. Nocturnal poaching and illegal fishing activity, especially in sensitive areas such as Eagle Marsh, frequently result in nest abandonment, suppressed breeding effort, or failure to rear young. In some years, despite the presence of 10 or more breeding pairs, no broods were observed, highlighting the extent to which disturbance disrupts reproductive output. Furthermore, evidence of abandoned ducklings and female desertion suggests that persistent disturbance may also compromise adult condition and maternal care. The study found a strong positive correlation between the number of breeding pairs and both brood presence ($r = 0.79$) and total duckling counts ($r = 0.85$), reinforcing the conclusion that disturbance not only affects habitat occupancy but directly impacts reproductive success. Even within the same wetland, Ferruginous Ducks consistently avoided disturbed zones and concentrated in more secluded reedbeds, indicating high sensitivity to human presence. The findings underscore the urgent need for stricter enforcement of protective regulations, improved public access control, and awareness campaigns in key breeding sites to reduce human pressure during the critical breeding period.

For dabbling ducks such as Mallards (*Anas platyrhynchos*), repeated human intrusion—whether from pedestrians, cyclists, anglers, or surveyors—leads to increased nest abandonment and up to 10% nest failure rates.

Masto *et al.* (2024) investigated how human access modulates mallard resource selection across wetlands during autumn and winter, using GPS-tracked movements of 426 individuals. They found that during the hunting season, mallards strongly avoided areas with daytime human



access, instead showing a preference for high-quality foraging patches at night when humans were absent. Even after the hunting season, habitat use did not immediately return to pre-hunting levels, suggesting a lingering wariness of human-disturbed areas. To maintain the ecological function of wetlands for breeding, overwintering and migratory waterfowl, management must go beyond habitat restoration and food provisioning. This study highlights that reducing human disturbance—especially during the day—is critical for allowing waterfowl species to use key habitats effectively. Integrating spatiotemporal zonation to limit human activity into existing management frameworks will improve habitat effectiveness, reduce stress-induced behavior, and contribute to the long-term conservation of migratory waterfowl populations.

➤ *Invasive species*

The impacts of invasive alien species in Europe Invasive alien species (IAS) are one of the most important direct drivers of biodiversity loss and ecosystem service changes, and constitute the greatest threat to fragile ecosystems such as islands. Although the introduction of alien species is known to bring benefits to specific sectors of society and produce high economic profit and social welfare in the short term, they may have far-reaching and harmful effects on biodiversity and natural resources for generations.

Study from southern Spain (Mediterranean shallow lakes) documented how common carp reduce submerged vegetation and benthic invertebrates—critical food for diving ducks such as White-headed Duck (*Oxyura leucocephala*) and Common Pochard — leading to sharp declines in their populations. When carp were eradicated using rotenone, waterbird numbers recovered; however, reinvasion reversed these gains. In SE Europe species like Carp are naturally occurring, but in the Grass carp (*Ctenopharyngodon idella*) can have significant negative effects on ducks breeding in Europe—particularly species that rely on aquatic vegetation and corresponding invertebrate prey. Grass carp are introduced to control excessive aquatic plants but often consume submerged macrophytes indiscriminately—a critical habitat component for many waterbird species. European cases (e.g., Masurian Lakes, Poland) reported extensive vegetation disappearance: *Chara*, pondweeds, and *Elodea* vanished, and reed swamps shrank by ~66%, severely degrading nesting and feeding areas. The introduction of this non-native species has also caused habitat degradation, e.g. the stocking of lakes with and accidental introduction of grass carp has caused reductions in plant and animal biomass available for the ducks to feed on. Removal of vegetation reduces benthic invertebrates (like chironomids and snails) that diving ducks feed on, further impacting food availability. Introducing grass carp into European breeding wetlands often reduces aquatic vegetation and invertebrates, harming herbivorous and diving ducks through degraded nesting and feeding grounds. Even low-density carp populations have shown marked negative effects.

Long-term monitoring revealed that nest predation by invasive carnivores, notably American mink (*Neovison vison*) and raccoon dog (*Nyctereutes procyonoides*), disproportionately decreased breeding success in wetland-nesting diving ducks. Experimental and observational work confirms that mink and raccoon dog predation near wetlands significantly reduces the success of duck nests, including diving species (Holopainen *et al.*, 2021).

One of Europe's most invasive shrubs – the False Indigo Bush (*Amorpha fruticosa*) forms dense thickets, fixes nitrogen, enhances soil fertility, and often outcompetes native riparian plants, leading to reduced plant diversity and altered ecosystem functioning. In Obedska Bara (Serbia), the False Indigo bush has colonized ~11% of the reserve (wetlands, meadows, ponds),



necessitating active management like grazing and soil tarping to control its spread. The invasive plant has covered large parts of wetland and riparian habitat along the Danube section of Bulgaria altering the wetland habitat and plant diversity significantly and creating suitable conditions for predators. Replacing diverse undergrowth with dense shrub layers can negatively affect species that depend on open or mixed-structure habitats—especially ground-nesting or shoreline nesting waterfowl.

