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Population dynamics of five riverbed breeding bird species on the lower Drava River, NE Slovenia

Populacijska dinamika petih gnezdilk struge spodnjega dela reke Drave (SV Slovenija)

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In 2006–2017, annual censuses of breeding bird species regarded as indicators of natural rivers were carried out on the 38.9 km long lowland stretch of the Drava riverbed between Maribor and Zavrč with altered flow regime due to the operating hydropower plants. Gravel bar habitats were surveyed in four years of the study period by combining orthophoto analysis and analysis of field photographs. Effects of gravel bar management were evaluated based at 20 locations. The Little Ringed Plover *Charadrius dubius* occurred on 39.8% of the gravel bars, but most were occupied only in a few years and held just one breeding pair. Low numbers between 2009 and 2012 (< 30 pairs) were followed by a steep population increase from 2014 onwards to a maximum of 66–73 pairs (1.7–1.9 p/km). Such population dynamics was attributed to the lack of large discharges (>500 m^3/s) and consequent overgrowing of riverbed in the first part of the study period, while the increase in the second part was due to the creation of extensive shingle areas (from 20,6 ha in 2009/10 to 37,8 ha in 2014) by the extreme flood in early November 2012, subsequent regular occurrence of large discharges outside the breeding seasons and large-scale removals of woody vegetation. Breeding population of Common Sandpiper *Actitis hypoleucos* remained at a rather similar low level (<20 p) during most of the period studied after an initial decline, and did not reflect changes in the overall surface area of riverbed habitats. Contrary to the general situation, the number of breeding pairs on gravel bars subjected to management increased several-fold. Maximum number of pairs on these bars was reached up to four years after the initiation of management measures, as only then the optimal mosaic of early successional stages interspersed with shingle areas developed at main sites. The species was widespread only on lower part of the Drava. Kingfisher *Alcedo atthis* was fairly widely distributed along the riverbed, but occurred in rather low densities throughout (c. one pair on 2–3 km of the studied riverbed on average), probably as a result of limited bank erosion and consequent overgrowing/lack of suitable nest sites. The population was estimated as stable with effects of harsh winter conditions on breeding numbers in some years. The majority of nest holes were excavated in eroded river banks along the main river channel (77.8%), followed by similar sites located in mouth areas of small tributaries of the Drava (14.8%). Regular breeding of Sand Martin *Riparia riparia* since 2012 (up to 259, mostly at only one location annually) was almost exclusively the result of the annual artificial nest site preparation programme. Fairly large gravel bar-breeding population of White Wagtail *Motacilla alba*, monitored since 2013 and predominantly ground nesting in sparsely vegetated areas, seems unusual considering the prevalent breeding habits of the species at the European scale. Conservation implications and guidelines for future management efforts are discussed.

Ključne besede: mali deževnik *Charadrius dubius*, mali martinec *Actitis hypoleucos*, vodomec *Alcedo atthis*, breguljka *Riparia riparia*, bela pastirica *Motacilla alba*, populacijski trendi, upravljanje prodišč, reka Drava
Key words: Little Ringed Plover *Charadrius dubius*, Common Sandpiper *Actitis hypoleucos*, Kingfisher *Alcedo atthis*, Sand Martin *Riparia riparia*, White Wagtail *Motacilla alba*, population trends, gravel bar management, Drava River

1. Introduction

Alluvial floodplains rank among the most altered and threatened ecosystems worldwide (Tockner & Stanford 2002). In a pristine state, undisturbed cut-and-fill alluviation (erosion, transport, deposition) creates a natural disturbance regime that plays an important role in maintaining a high diversity of habitats by forming a variety of patch types and succession stages. Characteristic geomorphic features of alluvial rivers include numerous gravel bars, eroded banks, deposits of sediment and large woody debris (Ward *et al.* 2002, Florsheim *et al.* 2008). Consequently, gravel-bed rivers harbour disproportionately high biodiversity (Allan & Flecker 1993, Rohde *et al.* 2004, Jensen *et al.* 2006, Hauer *et al.* 2016). However, the majority of European rivers have been severely degraded in the past by various anthropogenic interventions including flow regulation, channelization, damming, and water abstraction. Only a small fraction of large rivers or entire catchments remained free-flowing, mainly restricted to remote boreal and arctic regions. As a result, most rivers lost their natural dynamics and patterns with a consequent decline in habitat and species diversity (Ward 1998, Buijse *et al.* 2002, Pedroli *et al.* 2002, Lorenz *et al.* 2009, Tockner *et al.* 2009, Hauer *et al.* 2016).

Among species affected are also characteristic riverbed breeding birds, such as the Little Ringed Plover *Charadrius dubius*, Common Sandpiper *Actitis hypoleucos*, Kingfisher *Alcedo atthis* and Sand Martin *Riparia riparia* (van Vessem *et al.* 1997), the breeding populations of which either declined significantly in Central Europe and/or predominantly shifted from natural to anthropogenic habitats (Bauer *et al.* 2005, Petutschnig 2006a, b, Maumary *et al.* 2007, Schmid *et al.* 2010, Gedeon *et al.* 2014, BirdLife International 2015a, b, Ringert 2015, Samwald *et al.* 2015). These species are widely regarded as indicators of natural river dynamics and alluvial riverine habitats (Szep *et al.* 2003, Noble *et al.* 2008, Dröschmeister & Sukopp 2009, Schmidt *et al.* 2015).

Recently, numerous river restoration projects have been implemented, aiming to improve hydromorphological conditions, natural dynamics and connectivity functions of degraded rivers. In most cases these include various river widening measures that, among others, promote the re-establishment of once impoverished habitat diversity (Rohde *et al.* 2004, Jensen *et al.* 2006, Palmer *et al.* 2007, Jähnig *et al.* 2010). Recoveries of riverbed breeding bird populations due to an increased area of pioneer successional stages and bare alluvial deposits after restorations were reported from rivers in different countries (Petutschnig 2004, Arlettaz *et al.* 2012, Uhl & Weissmair 2012). River restoration projects started only recently in Slovenia and their conservation effects on bird populations has not been evaluated or published as yet.

After the first census of riverbed birds on the Drava River in NE Slovenia in 2006 (Božič & Denac 2010), DOPPS – BirdLife Slovenia dedicated substantial effort to provide suitable habitats for gravel bar-breeding species by (1) influencing the modification of prevailing harmful water-management practices to more meaningful measures with positive effects on both biodiversity and flood protection objectives (Denac & Božič

2012), and (2) implementation of shingle area restorations on multiple locations along the river as part of the project "LIVEDRAVA – Riparian Ecosystem Restoration of the Lower Drava River in Slovenia" (http://livedrava.ptice.si). At the beginning of this process, an annual census scheme was established to obtain solid background data as support for management decisions and to monitor development of target species populations. An overview of 10-year results is given in this study, with special focus on population dynamics of indicator bird species and effects of gravel bar management.

2. Study area

Drava is the fourth largest and longest river in the Danube River Basin spanning over five countries, where it drains an area of over 40,000 km². It has a glacial-nival flow regime with lowest discharge in January–February and highest in May–June. The second discharge peak occurs in late autumn due to high precipitation in the Southern Limestone Alps. However, the natural flow of the Drava River is strongly influenced by 23 hydropower plants, operating upstream of its confluence with the Mura River (Sommerwerk *et al.* 2009).

Our study area comprised a 38.9 km long stretch of the Drava riverbed on the westernmost fringes of the Pannonian plain between Melje dam on the outskirts of Maribor city (46.56°N, 15.67°E) and the border with Croatia at Zavrč (46.39°N, 16.06°E) (Figure 1). The hydrological regime here is completely governed by two channel-type hydropower plants with dams at Melje (HPP Zlatoličje, operating since 1969) and at Markovci pri Ptuju (HPP Formin, operating since 1978) (Šmon

Figure 1: Study area of the Drava River between Maribor and Zavrč, NE Slovenia. Riverbed included in surveys is depicted in dark blue.

Slika 1: Območje raziskave na reki Dravi med Mariborom in Zavrčem (SV Slovenija). Rečna struga, vključena v popise, je prikazana s temno modro barvo.

2000). The mean discharge is 321 m³/s (Šehič *et al.* 2010), but only the so-called "ecologically acceptable discharge" (20 m³/s downstream of Melje and 10 m³/s downstream of Markovci, between 15 Mar and 15 Oct and half of these values during the rest of the year) is released in the riverbed while most of the water is diverted into supply channels for generating electric power. Only when the discharge surpasses the capacity of power plants (i.e. installed flow at 500 m³/s – the maximum flow a plant can process) is the surplus flow diverted to the riverbed (ZRSVN 2006). It was estimated that sediment transport on the Drava River section between Ptuj in Zavrč decreased 400-fold after the construction of HPP Formin (Sovinc 1995). Moreover, considerable stretches of the Drava river have been regulated by rock ripraps from as early as the first half of the 19th century until the present day (Bašelj 2014, *own data*).

The riverbed was divided into three survey sections. We defined two sections between Maribor and Ptuj (Maribor–Starše, Starše–Ptuj) as the "upper part of the study area" and the section between Markovci and Zavrč as the "lower part of the study area" (Table 1). The two parts of the study area are separated by the artificial Lake Ptuj reservoir (not surveyed) (Figure 1).

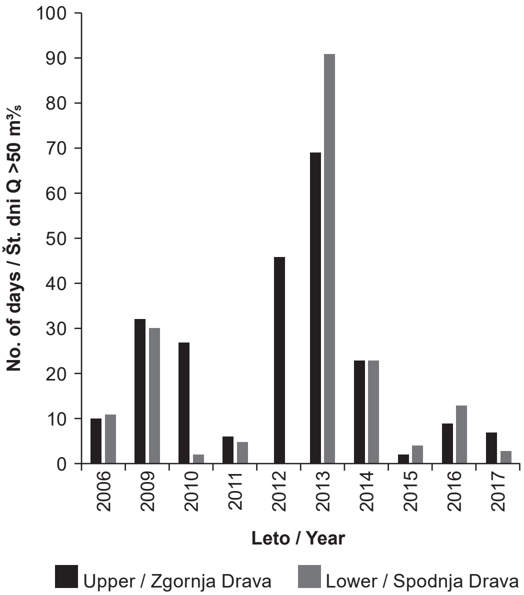

Figure 2: Number of days with discharges >50 m³/s in the Drava riverbed during the main breeding season (1 Apr–30 Jun) of a given year. Data for upper (black bars) and lower part (grey bars) of the study area are separated.

Slika 2: Število dni s pretoki >50 m³/s v strugi reke Drave v glavni gnezditveni sezoni (1. 4–30. 6.) posameznega leta. Podatki za zgornji (črni nizi) in spodnji del (sivi nizi) območja raziskave so ločeni.