➤ Climate change impacts

Though not reported for Ferruginous Duck, but for similar conspecifics - Common Pochard and Tufted Duck (*A. fuligula*) have shifted timing of arrival and potentially breeding due to warmer winters, improving female body condition before clutch initiation—with implications for reproduction (Gadjosova, et al., 2023). However, winter habitat degradation (e.g., eutrophic, low-transparency in fishponds) tied to climate and management practices can offset benefits, negatively affecting duckling survival. Warming climate leads to ducks are moving northward in both wintering and breeding ranges, tracking milder temperatures—a pattern seen broadly across dabbling and diving ducks. Predictive models forecast significant contractions (>50%) of breeding ranges for many wetland species, with breeding range centroids shifting ~5 km per year northward (Soultan et al., 2022).

In Mediterranean wetlands like Doñana (Spain), climate-driven changes (e.g., shorter hydroperiods, increased salinity) are reducing suitability for diving ducks such as Ferruginous Duck, Common Pochard, and Red-crested Pochard—leading to population declines and local breed extinctions. Changes in precipitation and drought patterns could severely degrade shallow wetlands crucial for breeding hence impacting territorial and foraging needs. In Bulgaria many of the major wetlands along the Danube River are impacted by severe droughts leading to complete or partial loss of water in mid/late summer and even early spring, compromising the breeding period for Ferruginous Duck and other waterfowl. The impact of water level on Ferruginous Duck numbers is well documented in Petkov (2005).

Altered food webs—like shifts in invertebrate emergence or plankton—can delay duckling growth, reduce survival, and create mismatches in feeding phenology. Fishpond food web changes combining nutrient loading and warming reduce food availability for diving chicks.

- Habitat loss: Reduced water levels and wetland shrinkage eliminate breeding territories and nesting sites (e.g., islands, emergent vegetation).
- Hydrological instability: Fluctuating moisture and salinity compress the breeding season window, potentially disrupting nesting success.
- Shifted distributions: Many breeding populations may be forced northward or to higher altitudes due to drier or more saline conditions.

7. Site-Specific Assessments

7.1 Srebarna Lake

Situated in northeastern Bulgaria along the southern bank of the Danube River, is a vital freshwater wetland recognized for its rich biodiversity and ecological importance. The lake and



its surrounding habitats have been designated under multiple conservation frameworks, including the **Important Bird Area (IBA)** program and the **Natura 2000** network. Habitat quality has declined due to siltation, water regulation, and encroachment of terrestrial vegetation. Restoration measures are needed to manage water levels and reed dynamics.

Srebarna Lake has been identified as an IBA (site code BG033) by BirdLife International due to its significance for bird conservation. The site meets several IBA criteria, notably:

- **A1:** Species of global conservation concern
- **A4i:** Congregations of waterbirds
- **B1i:** Globally threatened species
- **B2:** Species with a restricted range
- **B3:** Biome-restricted species
- **C1-C6:** Various conservation criteria

The IBA encompasses an area of approximately 1,448 hectares and includes diverse habitats such as open water, reedbeds (*Phragmites australis* and *Typha* spp.), and flooded forests with *Salix* and *Populus* species. These habitats support a wide array of bird species, including the globally threatened Dalmatian Pelican (*Pelecanus crispus*), Pygmy Cormorant (*Phalacrocorax pygmeus*), and Ferruginous Duck (*Aythya nyroca*).

Srebarna Lake is also part of the European Union's Natura 2000 network, designated under both the Birds Directive and the Habitats Directive. Specifically, it is recognized as:

- **Special Protection Area (SPA):** BG0000241
- **Special Area of Conservation (SAC):** BG0000169



Typical mosaic habitat with high interspersion of reedbeds and open water habitats in Srebarna Lake



The SPA designation, established in March 2007, aims to protect bird species and their habitats, while the SAC designation focuses on the conservation of natural habitats and other species of interest. The combined area under these designations covers approximately 6,672 hectares .

Conservation Measures and Management

The integration of Srebarna Lake into these conservation frameworks has led to the implementation of various management and restoration measures, including:

- **Hydrological Restoration:** Re-establishing the connection between the lake and the Danube River to maintain natural water levels and improve habitat conditions.
- **Habitat Management:** Controlling reed overgrowth and maintaining open water areas to support diverse bird communities.
- **Monitoring and Research:** Conducting regular surveys and studies to track bird populations and habitat changes.
- **Public Awareness and Education:** Establishing visitor centers and educational programs to promote conservation awareness.

The most important factor affecting a substantial change of the ecological nature of the Srebarna Lake and its surrounding areas is the construction of the dykes during the 1940s. The unfavorable effects of this are interruption of access of water from the Danube to the lake causing complete disturbance of the natural water regime of the wetland, interruption of the seasonal flow-through of the water, accelerated eutrophication and succession. Attempts to restore the link to the Danube were made in 1968 when a sluiced channel was excavated, and in 1979, during the building of a dyke, and also in 1994 during which a new canal with two sluices was constructed. The latter succeeded in improving the connection and circulation of the water from the Danube into the lake is possible during high-water level events.

These efforts have contributed to the preservation and maintaining of Srebarna Lake's ecological integrity, however they come short in ensuring the necessary ecological conditions for the ensuring its continued role as a critical habitat for numerous bird species and other wildlife. In 2025 despite rehabilitation measures to ensure more waterflow into the lake the conditions are severe drought and degradation of some areas, that lead to management authorities engaging into water transfer from Danube River with pumps. The level of Danube has been very low in 2025 and no significant flooding has occurred in any of the major wetlands. In the peak of its reflooding in the late 1990 and early 2000s the site supported one of the largest breeding populations of the Ferruginous Duck with 70-80 + pairs. However, in current conditions there are some tens of pairs and with doubtful breeding success.