2.1. Hydrological data

Discharges at or slightly above the prescribed minimum prevailed during all main breeding seasons (1 Apr–30 Jun), except in 2012 when discharges exceeding 50 m³/s (equivalent to c. 20 cm rise of water level in the riverbed) occurred in the upper part of the study area in 46 days of the season, and in 2013 when the increased discharges in the upper and lower part of the study area lasted for 69 and 91 days, respectively. More than 20 days with discharge >50 m³/s in both parts of the study area were also registered in the seasons of 2009 and 2014, while 2011, 2015 and 2017 seasons had fewer than 10 such days (Figure 2).

Discharges of >500 m³/s were rare throughout the study period, except between late 2012 and the first half of 2013, and did not occur in all years. This situation is even more pronounced for discharges >700 m³/s that occurred exclusively outside the main breeding season (Figure 3).

3. Methods

3.1. Bird census

Data were first collected in 2006 and then every year from 2009 to 2017. Target species were indicator breeding birds that exclusively utilize the characteristic, natural and semi-natural features within the riverbed (gravel bars, islands, river banks): Little Ringed Plover, Common Sandpiper, Kingfisher and Sand Martin. From 2013 onwards, White Wagtail *Motacilla alba* was included in the censuses as well.

The bird census was carried out using a boat with a minimum of two observers, inspecting the

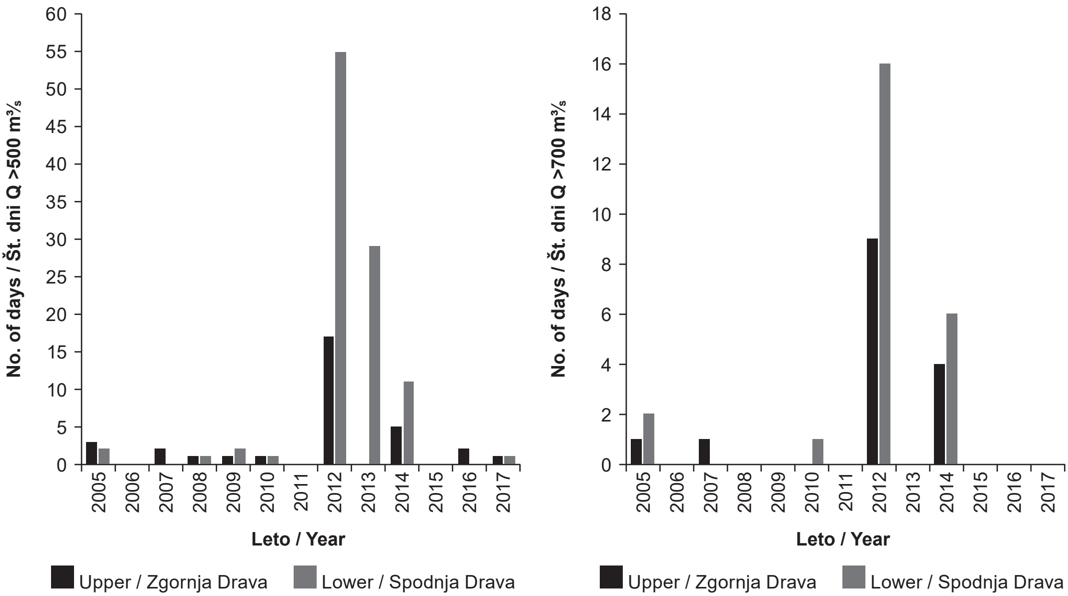

Figure 3: Occurrence of large discharges on the upper (black bars) and lower part (grey bars) of the Drava River study area presented as number of days with >500 m^3/s (left) and >700 m^3/s (right) in separate years between 2005 and 2017

Slika 3: Pojavljanje velikih pretokov na zgornjem (črni nizi) in spodnjem delu (sivi nizi) raziskovanega območja reke Drave, predstavljeno kot število dni s pretokom >500 m^3/s (levo) in >700 m^3/s (desno) v posameznih letih med 2005 in 2017

entire area of the riverbed while slowly progressing downstream. Regular stops were made along the transect and most gravel bars suitable for breeding of the target species were carefully walked by at least one observer and systematically checked by binoculars and/or spotting scope. All birds registered were accurately mapped using the most recent edition of orthophoto images produced by the Surveying and Mapping Authority of the Republic of Slovenia, at a scale of 1 : 5,000 and their behaviour recorded. The census was carried out in two visits annually during the breeding season of the target species; the first usually took place in the second half of April (median 21 Apr) and the second in the mid-May–early June (median 1 Jun). Only in 2010 (one survey section) and 2012 (both sections) the census was carried out considerably later in the season in the upper part of the study area due to unfavourable hydrological conditions (Table 1). The lower part remained unsurveyed in 2013 as large discharges persisted during the entire breeding season. Most of the work was carried out by a permanent team of observers and the census effort remained fairly constant over the entire study period.

3.2. Interpretation of results

Special criteria for breeding pair/territory-holding individual were developed for species censused based on our previous experience and recommendations from abroad (Andretzke *et al*. 2005, Božič & Denac 2010), and used for interpretation of registrations. (1) Little Ringed Plover individuals registered were distinguished by sex whenever possible. If the number of pairs during the first visit was higher than during the second visit on a certain gravel bar, or plovers were not registered during the second visit, the latter was regarded as the minimum number and the former as the maximum number of pairs. (2) In Common Sandpiper, particular importance was given to the territorial behaviour and intensively displaying individuals due to the large numbers of

Table 1: Survey sections on the Drava River, their lengths and dates of counts carried out during the censuses (V1 = 1st visit, V2 = 2nd visit)

Tabela 1: Popisni odseki na reki Dravi, njihova dolžina in datumi štetij v opravljenih popisih (V1 = 1. obisk, V2 = 2. obisk)

	Upper part / Zornji del				Lower part / Spodnji del	
Section / Odsek	Maribor–Starše		Starše–Ptuj		Markovci–Zavrč	
Geographic coordinates/ Geografske koordinate	46.5603°N, 15.6737°E–46.4700°N, 15.7733°E		46.4700°N, 15.7733°E–46.4243°N, 15.8582°E		46.3880°N, 15.9268°E–46.3929°N, 16.0623°E	
River kilometres / Rečni kilometri	350–336		336–326		319–305	
Length / Dolžina (km)	14.3		10.6		14.0	
Visit / Obisk	V1	V2	V1	V2	V1	V2
2006	13. 4.	12. 5.	14. 4.	14. 5.	17. 4.	18. 5.
2009	22. 4.	3. 6.	27. 4.	4. 6.	9. 5.	5. 6.
2010	21. 4.	1. 6.	22. 4.	25. 6.	26. 4.	18. 5.
2011	20. 4.	19. 5.	21. 4.	20. 5.	22. 4.	21. 5.
2012	20. 4.	20. 6.	23. 4.	22. 6.	22. 4.	29. 5.
2013	24. 4.	20. 5.	25. 4.	21. 5.	-	-
2014	7. 4.	3. 6.	8. 4.	4. 6.	11. 4.	6. 6.
2015	14. 4.	1. 6.	15. 4.	2. 6.	16. 4.	3. 6.
2016	11. 4.	16. 5.	11. 4.	16. 5.	13. 4.	18. 5.
2017	21. 4.	2. 6.	22. 4.	2. 6.	24. 4.	3. 6.

migrants during the first visit. (3) All potentially suitable steep natural banks were checked for Kingfisher nest holes and their details recorded or photographed. Registrations of individuals on locations ≥1,5 km apart were treated as separate pairs, while those ≤500 m apart were always regarded as belonging to the same pair (cf. Cramp 1985, Andretzke *et al.* 2005, Bauer *et al.* 2005), unless when simultaneously occupied nests were found. (4) For Sand Martin, a minimum EBCC breeding atlas code 9 (excavating nest-hole, Hagemeijer & Blair 1997) was required, i.e. only actual nesting colonies were considered in the study. The number of pairs was obtained by direct, prolonged multiple counts of completed holes in a colony, taking into consideration observations of birds flying in and out. No correction factors proposed by Kuhnen (1978) or Szep *et al.* (2003) were used as these would, according to our observations, underestimate the number of pairs (see Fenyősi 2005). Apart from these, no special attempts were made to find nests of target species during any of the census visits. (4) The number of White Wagtail pairs was estimated as maximum of individuals/pairs registered at separate locations, with special significance given to the observations suggesting confirmed breeding (adult carrying food and/or other circumstances indicating occupied nest, nests found, family parties with recently fledged young etc.).

In the analysis it was possible to assign most of the Little Ringed Plover, Common Sandpiper and White Wagtail pairs/territories to individual gravel bars. A gravel bar was defined as any elevated deposit of sediment, protruding above the water surface at usual discharge within the riverbed, either as a point bar, island or peninsula, regardless of successional stage. The minimum size of the area considered was set at 30 m^2. The breeding density is given as linear density, i.e. the number of pairs/territories per km of the river (e.g. Dougall *et al.* 2004).

For graphical presentation of species' occurrence, the kernel density tool in ArcGIS was used (Silverman 1986, ESRI 2009), based on all available point features (i.e. mapped registrations of individuals in all study years) for each species except Sand Martin. In kernel density, the value of smoothly curved surface fitted over each point is highest at the location of the point and diminishes with increasing distance from the point, reaching zero at the search radius distance from the point (ESRI 2009). Population field value for the point was set to account for number of individuals underlying each point registration.

3.3. Habitat survey and effects of gravel bar management

During census visits large sets of photographs were taken routinely of all gravel bars along the study area from multiple angles (up to 1,500 photos/ year). Habitat survey was then carried out by detailed analysis of all available orthophoto image editions produced in the study period (2006, 2009/2010, 2014, 2016) using ArcGIS (ESRI 2009), and ground truthing by field photographs of a given year. Gravel bar habitat types were classified into five broad categories: (1) bare shingle, (2) shingle interspersed with low plants, where vegetation cover does not exceed 50%, (3) herbaceous plants (dense layer of annual or perennial plants), (4) low woody vegetation (small shrubs up to 1 m), and (5) high woody vegetation (shrubs and trees taller than 1 m). Categories 1–2 and 4–5 were later merged, resulting in three main gravel bar habitat types used. During analysis, a basic polygon consisting of gravel bar outlines was cut into smaller features representing single-habitat type units. Thus, habitat changes over time were mapped on a gravel bar as well as study area level, and surface areas of habitat types calculated. For the two exclusively gravel bar-breeding species (Little Ringed Plover, Common Sandpiper), categories 1 and 2 are treated as suitable habitat (termed as "shingle" throughout), although the latter can marginally also select category 3 for breeding (Andretzke *et al.* 2005, *own data*) (Appendix 1, 2). For the calculation of areas of suitable habitat on managed gravel bars, Google Earth Pro imagery was used for years/periods, for which orthophotos were not available.