Detailed microhabitat and habitat selection studies have been done in this particular site and has been presented in the previous sections of the report based on studies in the period 2001-2003, when the ecological conditions for the Ferruginous Duck have been favourable in the wetland. The breeding numbers of the species have reduced significantly as they are influenced by the water level condition as indicated by Petkov (2006). Further efforts are needed to mitigate the



climate change impact and the deteriorating impact of the Iron Gates reservoir on the lower Danube water level and natural flow.

7.2 Belene Marshes

Situated on Persina Island along the Danube, the marshes have seen a decline from 56 breeding pairs due to drying trends and altered hydrology. Restoration efforts should focus on re-establishing seasonal flooding and maintaining open water patches.

Belene Islands Complex IBA consists of three large marshes with open-water patches, floating vegetation, and reed fringes (*Phragmites*, *Typha*, *Sparganium*, *Alisma*), surrounded by seasonally flooded willow and poplar forests, and wet meadows. Belene Islands encompass ~6 898 ha with three freshwater swamps connected via canals to the Danube, managed under Persina Nature Park. Primary threat: lowered water levels resulting from the Iron Gate dam and dyking operations, causing marsh drying and impacting breeding colonies.

A major wetland restoration project under the Danube-Black Sea Strategic Partnership targeted Belene Island (in Persina Nature Park): re-establishing hydraulic connectivity to flood marshes and monitoring ecological recovery, however in recent years it suffers the same low water pressure as many Danube riverside wetlands. In the peak following its restoration in 2010-2015 the site became the most significant breeding area for the Ferruginous Duck in Bulgaria with probably more than 70-90 breeding pairs in the marshes of the island. Currently the vegetation succession and droughts have severely impacted the species population.



Belene island in 2009 and marshes are still with limited flooding.





Belene island in 2014 with larger flooded areas in the peak of the summer in August

During the period of spring high water level of Danube river lower parts of the island are flooded. The flooding usually starts in March and continues until June when the water level of Danube reaches its maximum. The duration of the inundation of the islands depends on the elevation of the land. The water level of the marshes depends on Danube water level and underground waters as well. The depth of the marshes is between 1 and 2.5 m at high spring water levels. During the summer they gradually become shallow and often totally dry up. During the winter, in January and February marshes often freeze, but nowadays in winter the marshes are usually empty and dry. In the beginning of seventies was built the “Iron Gate” Dam in Serbia, which influence on the downstream water level of Danube. In 1970 the island was separated from the Danube with an embankment. At the end of the canal was building a sluice, allowing regulation of the water level in the marshes. Small dikes were built between the marshes separated them one from another. In the beginning of 1980s, a drainage system with 3 pumping stations was build and start to operate. The water level were maintained very low (0.5 – 0.6 m. depth in maximum) and the marshes dry up every year, usually in the middle of August. This has resulted in the fast overgrowing of the banks with rush, reed and willows, so that presently they cover more than 1/3 of the total area of the marshes.





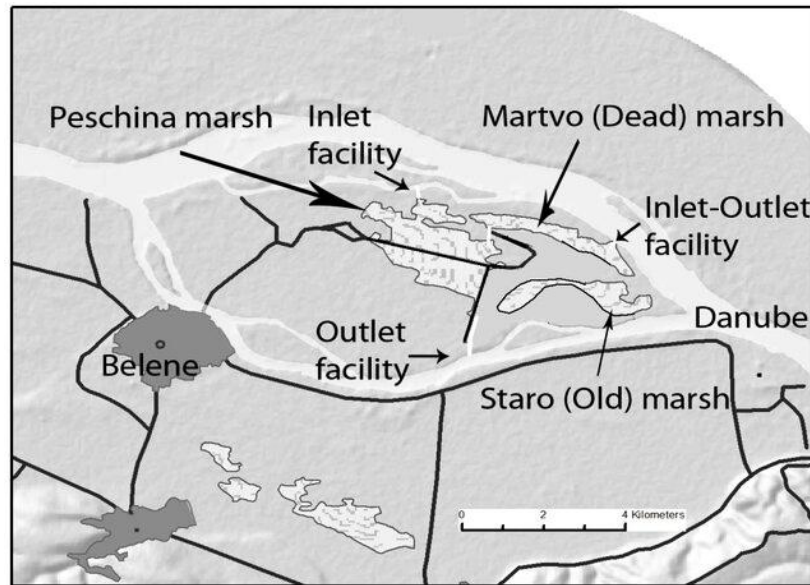
Aerial view of one of the marshes on Belene island in high water conditions

Belene complex is Bulgaria's largest group of islands in the Bulgarian part of the Danube River. The complex is located between 560 and 576 km, opposite the town of Belene, and 18 km west of the town of Svishtov. Elevation above sea level is 25.5 m. It has formed naturally by the processes of sediment transport and deposition. Presently, this group includes two larger and 15 smaller islands. The largest is Belene Island with its three fresh-water swamps, together with their surrounding old-growth riparian forests of *Alnus*, *Salix* and *Populus*. The three swamps are interlinked and drained in the Danube river through a canal. During high-spring waters and if the guard of the canal is open fresh water flows into the swamps. The withdrawal of the water coincides with the high summer temperatures, resulting in overgrowth of summer vegetation. This complex covers 6 897,58 ha, of which 1 714 ha of them are designated protected areas. The terrestrial territory of the Belene Complex is a part of the designated in the year of 2000 Nature park Persina. There are two reserves in the complex – the islands of Milka and Kitka established in 1956 and 1981 for protection of the unique riverine flooding forests. The Managed reserve “Persina east” and the adjacent buffer zone as well as the Protected site “Persina East” were designated in 1981 for protection of representative wetlands with characteristic habitats and nesting sites of terns, ducks and geese. In 1998 the Persina (Belene) island was proclaimed a CORINE site due to its significance for protection of rare and threatened habitat, plants and animals including birds on European level. The territory is proclaimed as an Important Bird Area in 1989 by BirdLife International. The complex falls into the boundaries of Natura 2000 protected sites according to both the Birds and Habitats Directives. In 2002 the complex is proclaimed a Ramsar site. Belene complex is an IBA. The site meets several IBA criteria, notably:

- **A1:** Species of global conservation concern
- **A4i:** Congregations of waterbirds
- **B1i:** Globally threatened species
- **B2:** Species with a restricted range



- **B3:** Biome-restricted species
- **C1-C6:** Various conservation criteria



Scheme of the sluices allowing water in and out of the wetlands on the island.

Persina Nature Park is established on December 4th 2000 and covers an area of 21 762 ha. In the period between 2002-2008 was implemented the project “Wetlands Restoration and Pollution Reduction Project GEF TF 050706 BUL”. Kalchev et al. (2010) consider that the results obtained from the restoration were less significant than those announced by the objective of the original project. The water surface area did not statistically change pre-versus post-restoration. However, from ornithological perspective the restoration has revived the marshes and allowed restoration of much of the wetland birds occurring previously in the area. Currently due to climate related changes with reduced rainfall and lower levels of Danube River, lack of spring and early summer high waters (partially linked to Iron Gates dam) the conditions in the marshes have changed significantly and some adjacent flooded area also frequented by the Ferruginous Duck have disappeared and the marshes succession has speed up. Still considerable good breeding habitats on the island exist, but the population no longer flourish as it used to be in the 2008-2015.

7.3 Kalimok Complex

The Kalimok Complex includes a large former Danube River bank marsh located north of the village of Nova Cherna that was transformed into fishponds, the Bezimenen (Nameless) Island covered by flooded forests, as well as the section of the Danube bank between them. The marsh was drained during the 50s. It was separated from the Danube by a dyke and with drainage channels. Because the lands are not suitable for agriculture, fishponds are build, the water surfaces of which are divided by wet and boggy meadows into two sections – eastern and western. The water basins get periodically dry and the water level is maintained by pumping water from the Danube. At present the fishponds are abandoned for economic reasons. South of the fishponds’ eastern part the wet meadows get transformed into a marsh.





High water level conditions in Kalimok Complex basins

In the 1990s Kalimok hosted 15–39 breeding pairs, benefiting from structured pond management. However, risks remain from changes in fish farming practices and water quality. Rotational harvesting and maintaining aquatic vegetation diversity are recommended. In the late 1990s the fishfarming was abandoned completely and the area is included in Natura 2000 site and designate also national protected territory. The Kalimok fish farms are internationally important for water birds along the Danube. Some 188 bird species, of which 61 are listed in Bulgaria's Red Data Book, have been established there. 85 of the species occurring there are species of European conservation concern (SPEC) (BirdLife International, 2004). This wetland provides suitable habitats to 71 species from Annex 2 of the Biodiversity Act (equal to Annex I of Bird Directive), which are in need of special protection measures. Of these, 64 are also listed in Annex I of Directive 79/409/EU. The fishponds are of a global importance for the Ferruginous Duck (*Aythya nyroca*) nesting here, as well as a resting site for the Dalmatian Pelican (*Pelecanus crispus*). One of the few nesting Black-winged Stilt (*Himantopus himantopus*) colonies are present here.