The general purpose of gravel bar management carried out by a contracted public service as part of regular water management maintenance works was flood control and no special goals related to nature-conservation issues were set. One of the aims of the LIVEDRAVA project was to develop gravel bar management practices that simultaneously enhance breeding habitats of riverbed bird species, and provide better flood safety by increasing the cross-section of the river (see Klaneček *et al.* 2005). Six gravel bars were managed within the project in that way. For the evaluation of gravel bar management effects as of 2013, the following sites were taken into consideration: (1) management consisted of removal of woody vegetation and upper layer of organic matter by heavy machinery, and was subjected to nature-conservation guidelines; (2) held Little Ringed Plover at least once during the study. For gravel bars managed within LIVEDRAVA, additional conditions required included: (a) strictly no gravel was to be removed from the riverbed during management operations, (b) the existing size and height of gravel bars were not reduced, and (c) organic material was removed from the riverbed as much as possible. According to the time-scale of management, the corresponding years were divided into two management periods, 2013–2015 (management period 1) and 2016–2017 (management period 2). In comparisons of number of pairs/habitat area on gravel bars before and after management works, the latest available data were used as reference.

3.4. Trends

Trends were calculated using TRIM, a program designed to analyse time-series of counts with missing observations using Poisson regression (Pannekoek & van Strien 2005). The multiplicative overall slope (trend) estimate for individual bird species is classified by the program into one of the following categories, based on the overall slope and its 95% confidence interval (slope ±1.96 SE): strong increase, moderate

Table 2: Number of the Little Ringed Plover *Charadrius dubius* breeding pairs in survey sections on the Drava River

Tabela 2: Število gnezdečih parov malega deževnika *Charadrius dubius* na popisnih odsekih reke Drave

Year/ Leto	Section / Odsek						Total / Skupaj	
	Maribor–Starše		Starše–Ptuj		Markovci–Zavrč			
	min	max	min	max	min	max	min	max
2006	10	12	17	20	22	25	49	57
2009	1	1	7	10	7	12	15	23
2010	2	6	4	7	9	18	15	31
2011	4	6	8	8	13	16	25	30
2012	0	5	9	9	4	6	13	20
2013	4	5	8	10	-	-	12	15
2014	14	15	14	17	38	41	66	73
2015	10	13	11	13	34	38	55	64
2016	10	15	7	10	31	38	48	63
2017	8	12	5	5	24	30	37	47

* Section Markovci–Zavrč was not surveyed in 2013 due to unfavourable hydrological conditions during the entire breeding season. It is unlikely the species bred there in that year at all. / Odsek Markovci–Zavrč v letu 2013 ni bil popisan zaradi neugodnih hidroloških razmer med celotno gnezditveno sezonoe. Malo verjetno je, da je vrsta v tem letu tam sploh gnezdila.

Table 3: Linear breeding density of Little Ringed Plover *Charadrius dubius* in survey sections on the Drava River

Tabela 3: Linearna gnezditvena gostota malega deževnika *Charadrius dubius* na popisnih odsekih reke Drave

Year/ Leto	Section / Odsek						Total / Skupaj	
	Maribor–Starše		Starše–Ptuj		Markovci–Zavrč			
	min	max	min	max	min	max	min	max
2006	0.7	0.8	1.6	1.9	1.6	1.8	1.3	1.5
2009	0.1	0.1	0.7	0.9	0.5	0.9	0.4	0.6
2010	0.1	0.4	0.4	0.7	0.6	1.3	0.4	0.8
2011	0.3	0.4	0.8	0.8	0.9	1.1	0.6	0.8
2012	0.0	0.3	0.8	0.8	0.3	0.4	0.3	0.5
2013	0.3	0.3	0.8	0.9	-	-	0.3	0.4
2014	1.0	1.0	1.3	1.6	2.7	2.9	1.7	1.9
2015	0.7	0.9	1.0	1.2	2.4	2.7	1.4	1.6
2016	0.7	1.0	0.7	0.9	2.2	2.7	1.2	1.6
2017	0.6	0.8	0.5	0.5	1.7	2.1	1.0	1.2

* The Markovci–Zavrč section was not surveyed in 2013 due to unfavourable hydrological conditions during the entire breeding season. It is unlikely the species bred there in that year at all. / Odsek Markovci–Zavrč v letu 2013 ni bil popisan zaradi neugodnih hidroloških razmer med celotno gnezditveno sezono. Malo verjetno je, da je vrsta v tem letu tam sploh gnezdila.

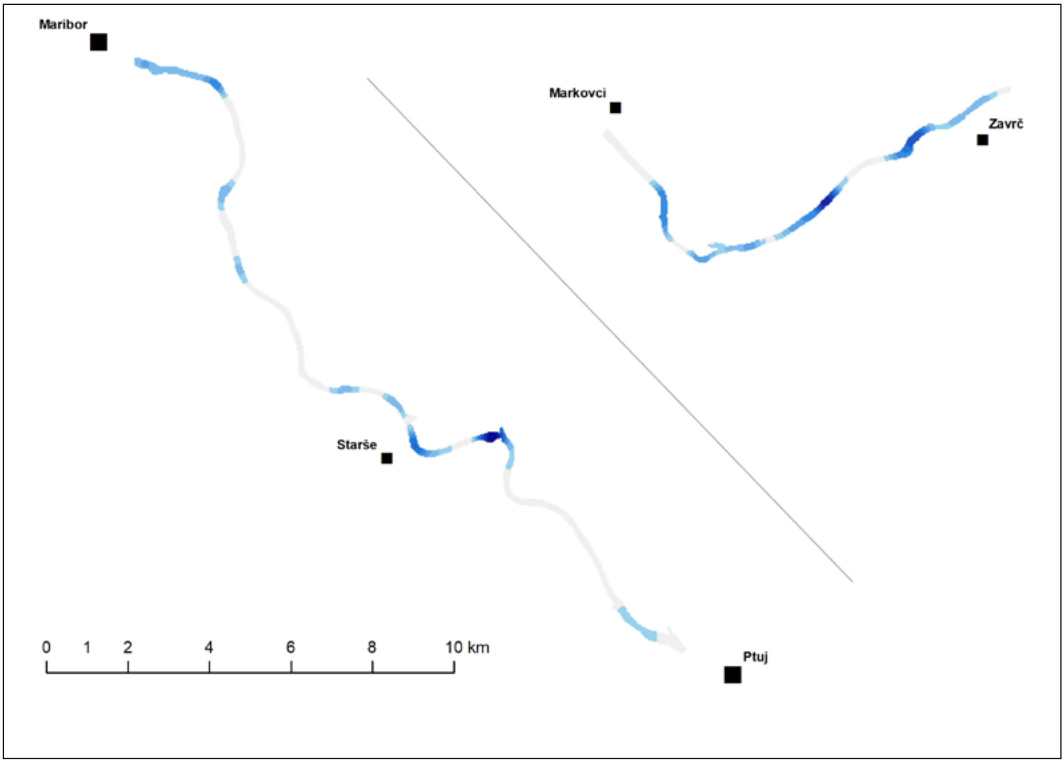

Figure 4: Density of Little Ringed Plover *Charadrius dubius* after the kernel method, based on registrations of individuals during the entire study period (N = 527 registrations of 1070 ind.). The darker the shade of blue colour, the greater the density in that area. Outside blue-coloured areas, only single records may exist.

Slika 4: Gostota malega deževnika *Charadrius dubius* po kernelski metodi na osnovi registracij osebkov v celotnem obdobju raziskave (N = 527 zapisov o 1070 os.). Temnejši ko je odtenek modre barve, večja je gostota na tistem območju. Zunaj modro obarvanih območij lahko obstajajo le posamezni podatki.

increase, stable, uncertain, moderate decline and steep decline. As our dataset contained numerous zero counts, linear trend model with all change-points selected, except the years without positive count data available (2007 and 2008), was used in the analysis (Pannekoek *et al.* 2005). In graphic presentations, imputed time indices with standard errors are given.

4. Results

4.1. Little Ringed Plover

The total breeding population of Little Ringed Plover ranged from 12–15 pairs in 2013 to 66–73 pairs in 2014, resulting in a linear density of 0.3–0.4 p/km and 1.7–1.9 p/km, respectively. Except in 2012 and 2013, the number of pairs was highest in the lower part of the study area. Linear density exceeded 2 p/km in the years from 2014 to 2016 (max 2.7–2.9 p/km in 2014) only there, while in the first survey section it remained below 1 p/km in all years except for 2014 (Tables 2, 3).

Its distribution along the study area was not continuous; up to several kilometres long gaps were typical, especially in the upper part of the study area (Figure 4).

Little Ringed Plover occurred on 74 gravel bars in total (annual range 12–36), 39.8% of all present within the study area during the entire study period. However, the species only bred in all years at two gravel bars in the upper part of

Table 4: Number of the Common Sandpiper *Actitis hypoleucos* breeding pairs in survey sections on the Drava River

Tabela 4: Število gnezdečih parov malega martinca *Actitis hypoleucos* na popisnih odsekih reke Drave

Year/ Leto	Section / Odsek						Total / Skupaj	
	Maribor–Starše		Starše–Ptuj		Markovci–Zavrč			
	min	max	min	max	min	max	min	max
2006	5	5	3	4	17	20	25	29
2009	4	4	4	4	14	16	22	24
2010	3	3	1	1	13	14	17	18
2011	1	1	2	2	11	12	14	15
2012	1	1	1	1	13	14	15	16
2013	1	1	1	1	-	-	2	2
2014	2	2	1	1	12	13	15	16
2015	1	1	1	1	10	11	12	13
2016	2	3	1	1	11	12	14	16
2017	2	2	1	1	12	14	15	17

* Section Markovci–Zavrč was not surveyed in 2013 due to unfavourable hydrological conditions during the entire breeding season. It is unlikely the species bred there in that year at all. / Odsek Markovci–Zavrč v letu 2013 ni bil popisan zaradi neugodnih hidroloških razmer med celotno gnezditveno sezono. Malo verjetno je, da je vrsta v tem letu tam sploh gnezdila.