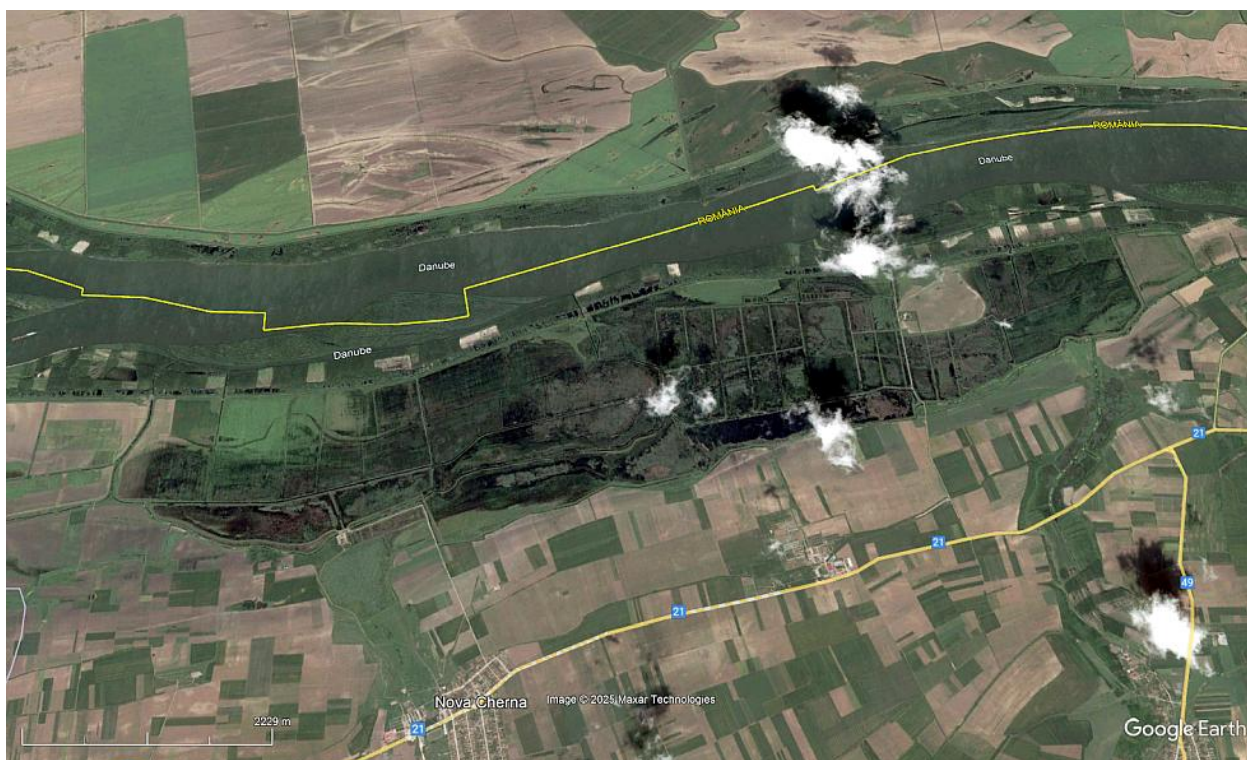
Summer high water conditions in Kalimok Complex

The former marsh and fishponds have been part of the same restoration project in the early 2000s – “Wetlands Restoration and Pollution Reduction Project GEF TF 050706 BUL”. Sluice system has been constructed and some of the ponds dikes destroyed to restore some more natural floodplain wetland character of the area. However in recent decade due to climate change with reduced precipitation and restricted water regime of Danube due to Iron Gates the marshes suffer severe water shortage and they dry up for quite long periods of time and in some years they do not provided sufficient breeding habitat for the Ferruginous Duck and other waterfowl species breeding there.

The implemented restoration measures had initial positive impact on the wetland reviving it for a certain period of time, but the succession of the marshes continues to be an ecological problem. The later leads to habitat degradation, closing of open water surfaces by reed and bulrush massifs and decrease of the population of species of high conservation value. Currently the detrimental impact of the prolonged dry period result in significant decline in waterbirds during breeding season, including the Ferruginous Duck breeding population.

Below are given example of the changing pattern of the flooding of the marshes.





Flooding situation in Kalimok Complex in May 2013



Flooding situation in Kalimok Complex in August 2020.

Identification and implementation of effective measures for limitation of the succession, through management of reed beds aiming at clearance of open water surfaces and canals, which are necessary for the migration and reproduction of fishes and restoration of the colonial nesting birds along with upscaled measures to maintain higher water level in the marshes and ponds. More efficient management of the flooding of the area is necessary and cleaning of the overgrown canals.



8. Management Recommendations

Conservation of breeding habitats for *Aythya nyroca* requires:

- **Maintaining water level stability** during nesting season.
- **Preserving and managing reedbeds**, especially fragmented mosaics and edges.
- **Limiting reed harvesting**, livestock grazing, and disturbance during breeding months.
- **Creating artificial nesting platforms or islands** in heavily modified wetlands.

Effective management of breeding habitats for the Ferruginous Duck requires a multifaceted approach that combines hydrological control, vegetation management, protection from disturbance, and active monitoring. Drawing from literature, as well as practices adopted for similar species like the Common Pochard (*Aythya ferina*) and Tufted Duck (*Aythya fuligula*), we propose the following measures:

Hydrological Management

- Maintain stable water levels between April and July, the key breeding season. Fluctuating water levels can destroy nests or reduce foraging opportunities for the species. A water level between 1 and 3m is deemed favourable, based on data and existing publications.
- Mimic natural flooding regimes in managed wetlands such as fishponds by slowly flooding reedbeds early in the breeding season to promote nest site establishment.
- In fishpond systems, implement rotational pond draining that avoids the breeding season and maintains a mosaic of habitat types.

Vegetation Management

- Preserve and restore extensive reedbeds, especially those that exhibit structural heterogeneity (e.g., variation in stem height and density). This promotes microhabitat diversity and reduces predator access (Petkov, 2001, 2003).
- Avoid mechanical reed cutting or burning during the breeding period. If necessary, conduct such management in winter and on a rotational basis.
- Promote the growth of submerged macrophytes like *Ceratophyllum*, *Myriophyllum*, and *Potamogeton* spp., which support invertebrate prey important for ducklings and adults along.

Recommendations for Reedbed Management to Enhance Breeding Habitat for Ferruginous Duck

By fostering heterogeneous reed-water boundaries and maintaining sheltered inlets and outlets, managers can create optimal breeding habitats that balance feeding, resting, and nesting needs of diving ducks, particularly the Ferruginous Duck. Adaptive water level management and minimizing disturbance further enhance habitat suitability.

- **Maintain and Enhance Line Heterogeneity of Reed-Water Interfaces**



- **Rationale:** The structural complexity at the boundary between reedbeds and open water is critical for diving ducks. Heterogeneous edges—characterized by irregular reed margins, patches of open water, and varied reed density—offer diverse microhabitats for feeding, resting, and predator avoidance.
- **Management Actions:**
 - Avoid uniform, dense reed stands extending continuously into the water.
 - Promote a mosaic of reed density by rotational cutting or partial clearing, creating a patchwork of dense, medium, and sparse reed areas.
 - Retain or create small channels and open water patches within the reedbeds to increase edge complexity.

Many publications emphasize the importance of structurally complex wetland edges for waterfowl habitat quality and demonstrated that reedbed edges with varied vegetation structure support higher diversity and abundance of diving ducks.

➤ **Preserve and Restore Inlets and Outlets to Provide Secluded Access and Resting Areas**

- **Rationale:** Natural or artificial inlets and outlets create sheltered, low-disturbance zones with calmer water and reduced predator presence. These areas are crucial for diving ducks to rest and safely access nests hidden deep within dense reedbeds. The Ferruginous Duck, in particular, benefits from such secluded access corridors due to its shy nature and preference for dense reed habitats.
 - **Management Actions:**
 - Protect existing natural inflows and outflows from alteration or pollution.
 - Where feasible, restore or create small, narrow inlet/outlet channels with gentle water flow, lined by emergent vegetation to maintain cover.
 - Ensure these channels connect open water to dense reed interiors, facilitating undisturbed movement.
- **Manage Water Levels to Support Reed Growth and Nest Accessibility**
- **Rationale:** Stable water levels that allow reedbeds to develop dense, stable stands are essential for nesting cover. Fluctuating or excessively low water levels can reduce reed density and increase predator access.
 - **Management Actions:**
 - Maintain water levels that support reed growth but avoid prolonged flooding that may drown reeds.
 - Implement water regime management mimicking natural seasonal fluctuations to stimulate reed regeneration and maintain habitat heterogeneity. The



controlled water level management improves reedbed quality for waterfowl breeding

➤ **Minimize Disturbance and Predation Risk in Reedbed Areas**

- **Rationale:** Ferruginous Ducks are sensitive to disturbance during breeding. Minimizing human access and predator ingress enhances breeding success.
- **Management Actions:**
 - Restrict human activities (boating, fishing) near reedbeds during breeding season.

Install predator exclusion measures where necessary, especially near key nesting sites.

Disturbance Control

- Restrict recreational and fishing activities near core nesting zones during the breeding season.
- Install buffer zones (at least 50–100 meters) around breeding sites using physical barriers or signs if necessary.
- Control invasive species such as *Amorpha fruticosa*, *Ailanthus altissima* or *Acer negundo* that may encroach on wetland margins and degrade nesting vegetation.

Predator Management

- Monitor populations of mammalian predators (e.g., American Mink, Red Fox, Raccoon Dog) and implement ethical control measures if evidence of predation is linked to nest failure.
- Encourage habitat mosaics that reduce predator movement pathways, such as maintaining open water belts between terrestrial habitats and reedbeds.

Habitat Restoration and Expansion

- Rehabilitate drained or degraded wetland areas adjacent to existing breeding sites to increase available habitat.
- Support re-wetting initiatives under agri-environmental schemes, especially in floodplain zones along the Danube.

Integrated Site Management

- Coordinate actions under Natura 2000 management plans and Ramsar site guidelines to ensure synergy between local and national conservation efforts. Engage stakeholders including fishpond owners, farmers, and local communities in participatory wetland management.

Adaptive Management and Research

- Apply adaptive management practices based on regular monitoring and field research.
- Encourage long-term ecological studies focusing on nest success, chick survival, and the effects of climate variability, food resources or other factors influencing the species.



Through targeted management, particularly at key breeding sites, it is possible to enhance reproductive success and stabilize the national population. Collaborative efforts among governmental bodies, NGOs, and local stakeholders are essential. These recommendations aim not only to protect existing breeding habitats but also to enhance the ecological resilience of wetland systems critical for the Ferruginous Duck and other associated waterbird species.