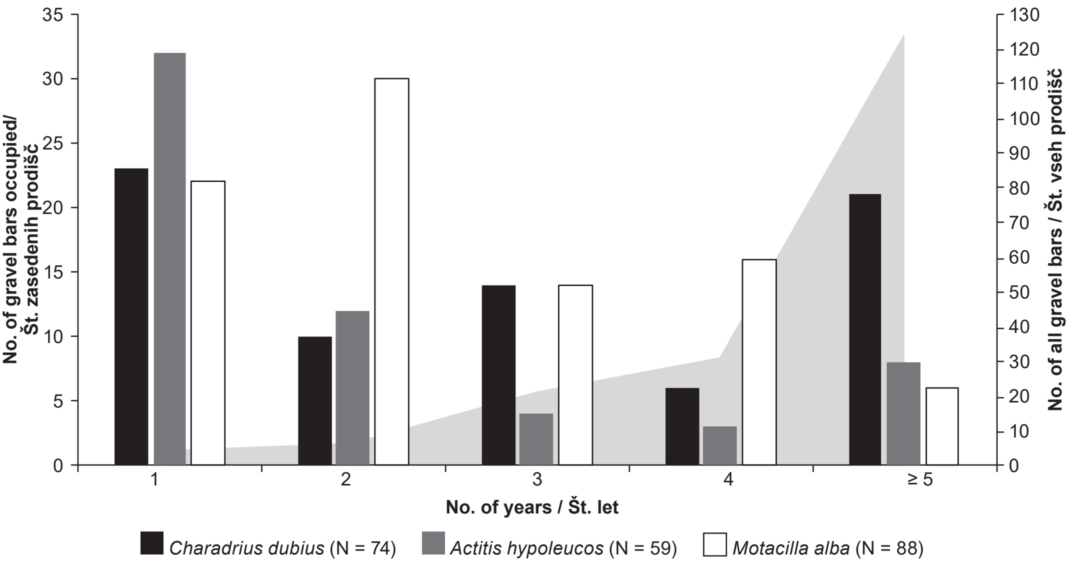

Figure 5: Gravel bars occupied by individual breeding bird species (bars) and all existing gravel bars (grey area chart, N = 186) in a given number of years during the study period (10 years)

Slika 5: Prodišča, ki so jih zasedale posamezne gnezdeče vrste ptic (stolpci) in vsa obstoječa prodišča (sivi ploščinski grafikon, N = 186) v določenem številu let obdobja raziskave (10 let)

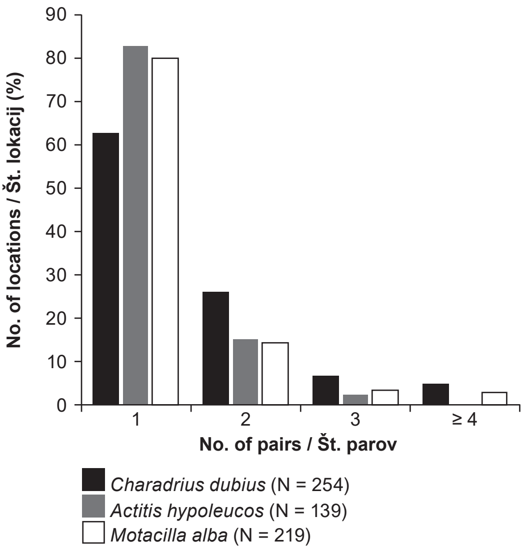

Figure 6: Percentage of locations occupied by a given number of pairs of individual breeding bird species in study area of the Drava River

Slika 6: Odstotek lokacij, ki jih je zasedalo določeno število gnezdečih parov posameznih vrst ptic na raziskovanem območju reke Drave

the study area, and two further gravel bars were occupied in all years except in 2013 in the lower part. Overall, breeding took place in at least half of the study years at only 28.4% of gravel bars (Figure 5). On most gravel bars (62.6% locations), one pair bred. Four or more pairs on a single gravel bar were registered only at two locations in the upper part (one year, max 5 p) and at two locations in the lower part of the study area (all years of the 2014–2017 period, max 10 p) (Figure 6).

The 2009–2013 period with lower number of breeding pairs was followed by a substantial population increase from 2014 onwards. The multiplicative overall trend of Little Ringed Plover was estimated as a moderate increase with an annual increase of 4.3% (± 1.7) (Figure 7).

4.2. Common Sandpiper

The Common Sandpiper breeding population was 25–29 pairs at the beginning of the study in 2006, but never exceeded 20 pairs after 2009. In the upper part, numbers were always fairly low and only single or few pairs bred there in most years (Table 4). Overall linear density varied from less than 0.1 p/

Table 5: Linear breeding density of Common Sandpiper *Actitis hypoleucos* in survey sections on the Drava River

Tabela 5: Linearna gnezditvena gostota malega martinca *Actitis hypoleucos* na popisnih odsekih reke Drave

	Section / Odsek							
	Maribor–Starše		Starše–Ptuj		Markovci–Zavrč		Total / Skupaj	
Year/ Leto	min	max	min	max	min	max	min	max
2006	0.3	0.3	0.3	0.4	1.2	1.4	0.6	0.7
2009	0.3	0.3	0.4	0.4	1.0	1.1	0.6	0.6
2010	0.2	0.2	0.1	0.1	0.9	1.0	0.4	0.5
2011	0.1	0.1	0.2	0.2	0.8	0.9	0.4	0.4
2012	0.1	0.1	0.1	0.1	0.9	1.0	0.4	0.4
2013	0.1	0.1	0.1	0.1	-	-	0.1	0.1
2014	0.1	0.1	0.1	0.1	0.9	0.9	0.4	0.4
2015	0.1	0.1	0.1	0.1	0.7	0.8	0.3	0.3
2016	0.1	0.2	0.1	0.1	0.8	0.9	0.4	0.4
2017	0.1	0.1	0.1	0.1	0.9	1.0	0.4	0.4

* Section Markovci–Zavrč was not surveyed in 2013 due to unfavourable hydrological conditions during the entire breeding season. It is unlikely the species bred there in that year at all. / Odsek Markovci–Zavrč v letu 2013 ni bil popisan zaradi neugodnih hidroloških razmer med celotno gnezditveno sezono. Malo verjetno je, da je vrsta v tem letu tam sploh gnezdila.

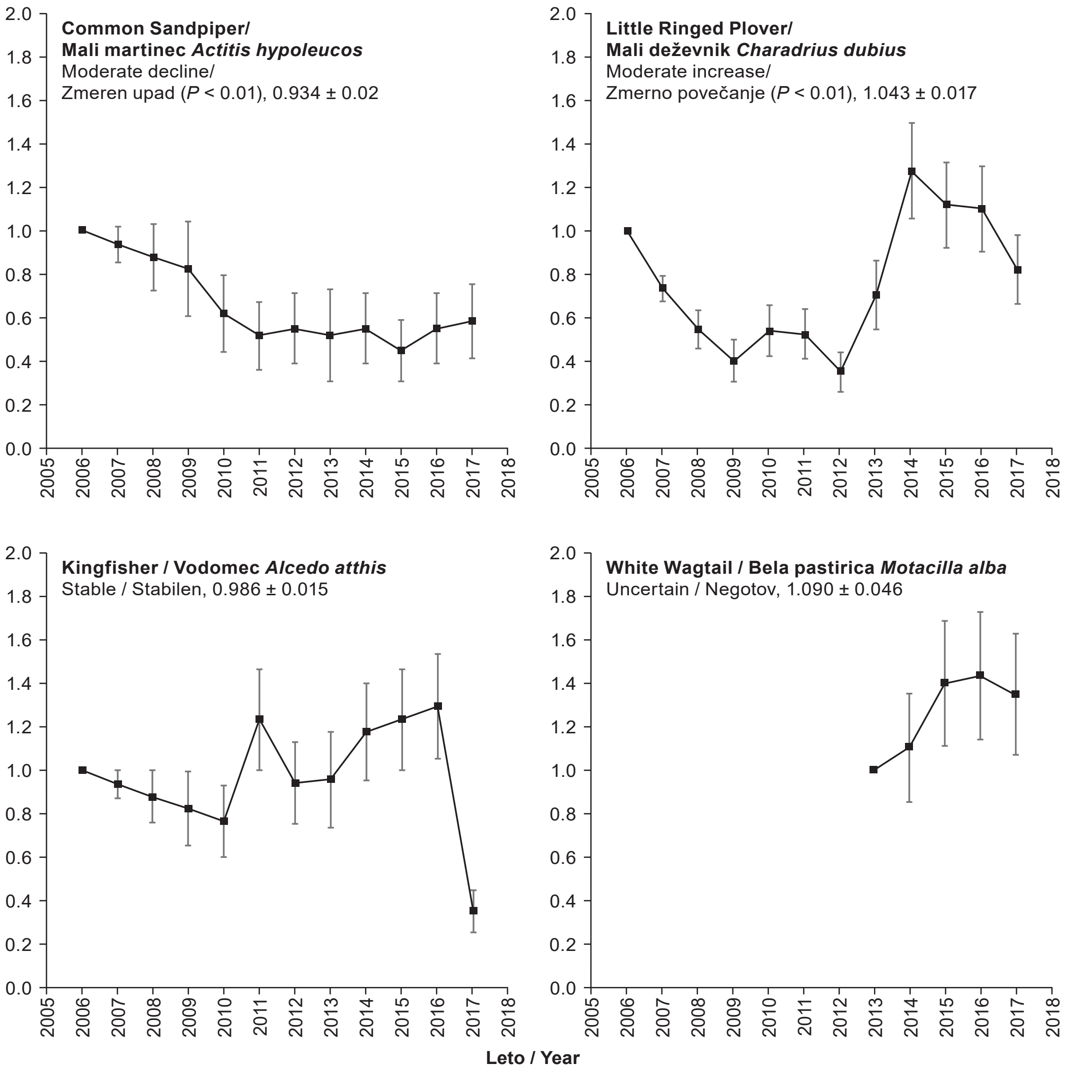

Figure 7: Population trends (multiplicative slope) and indices (± SE) of individual breeding bird species over the study period

Slika 7: Populacijski trendi (multiplikativen naklon) in indeksi (± SE) posameznih vrst ptic v obdobju raziskave

km in 2013 to 0.6–0.7 p/km in 2006. Only in the lower part of the study area Drava did it occasionally reach 1 p/km (max 1.2–1.4 p/km in 2006) (Table 5).

Common Sandpiper was widespread in the lower part of the study area. In the upper part, it was distributed mainly along some short middle and uppermost stretches, but was absent from most of the river course there (Figure 8).

The species was registered on 59 gravel bars of the study area (31.7% of all, annual range 2–23). Only two gravel bars on the upper part of the study area were occupied in more than two years, but none held breeding Common Sandpipers in all study years. In the lower part, two gravel bars held breeding pairs in all study years except 2013 and further four sites had breeding pairs in at least half of the study years

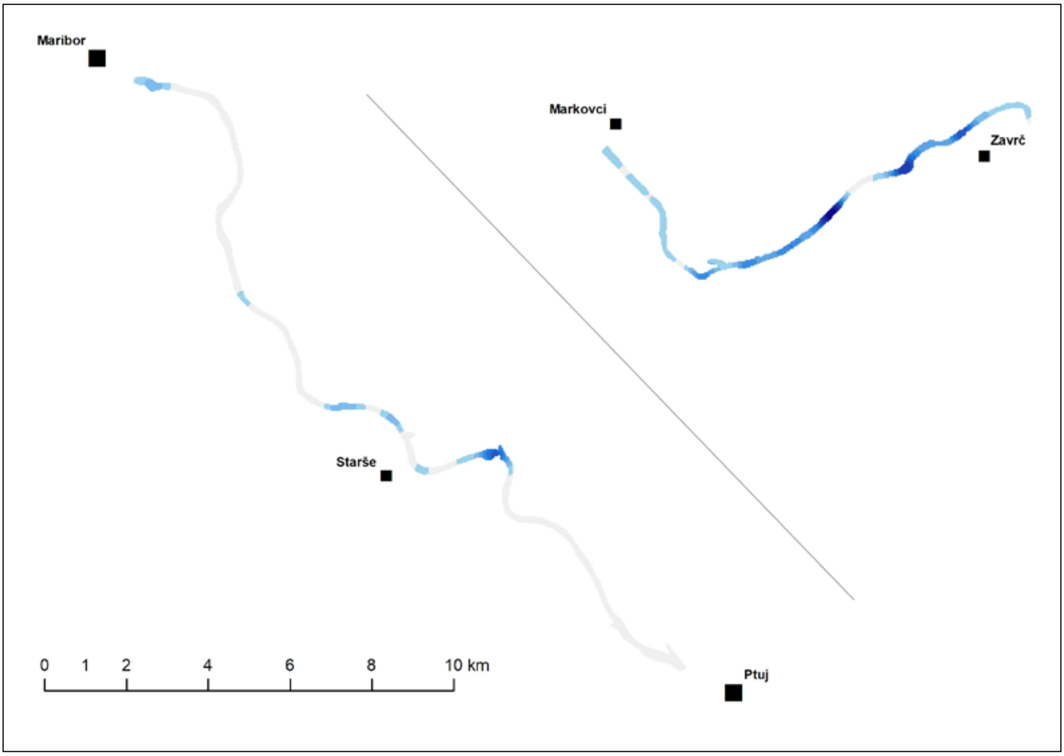

Figure 8: Density of Common Sandpiper *Actitis hypoleucos* after the kernel method, based on registrations of individuals during the entire study period (N = 258 registrations of 415 ind.). The darker the shade of blue colour, the greater the density in that area. Outside blue-coloured areas, only single records may exist.

Slika 8: Gostota malega martinca *Actitis hypoleucos* po kernelski metodi na osnovi registracij osebkov v celotnem obdobju raziskave (N = 258 zapisov o 415 os.). Temnejši ko je odtenek modre barve, večja je gostota na tistem območju. Zunaj modro obarvanih območij lahko obstajajo le posamezni podatki.

(13.6% of gravel bars) (Figure 5). On the majority of gravel bars (82.7% locations), single pairs bred. Simultaneous breeding three pairs was registered only at two gravel bars in the lower part of the study area (2009, 2010 and 2017) (Figure 6).

The number of breeding pairs declined notably at the turn of the decade and then remained similar further on. The multiplicative overall trend of Common Sandpipers was estimated as moderate decline with an annual decline of 6.6% (± 2.02) (Figure 7).

4.3. Kingfisher

The number of Kingfisher pairs reached its lowest point with 6 pairs in the entire study area in 2017, while the highest total number of 17–22 pairs bred in 2016 (Table 6). Overall linear densities showed little variation from 0.2 p/km to 0.4–0.6 p/km, being fairly similar also on the level of individual survey sections in most years (max 0.5–0.8 on the second in 2011 and 0.6–0.7 p/km on the third section in 2016) (Table 7). The shortest distance between nest sites of two simultaneously breeding pairs was 500 m in the upper part (2006) and 400 m in the lower part of the Drava (2014–2016).

Only a few short gaps (< 2 km) in its distribution were visible along the studied area of the Drava River (Figure 9). The multiplicative overall population trend was estimated as stable (Figure 7).

In total, 54 active Kingfisher nest holes were encountered at 23 locations during the study.

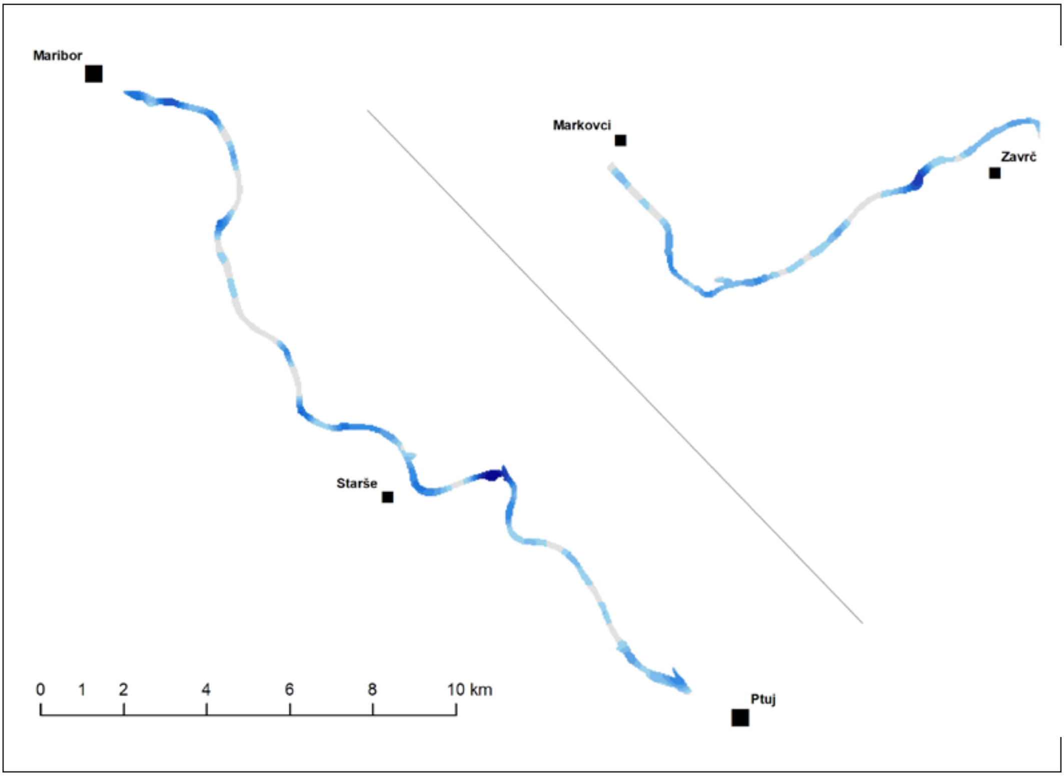

Figure 9: Density of Kingfisher *Alcedo atthis* after the kernel method, based on registrations of individuals during the entire study period (N = 341 registrations of 373 ind.). The darker the shade of blue colour, the greater the density in that area. Outside blue-coloured areas, only single records may exist.

Slika 9: Gostota vodomca *Alcedo atthis* po kernelski metodi na osnovi registracij osebkov v celotnem obdobju raziskave (N = 341 zapisov o 373 os.). Temnejši ko je odtenek modre barve, večja je gostota na tistem območju. Zunaj modro obarvanih območij lahko obstajajo le posamezni podatki.

Half of the nesting locations (52.2%) were occupied in more than one year, while only two locations were used by breeding Kingfishers in at least half of the study years (Figure 10), one in the upper (5 years) and one in the lower part (7 years) of the study area. The majority of nest holes were excavated in eroded river banks with an exposed steep surface of suitable alluvial soil along the main river channel (77.8%), followed by similar sites located in mouth areas of small tributaries of the Drava River (14.8%). Few nest holes were found in vertical sections of the fluvial terrace, and other features within the boundaries of the study area (Figure 11) (Appendix 3). The median height of the Kingfisher's nest hole above water and nesting wall used was 2.0 m (range 0.3–15 m) and 2.5 m (range 0.5–15 m), respectively (Figure 12). The median length of a nesting wall was 20 m (range 3–350 m).

4.4. Sand Martin

In the studied area of the Drava riverbed, Sand Martin bred from 2012 onwards at three different locations (1 in the upper and 2 in the lower part of the study area), with the number of pairs ranging from 55 to 259 (Table 8, Figure 13, Appendix 4). However, in any given year breeding occurred at

Table 6: Number of the Kingfisher *Alcedo atthis* breeding pairs in survey sections on the Drava River

Tabela 6: Število gnezdečih parov vodomca *Alcedo atthis* na popisnih odsekih reke Drave

Year/ Leto	Section / Odsek: Maribor–Starše		Starše–Ptuj		Markovci–Zavrč		Total / Skupaj	
	min	max	min	max	min	max	min	max
2006	4	7	4	5	4	5	12	17
2009	4	4	5	5	5	5	14	14
2010	2	4	1	3	5	6	8	13
2011	6	6	5	8	5	7	16	21
2012	6	7	4	4	4	5	14	16
2013	5	6	3	4	-	-	-	-
2014	5	8	5	6	5	6	15	20
2015	5	7	5	6	7	8	17	21
2016	5	8	4	4	8	10	17	22
2017	1	1	2	2	3	3	6	6

* Section Markovci–Zavrč was not surveyed in 2013 due to unfavourable hydrological conditions during entire breeding season. / Odsek Markovci–Zavrč v letu 2013 ni bil popisan zaradi neugodnih hidroloških razmer tekom celotne gnezditvene sezone.

Table 7: Linear breeding density of Kingfisher *Alcedo atthis* in survey sections on the Drava River

Tabela 7: Linearna gnezditvena gostota vodomca *Alcedo atthis* na popisnih odsekih reke Drave

Year/ Leto	Section / Odsek: Maribor–Starše		Starše–Ptuj		Markovci–Zavrč		Total / Skupaj	
	min	max	min	max	min	max	min	max
2006	0.3	0.5	0.4	0.5	0.3	0.4	0.3	0.4
2009	0.3	0.3	0.5	0.5	0.4	0.4	0.4	0.4
2010	0.1	0.3	0.1	0.3	0.4	0.4	0.2	0.3
2011	0.4	0.4	0.5	0.8	0.4	0.5	0.4	0.5
2012	0.4	0.5	0.4	0.4	0.3	0.4	0.4	0.4
2013	0.3	0.4	0.3	0.4	-	-	-	-
2014	0.3	0.6	0.5	0.6	0.4	0.4	0.4	0.5
2015	0.3	0.5	0.5	0.6	0.5	0.6	0.4	0.5
2016	0.3	0.6	0.4	0.4	0.6	0.7	0.4	0.6
2017	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2

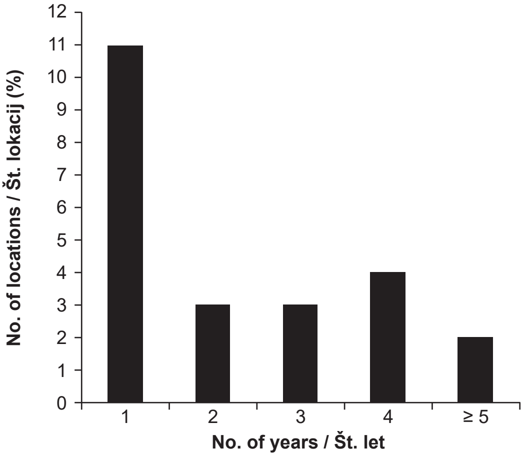

Figure 10: Occupancy of the Kingfisher *Alcedo atthis* nesting locations (N = 23) in a given number of years during the study period (10 years)

Slika 10: Zasedenost gnezditvenih lokacij vodomca *Alcedo atthis* (N = 23) v določenem številu let obdobja raziskave (10 let)