8.1. Management Guidelines for Breeding Ferruginous Duck (*AYTHYA NYROCA*)

Management Feature	Detailed Description	Justification / Evidence
1. Hydrological Regime	Maintain stable water levels (80–200 cm) throughout the breeding season (April–July); avoid sudden fluctuations caused by drainage or fishpond management. Periodic flooding beneficial before nesting to create early growth of emergent vegetation.	Ferruginous Ducks nest on platforms built over water, usually in dense emergent vegetation. Stable water is critical to prevent nest desertion or loss. In Doñana, Spain, and in fishponds of Bulgaria and Romania, hydrological instability has been linked to nesting failure.
2. Vegetation Structure & Habitat Mosaic	Preserve a mosaic of dense emergent (Phragmites, Typha), floating-leaved (Nymphaea, Trapa), and submerged aquatic plants. Ensure presence of open water patches for foraging near nesting zones. Encourage vegetation succession with varying management (cutting/grazing in some areas).	Nesting success depends on vegetation cover density (both concealment and support for nests). Open water access nearby allows ducklings to forage while remaining under cover. Overgrowth or vegetation collapse reduces habitat quality.
3. Fishpond Management Practices	Promote extensive fish farming regimes : – Low stocking densities – Use of polyculture (avoid predatory fish like pike/perch) – No complete drainage during breeding season – Avoid rotenone or herbicide treatments during breeding – Maintain fish-free zones where possible.	Intensive aquaculture often results in vegetation removal, eutrophication, and invertebrate decline. Predatory fish and frequent water-level changes directly harm ducklings and disrupt nesting. Low-intensity fishponds provide ideal habitat, especially in Central/Eastern Europe.
4. Nesting Substrate & Island Availability	Promote creation or conservation of floating islets , artificial islands, or vegetated platforms. Nesting is most successful when water surrounds nest sites and vegetation is tall (>1 m).	Studies from Algeria, Hungary, and Ukraine report higher nesting success on vegetated islets with deeper surrounding water, reducing predation. Artificial islands can significantly enhance breeding density when natural nesting structures are limited.
5. Control of Human Disturbance	Limit access to breeding wetlands from April–July. Restrict: – Recreational boating – Shoreline fishing – Birdwatching near nests	Human presence can trigger nest abandonment or increased predation risk. Ferruginous Ducks are highly sensitive to disturbance. LIFE projects in Romania, Hungary, and Italy demonstrate improved



Management Feature	Detailed Description	Justification / Evidence
	– Use of loud engines or dogs Establish buffer zones (100–300 m) around key nesting areas.	success when access is managed during breeding.
6. Invasive Species Control	Monitor and control invasive aquatic species such as Common Carp (<i>Cyprinus carpio</i>), Grass Carp (<i>Ctenopharyngodon idella</i>), American Mink (<i>Neovison vison</i>), and Raccoon Dog (<i>Nyctereutes procyonoides</i>).	Invasive fish degrade vegetation and reduce invertebrate prey, while invasive mammals are key nest predators. Presence of carp linked to habitat degradation in Spain and Italy; mink predation documented in northern Europe.
7. Legal Protection & Site Governance	Integrate sites into Natura 2000, Ramsar, or national protected area networks. Develop site-specific management plans including zoning, habitat monitoring, and active enforcement. Involve local stakeholders (fisheries, farmers, NGOs).	Protected designation provides a legal basis for enforcement and eligibility for conservation funding. Projects like LIFE Green Borders show the benefit of cross-border site governance and involvement of site custodians.
8. Monitoring & Adaptive Management	Establish annual monitoring programs for: – Breeding population size and success – Habitat quality (vegetation, water level, food resources) – Disturbance levels Adjust management based on data.	Adaptive management ensures that conservation actions respond to environmental variability and land-use changes. Monitoring helps track species recovery and management efficacy.



8.2. Site specific recommendation and directions linked to Lake Cerknica

General site recommendations

Although general habitat recommendations for Ferruginous Duck conservation are broadly applicable to Lake Cerknica, there are several specific features and issues that require particular attention to enhance breeding suitability and overall habitat quality for the species. Below are the key points that should be addressed:

1. Diversification of Reedbed Edges

At present, several areas around the lake are characterized by extensive, uniform stretches of reed and emergent vegetation with flat, linear edges. Such homogeneous structures reduce habitat quality for many waterfowl species, including Ferruginous Duck. To enhance habitat value, efforts should be made to diversify the transition zone between open water and reedbeds. Structurally complex reed edges—with patches of low vegetation, channels, and gradual transitions—are more attractive to waterfowl, supporting higher species diversity and providing better feeding and nesting opportunities. Mechanical or manual creation of undulating reed margins, interspersed with open pockets of water, can help achieve this.

2. Improvement of Breeding Substrate

Ferruginous Ducks require relatively solid and concealed substrates to build their nests. Unlike grebes, coots, and moorhens, they do not typically nest in open water or on submerged reed stems. In areas where floating reedbeds are lacking, or where high water levels reduce suitable nesting substrate within the reedbeds, it is advisable to leave some of the previous year's dead reed stems standing. These provide anchoring and structure for ground-nesting ducks. Additionally, artificial interventions can support breeding success. Installing small, semi-floating rafts anchored among reed stands can create secure nesting platforms. These can be designed to support natural vegetation growth, offering concealment and mimicking natural conditions. Alternatively, artificial nest boxes or baskets, camouflaged with reeds and placed in secluded wetland patches, may be considered to enhance nest success (see the text further below).

3. Protection and Management of Breeding Microhabitats

Ferruginous Ducks prefer to breed in quiet, sheltered water bodies such as shallow ponds, oxbows, and open patches within reedbeds, rather than in main river channels or fast-flowing canals. However, in well-vegetated, slow-flowing irrigation canals with a mix of emergent plant species, nesting may occur. Existing suitable areas around Lake Cerknica—those with a mosaic of open water, floating vegetation, and dense emergent stands—should be designated as low-disturbance zones during the breeding season. Restrictions on fishing, angling, and recreational access should be enforced in these zones to minimize human disturbance and allow the species to establish breeding territories.