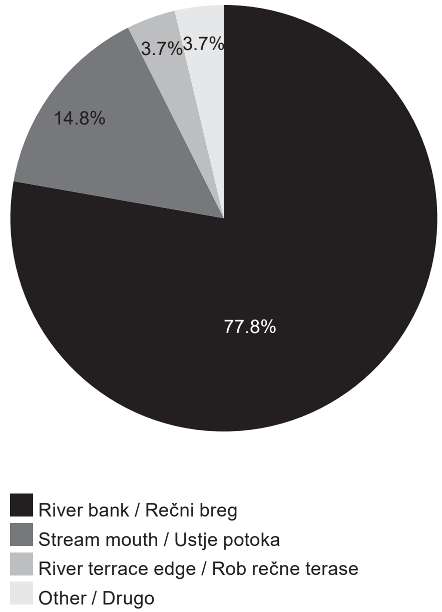

Figure 11: Percentages of the different Kingfisher *Alcedo atthis* nest site types (N = 54 active nest holes) in study area of the Drava River

Slika 11: Odstotki različnih tipov gnezdišč vodomca *Alcedo atthis* (N = 54 aktivnih gnezdilnih rovov) na raziskovanem območju reke Drave

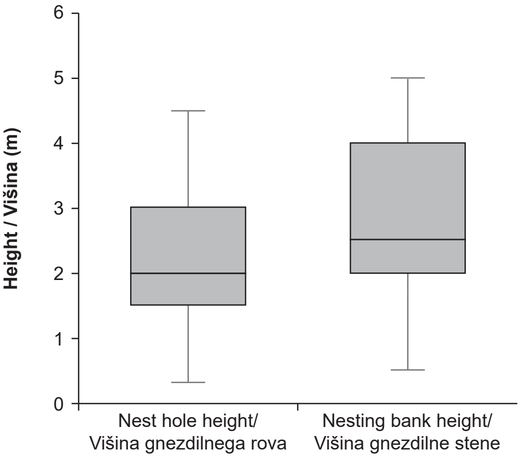

Figure 12: Height of Kingfisher *Alcedo atthis* nest hole and nesting bank in study area of the Drava River

Slika 12: Višina gnezdilnega rova in gnezdilne stene vodomca *Alcedo atthis* na raziskovanem območju reke Drave

only one location throughout, except in 2015, when a small colony (20 pairs) was established in an unaltered natural river bank beside the location specifically managed for the species.

4.5. White Wagtail

Several tens of White Wagtail pairs bred in the study area from 2014 onwards, giving an overall linear density of up to 1.9–2.1 p/km. In all years with complete data, population was the highest in the lower part of the study area, where linear density reached 2.8–3.0 p/km in 2016 (Tables 9, 10).

The species was widespread along the entire study area, missing only along few short stretches (Figure 14). After somewhat lower numbers registered in the first two study years, population size remained remarkably similar further on, including the three survey sections. The multiplicative overall population trend of White

Table 8: Number of the Sand Martin *Riparia riparia* breeding pairs in survey sections on the Drava River in separate years. All separate pairs belonged to a single colony.

Tabela 8: Število gnezdečih parov breguljke *Riparia riparia* na popisnih odsekih reke Drave v posameznih letih. Vsi ločeno prikazani pari so pripadali eni koloniji.

Year/ Leto	Section / Odsek: Maribor –Starše	Starše–Ptuj	Markovci –Zavrč	Total/ Skupaj
2006	0	0	0	0
2009	0	0	0	0
2010	0	0	0	0
2011	0	0	0	0
2012	0	55	0	55
2013	0	259	0	259
2014	0	113	0	113
2015	0	40	20	60
2016	0	0	64	64
2017	0	0	96	96

Wagtail in the 2013–2017 period was estimated as uncertain (Figure 7).

White Wagtails were registered on 88 gravel bars in total (47.3% of all, annual range 46–53), constituting the stronghold of population breeding in the Drava riverbed. At six gravel bars on the upper part of the study area, the species bred in all years of the 2013–2017 period (5), and on further 16 in four years of the given period. Overall, three quarters of sites were occupied in two or more years (Figure 5). The majority of gravel bars (79.9% locations) held one pair (Figure 6). Furthermore, smaller numbers of White Wagtails also bred in natural and stabilised river banks on regular basis (Figure 15) (Appendix 5).

4.6. Gravel bar habitats

The number of gravel bars and their total surface area in the studied area of the Drava River increased in the second half of the 10-year study period, from 91 in 2006 and 104 in 2009/10 (75.6–80.2 ha) to 135 in 2014 and 144 in 2016 (98.2–104.8 ha). From 2006 to 2009/2010, shingle area of gravel bars declined by one third (–32.9%), while herbaceous (+55.1%) and woody vegetation (+26.8%) increased substantially. In 2014, areas of shingle and herbaceous plants increased by 83.5% and 134.9%, respectively, reaching their highest values in the study period. At the same time area covered with woody vegetation declined by 35.0% to the lowest level recorded. Until 2016, however, significant reduction of shingle area and expansion of woody vegetation occurred once more (Figure 16).

Table 9: Number of the White Wagtail *Motacilla alba* breeding pairs in survey sections on the Drava River

Tabela 9: Število gnezdečih parov bele pastirice *Motacilla alba* na popisnih odsekih reke Drave

Year/ Leto	Section / Odsek: Maribor–Starše min	Maribor–Starše max	Starše–Ptuj min	Starše–Ptuj max	Markovci–Zavrč min	Markovci–Zavrč max	Total / Skupaj min	Total / Skupaj max
2013	12	12	16	17	-	-	-	-
2014	19	21	14	16	25	26	58	63
2015	17	17	18	22	38	41	73	80
2016	19	20	17	20	39	42	75	82
2017	19	21	16	19	35	37	70	77

Management of gravel bars as defined herein was implemented at 20 sites (Figure 17). The majority of management works were carried out prior to the 2014 (10 sites) and 2017 (11 sites) breeding seasons and eight sites were managed in both periods. In the first period, the number of Little Ringed Plover and Common Sandpiper

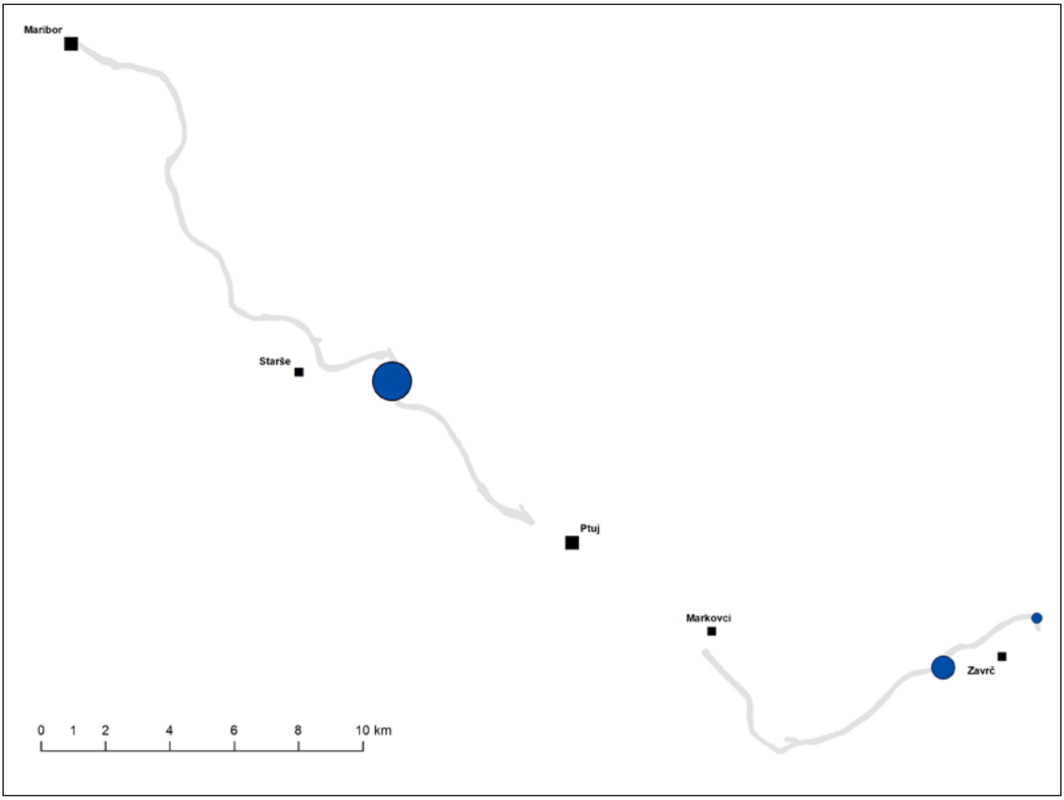

Figure 13: Locations of the Sand Martin *Riparia riparia* breeding colonies in study area of the Drava River. Size of the point corresponds to the maximum number of pairs registered.

Slika 13: Lokacije gnezditvenih kolonij breguljke *Riparia riparia* na raziskovanem območju reke Drave. Velikost točke ustreza največjemu zabeleženemu številu parov.

Table 10: Linear breeding density of White Wagtail *Motacilla alba* in survey sections on the Drava River

Tabela 10: Linearna gnezditvena gostota bele pastirice *Motacilla alba* na popisnih odsekih reke Drave

Year/ Leto	Section / Odsek						Total / Skupaj	
	Maribor–Starše		Starše–Ptuj		Markovci–Zavrč			
	min	max	min	max	min	max	min	max
2013	0.8	0.8	1.5	1.6	-	-	-	-
2014	1.3	1.5	1.3	1.5	1.8	1.9	1.5	1.6
2015	1.2	1.2	1.7	2.1	2.7	2.9	1.9	2.1
2016	1.3	1.4	1.6	1.9	2.8	3.0	1.9	2.1
2017	1.3	1.5	1.5	1.8	2.5	2.6	1.8	2.0

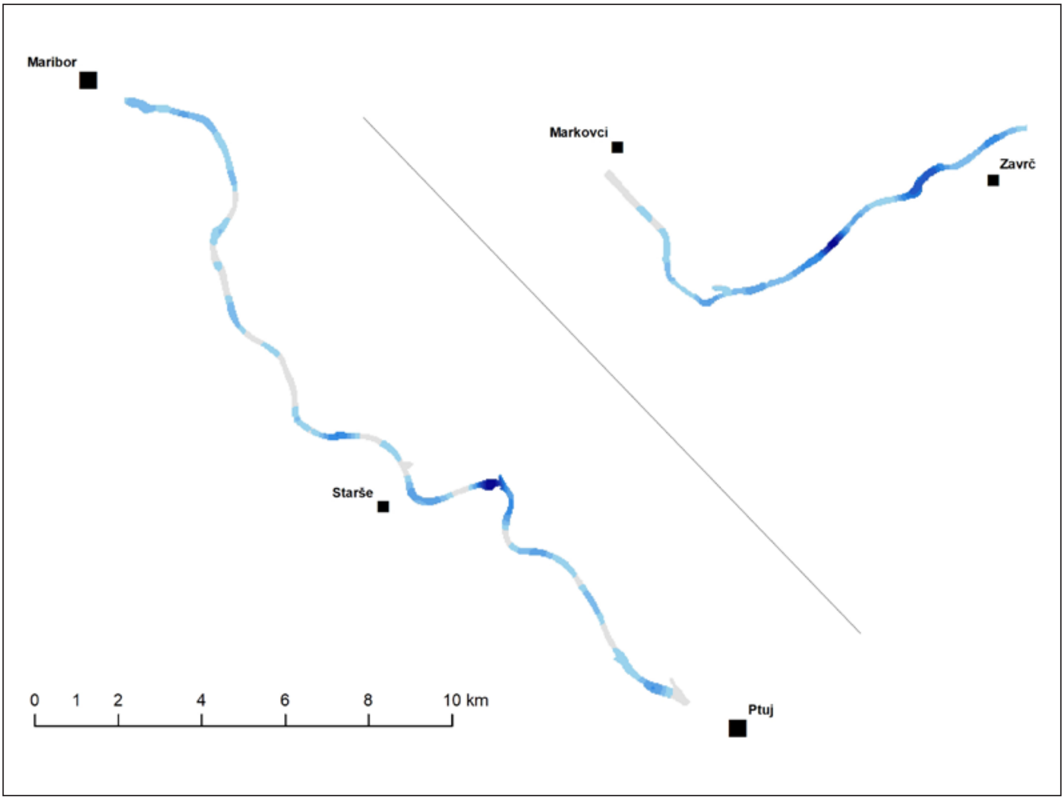

Figure 14: Density of White Wagtail *Motacilla alba* after the kernel method, based on registrations of individuals during the entire study period (started in 2013, N = 392 registrations of 659 ind.). The darker the shade of blue colour, the greater the density in that area. Outside blue-coloured areas, only single records may exist.

Slika 14: Gostota bele pastirice *Motacilla alba* po kernelski metodi na osnovi registracij osebkov v celotnem obdobju raziskave (začetek 2013, N = 392 zapisov o 659 os.). Temnejši ko je odtenek modre barve, večja je gostota na tistem območju. Zunaj modro obarvanih območij lahko obstajajo le posamezni podatki.

pairs (4,08-fold and 3,5-fold, respectively) as well as shingle area (5,07-fold) increased several-fold at these sites after the management implementation. Within 1–3 years thereafter (median = 2 years) the area of suitable habitat declined by 56.3%, but gravel bar-breeding species responded differently: Little Ringed Plover declined by one third (–32.7%), while the number of Common Sandpipers remained the same. After conclusion of the management during the second period, the shingle area increased again to 77.5% of the first-period level. At the same time, the number of Little Ringed Plover pairs at a given subset of gravel bars increased only slightly (+9.1%), while Common Sandpiper increased by a further 42.9% (Figure 18, Appendix 6). Development of habitats at one of the major gravel bars throughout both management periods is presented in Appendix 7.

5. Discussion

Long-term monitoring enabled an insight into population development of several riverbed-breeding bird species over a 10-year period. Owing to a constant inter-annual fieldwork effort that followed the same protocol, and highly-efficient census of birds using a boat, supplemented by certain interpretation criteria, the population estimates obtained

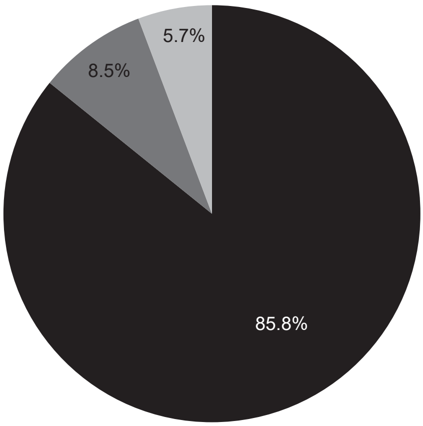

Figure 15: Percentages of the different White Wagtail *Motacilla alba* nest site types (N = 331 breeding pairs) in study area of the Drava River

Slika 15: Odstotki različnih tipov gnezdišč bele pastirice *Motacilla alba* (N = 331 gnezdečih parov) na raziskovanem območju reke Drave

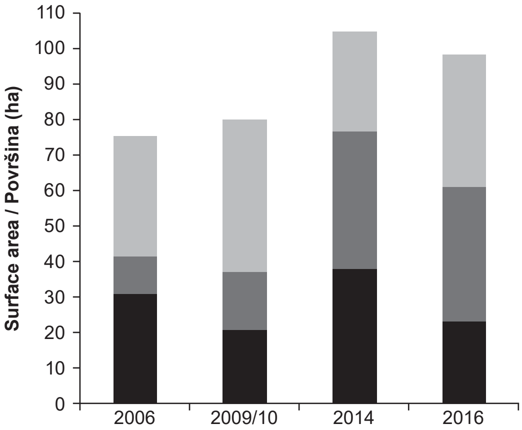

Figure 16: Surface areas of the main gravel bar habitat types in study area of the Drava River in years with orthophoto images available (N = 186 gravel bars)

Slika 16: Površine glavnih tipov habitatov prodišč na raziskovanem območju reke Drave v letih z razpoložljivimi ortofoti (N = 186 prodišč)

are comparable between years and probably fairly close to their true values (e.g. Gregory *et al.* 2004, Fletcher & Hutto 2006). The latter indication is supported by a high detection probability for territory-holding Little Ringed Plovers and especially Common Sandpipers found in different studies, resulting in high efficiency of line transects along rivers in estimating breeding numbers (Yalden & Holland 1993, D'Amico 2002, Arlettaz *et al.* 2012).

Among variations in numbers detected over time, large decline of Little Ringed Plover in the first part of the study period and subsequent rapid several-fold increase are remarkable. The most plausible explanation for such population development can be ascertained from substantial changes in surface area and proportions of the main habitats in the riverbed that reveal the same pattern of occurrence: reduction in shingle area and simultaneous encroachment of woody vegetation caused a decline of breeding pairs, while the reverse triggered a population recovery. In terms of well-known and rather simple habitat requirements of the species (e.g. Geister 1997, Bauer *et al.* 2005, see also Appendix 1), this conclusion seems straightforward. However, underlying causes of the observed changes are fairly complex and comprise an interplay of occurrence of large discharges and implementation of appropriate management practices. Gravel bars are the result of erosion and sedimentation processes and are very dynamic systems characterized by a high proportion of deposits without or sparse vegetation cover. Their succession is, among others, related to the duration and frequency of flooding (Gilvear *et al.* 2008). However, rivers with altered flow regime and diminished bedload transport are subjected to overgrowing, evolving over time into a stage where typical infrequent and reduced floods are insufficient to supress vegetation growth (Junk *et al.* 1989, Reich 1994, Hicks *et al.* 2008). This is also the case in the studied area of the Drava River where most of today's gravel bars are more or less stabilised remains of higher parts of the former riverbed bottom, which became dry after the reduction of discharges due to operation of hydroelectric power

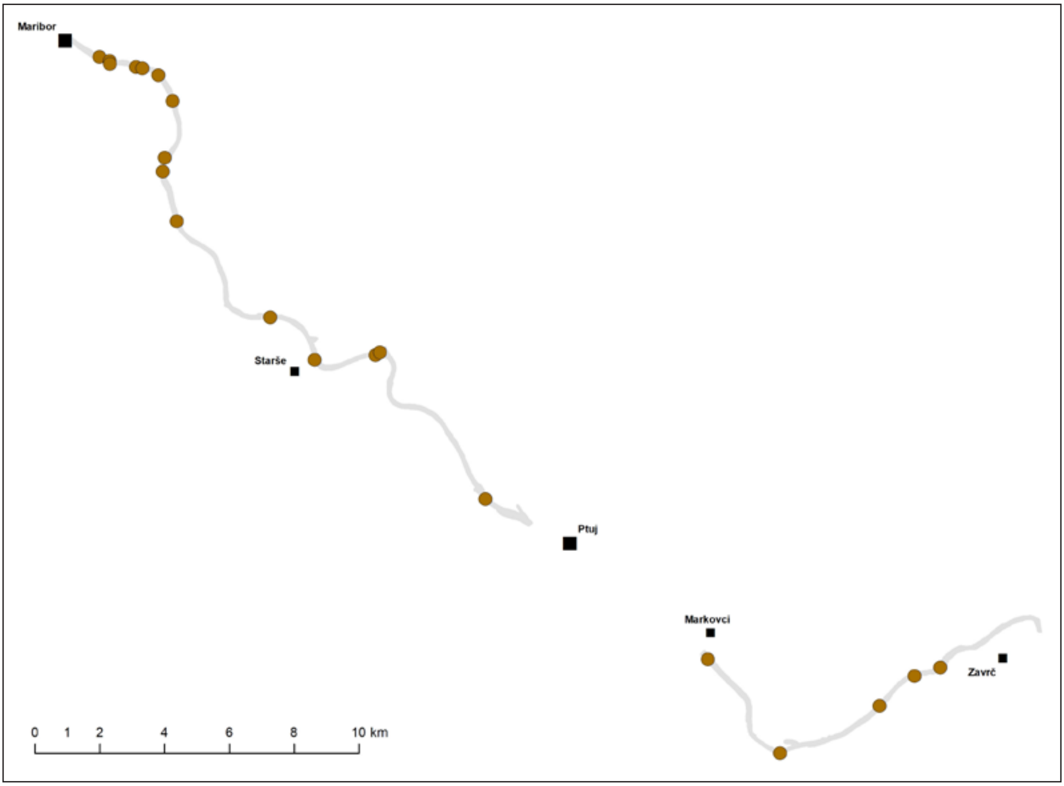

Figure 17: Locations of gravel bars in study area of the Drava River with management carried out between 2013 and 2017 (N = 20)

Slika 17: Lokacije prodišč na raziskovanem območju reke Drave, na katerih je potekalo upravljanje med letoma 2013 in 2017 (N = 20)

plants (Sovinc 1995, Klaneček *et al.* 2005). The amount of early successional stages and formation of new gravel bars is therefore dependent on rare and unpredictable high-flow events capable of starting bedload transport and mobilising confined gravel bars, i.e. discharges of min. 400–600 m^3/s (hereafter referred to as "large discharges") as estimated for the study area by Klaneček *et al.* (2005). This situation is reflected in: (1) the very low number of locations suitable for both specialised gravel bar-breeding bird species for more than a couple of years throughout the entire decade, and (2) the small area of individual patches of early successional stages, a phenomenon noted also on other rivers with a similarly altered flow regime (Reich 1994), making most of the gravel bars unable to hold more than a single breeding pair. Therefore, the low Little Ringed Plover numbers during 2009–2012 can largely be attributed to the lack of large discharges and consequent overgrowing of the riverbed in this period. The intensity of any kind of management works was also fairly low at that time. As the turning point for the population increase after 2013, the following is of particular importance: (1) the extreme flood in early November 2012 when discharge in the riverbed reached the modern-time record value of 3,300 m^3/s (Klaneček 2013), (2) the subsequent regular occurrence of large discharges prior to the 2014 and 2015 breeding seasons, (3) large-scale removal of woody vegetation on multiple gravel bars in the study area with several of them within the LIVEDRAVA project