4. Water Level and Vegetation Management



The structure and heterogeneity of the wetland is crucial to its value for Ferruginous Ducks. Management of water levels and emergent vegetation (especially reeds, bulrushes, and other helophytes) should aim to promote a patchy, interspersed wetland structure rather than continuous, monotonous reed expanses. Maintaining a dynamic wetland mosaic—with alternating patches of open water, reedbeds, and transitional habitats—will provide optimal conditions for breeding, feeding, and brood-rearing. Careful planning of mowing, reed cutting, and water level manipulation should be aligned with the breeding phenology of Ferruginous Duck to avoid disturbance and habitat degradation during critical periods. Foraging areas of the species might be enhanced by enriching and improving the stands of submerged vegetation and floating stands of vegetation such as *Nymphoides peltate*, *Nymphaea alba*, *Nuphar lutea*, *Ranunculus* sp., *Persicaria amphibia*, *Potamogeton* sp. if they are typical for the lake habitats.

Potential for supporting breeding efforts of duck by installing artificial nests

Installing artificial nests in wetlands can significantly enhance breeding success for duck species, particularly in areas where natural nesting habitat is scarce or degraded. For species like the Ferruginous Duck, which prefer dense emergent vegetation for nesting, artificial platforms or nest baskets can provide safe, elevated nesting sites that reduce the risk of flooding and predation. These structures are especially beneficial in modified wetlands such as fishponds, reservoirs, or drained marshes where suitable vegetation may be lacking.

Artificial nests can also help mitigate the impacts of habitat fragmentation and human disturbance by offering secluded and secure sites in otherwise suboptimal environments. When strategically placed—near foraging areas and within or adjacent to reedbeds—they can attract breeding pairs and increase local population density. Studies from Europe and North America have shown that properly designed and maintained artificial nest structures improve hatching success and duckling survival, making them a practical and low-cost tool in wetland management and species conservation.

In addition to supporting breeding efforts, artificial nests can serve as effective tools for monitoring nesting activity and population trends, aiding long-term conservation planning. When combined with broader habitat restoration and water management measures, artificial nesting programs contribute to the resilience and sustainability of waterbird populations in managed wetland ecosystems.

We recommend the installation of artificial nests as a way both to encourage breeding and also provide additional nests that could either be taken by the target species or by other species with which it might be competing for nesting space. However these need to be fitted close to the lake shores/vegetation-water intercourse and low to the water level unlike the tall constructions used for dabbling ducks with 1-2m above water level. The incorporated pictures are for illustration purposes from Internet and also lot of video clips exist with instructions how these could be made. One good option is knitted/ weaved baskets constructions from willow or alder twigs which are traditional in many riverine areas. However, constructions with iron mesh and hard or rush grasses should do work if traditional options are unavailable. The artificial nest should be



placed in areas and location where it is likely that the target species might construct its nest naturally.



9. Conclusion

The Ferruginous Duck (*Aythya nyroca*) is a habitat specialist whose breeding success is tightly linked to shallow, well-vegetated freshwater wetlands with stable hydrological regimes. This report highlights the species' strong preference for complex wetland structures that feature a mosaic of emergent, floating, and submerged vegetation, shallow water depths under 1.5 meters, and minimal human disturbance. Site-specific analyses confirm that such habitats support higher nesting densities and brood success, reinforcing the need for maintaining habitat heterogeneity and stability during the critical breeding period.

The findings also underscore that threats such as water regime alterations, habitat degradation, pollution, invasive species, and human disturbance continue to affect breeding outcomes. Sites like Srebarna Lake, Kalimok Complex/Fishponds and Belene Marshes illustrate how shifts in water levels and vegetation structure can lead to substantial population declines. Addressing these threats requires integrated habitat management strategies—including hydrological control, vegetation restoration/management, enforcement of protection zones, and water quality monitoring—tailored to each wetland's ecological context.

Ensuring the long-term conservation of the Ferruginous Duck depends on sustained collaboration among governmental bodies, NGOs, site managers, and local stakeholders. The recommendations provided in this report offer practical, evidence-based guidance to enhance habitat quality and reproductive success. The recommendations and conclusions are based on current knowledge on the species and thematic publications on other or ecologically similar species. When implemented in synergy with existing conservation frameworks such as Natura 2000 and national biodiversity strategies, these measures can contribute significantly to stabilizing and potentially increasing the regional Ferruginous Duck population, while simultaneously improving broader wetland ecosystem health, benefiting other co-existing species in the wetlands.

Lake Cerknica in Slovenia stands out as a site with high potential for implementing these recommendations. Despite its seasonal hydrological dynamics, the lake supports extensive reedbeds and shallow water zones suitable for Ferruginous Duck breeding. However, targeted improvements—such as increasing the structural complexity of reedbed edges, securing undisturbed microhabitats, and optimizing water level management to retain a diverse wetland mosaic—are essential to enhance the site's suitability. With appropriate habitat interventions and continued conservation attention, Lake Cerknica can serve as a regional model for breeding habitat restoration and species recovery.



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