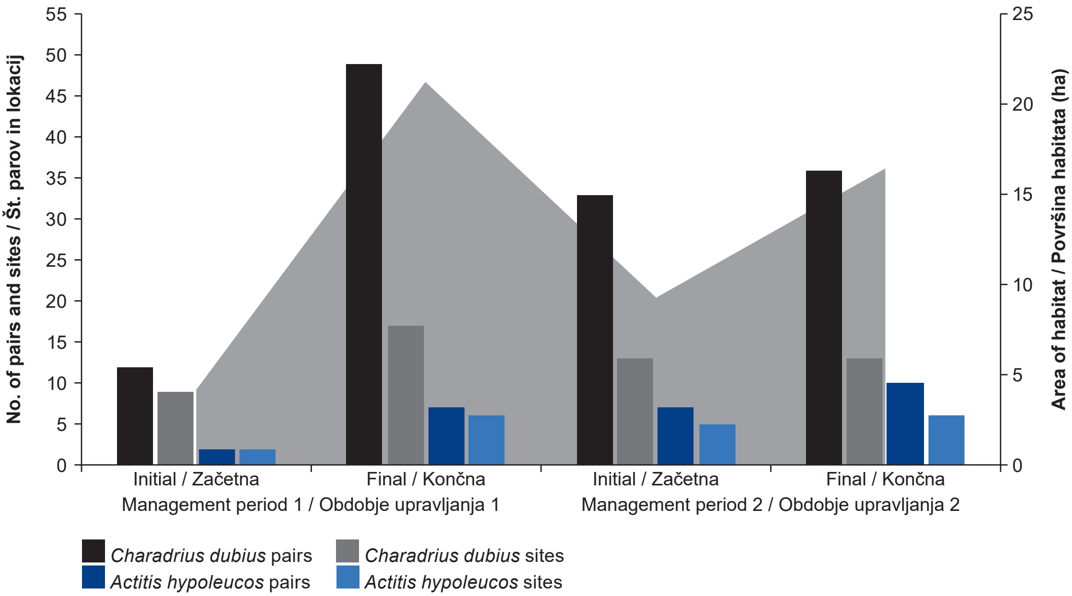

Figure 18: Number of the Little Ringed Plover *Charadrius dubius* and Common Sandpiper *Actitis hypoleucos* breeding pairs and gravel bars occupied (bars) and surface area of suitable shingle habitat (area chart) in two management periods, 2013–2015 and 2016–2017. Initial and final situation for each management period is given (before and after the management implementation).

Slika 18: Število gnezdečih parov in zasedenih prodišč malega deževnika *Charadrius dubius* in malega martinca *Actitis hypoleucos* (nizi) ter površina primernega prodnatega habitata (ploščinski grafikon) v dveh obdobjih upravljanja, 2013–2015 in 2016–2017. Za vsako obdobje upravljanja je predstavljena začetna in končna situacija (pred in po izvedbi upravljanja).

specifically targeting habitat restoration of gravel bar breeding birds. Extreme floods are known to act as major drivers of intensive geomorphic processes within river corridors (Junk *et al.* 1989). These can result in notable diversification of the river channel and formation of extensive areas of natural riverine habitats, followed by sudden several-fold increases of riverbed breeding bird populations, as demonstrated by Kajtoch & Figarski (2013). Evidently, both geomorphic changes mentioned took place in our study area (diversification by increased overall number of gravel bars, formation of new shingle areas) with similar-scale consequences for the Little Ringed Plover population. Also, management works carried out in the aftermath of the extreme flood created further new shingle areas, thus contributing substantially to the total surface area of suitable habitat for the species. Both major floods as well as restoration measures were assessed as important factors in the Little Ringed Plover population increase on the Swiss section of the Rhone River (Arlettaz *et al.* 2012). Several high water events that coincided with management works in this period prevented immediate overgrowing of restored sites (see Appendix 7). It is known that large discharges have landscape-level implications in rivers by creating natural disturbance necessary to counter natural successional trends (Ward *et al.* 2002). Some evidence suggests that frequent large discharges can maintain stable Little Ringed Plover population by sustaining a favourable state of its breeding habitat (Zintl 1988). Moreover, successive occurrence of both factors proved to be an effective combination for creating extensive shingle areas due to flushing of exposed organic material and soil particles from formerly overgrown gravel bars that became devoid of vegetation cover after management, and enabled partial mobilisation and/or relocation of these gravel bars. By 2017, however, after an absence of large discharges prior to the two consecutive breeding seasons, the total Drava River Little Ringed Plover population declined again. At the same time, the number of pairs at sites managed during the second period increased only marginally despite substantial increase of suitable habitat area there. Thus, the notion that floods are a major factor in river channel restoration (Kajtoch & Figarski 2013) can be supported from the perspective of the Little Ringed Plover. However, very frequent increased discharges during the breeding season may have affected breeding in some years (e.g. low numbers on the upper part of the study area in 2009, 2010 and 2012), further aggravating the negative impact of riverbed overgrowing in that period. The disruptive effect of high water levels on the occupancy of the Little Ringed Plover and Common Sandpiper territories in the riverbed is reported by Fenyősi (2005) and Schmidt (2016). The extreme situation in 2013 presumably completely prevented breeding in the lower part of the study area Drava as all gravel bars were under water due to constant large flow in the first half of the year.

On the other hand, causes of Common Sandpiper population development are more difficult to ascertain. Obviously, the total breeding population size of this species did not reflect changes in overall surface area of the main riverbed habitats, but instead, after an initial substantial decline, remained at a rather similar level during most of the study period. It seems that the decline noted in the study period is merely a continuation of a long-term negative trend as the total breeding population of the Slovenian lowland part of the Drava River in the late 1990s was even higher than in 2006 (Štumberger 2000, Božič & Denac 2010). This is in accordance with the decreasing European population trend, more pronounced in the EU countries (BirdLife International 2015b). Some evidence exists that depletion of the Common Sandpiper populations is at least partly due to declining adult survival rates, related to changing conditions in wintering and migratory stopover areas, i.e. factors largely operating outside its European breeding grounds (Pearce-Higgins *et al.* 2009). However, contrary to the general situation, the number of breeding pairs on gravel bars subjected to vegetation removal first increased several-fold after the start of management and then again to a lesser extent by the end of it. Common Sandpiper readily accepts restored areas as several cases of population increases and re-colonisations, even on fairly short such sections of riverbed are documented from a wide array of rivers, from alpine to lowland. Different studies state promotion of alluvial habitats with some grass and bush/small trees cover, creation of richly structured areas with sufficient proportion of open surface, areas with numerous river islands and large gravel bars and river widening as main causes for population recovery (Metzner 2002, Petutschnig 2004, Arlettaz *et al.* 2012, Uhl & Weissmair 2012). Unlike the Little Ringed Plover, the Common Sandpiper numbers did not decline in a relatively short time scale between the two management episodes despite the accompanying reduction in shingle surface area. This can be explained by the fact that breeding habitat of the species at least partly consists of some areas with denser herbaceous vegetation as well, herein not treated as shingle habitat category (cf. Frühauf & Dvorak 1996, Elas & Meissner 2014, see also Appendix 2). Preference of Common Sandpiper for slightly more advanced succession stages also means that it is a later colonizer of newly created areas in river systems, as some time is needed before suitable habitats are progressively formed (Arlettaz *et al.* 2012). It is therefore possible that only as late as 2017, i.e. up to four years after the start of management measures, an optimal mosaic of early successional stages interspersed with shingle areas developed at main sites in our study area. Reasons for the scarcity of Common Sandpiper along the upper Drava, notably after 2009, despite existence of apparently suitable breeding sites there, remain unknown.

Although fairly widely distributed along the riverbed, the Kingfisher occurred in rather low densities throughout the study period. Similar low number of breeding locations occupied more than a few years throughout the study period to both specialised gravel bar breeders, suggests that causes for such a state probably originated in the altered flow regime with rare high-flowevents, resulting in limited bank erosion and consequent overgrowing/ lack of suitable nest sites. The latter was often judged as a limiting factor for the Kingfisher populations (Čech 2006, Schmidt & Zuna-Kratky 2009). Otherwise, long-term, up to several decades long, use of preferred nest sites is typical of the species (Čech 2006, Wiggler *et al.* 2015). This assumption is supported by (1) the moderate increase in number of pairs after the extreme 2012 flood that created some new exposed vertical surfaces by opening previously uniformly vegetated and/or consolidated river stretches, and (2) observations indicating that most of the new potential nest sites, even suboptimal (e.g. low above usual water level exposed to high risk of flooding), are usually occupied already in the first breeding season after formation (*own data*) as observed elsewhere (Westermann & Westermann 1998). Kingfisher is known to be susceptible to harsh winter conditions that can decimate its numbers, mainly through high mortality of adults caused by starvation due to prevented fishing on frozen waters (Morgan & Glue 1977, Libois 1997, Sackl 1997, Čech 2006, Schmidt & Zuna-Kratky 2009). Therefore, the prolonged period of the exceptionally severe winter temperatures in January 2017 (Cegnar 2017) is probably responsible for very low number of pairs registered in the breeding season that year. Characteristics of nest sites in our study confirm the preference for nesting close to the bank top (Isotti & Consiglio 1998, Hartwig 2005, Straka & Grim 2007), however, these features can also be related to the availability of a suitable soil layer in a situation of general nest site shortage.

Sufficiently sizeable exposed banks with suitable substrate for colonially nesting Sand Martin (e.g. Heneberg 2003, Bauer *et al.* 2005) are only very rarely found along the studied area of the Drava riverbed. Such situation differs substantially from the remaining vast natural stretches of other major rivers in the region, including the Drava downstream of confluence with the Mura River (Szep *et al.* 2003, Reeder *et al.* 2006, Mikuska & Grlica 2013), but is typical for rivers with altered flow regime (e.g. Schmidt *et al.* 2015). Regular breeding since 2012 was almost exclusively a result of the annual artificial nest site preparation programme (manual removal of vegetation and shaping of proper inclination by a team of volunteers) initiated in that year.

The discovery of a previously unknown fairly large gravel bar-breeding population of White Wagtail in the study area is interesting, considering the prevalent breeding habits of the species on the European scale. The species is a widespread breeding bird of open landscapes, in recent times closely associated with areas of various anthropogenic activities from agricultural land to settlements, while riverine habitats such as natural banks and gravel bars are considered its primary breeding habitat (Bauer *et al.* 2005). The latter were not described as nest sites neither in the old Slovenian ornithological literature (Ponebšek & Ponebšek 1934, Krečič & Šušteršič 1963) nor in more recent species accounts where only nesting in steep eroded banks, overhanging vegetation atop of melioration ditches and uprooted trees is mentioned (Geister 1995, Bračko 1997, Tome *et al.* 2005). Elsewhere, natural nest sites along rivers are mostly different cavities, niches or crevices and old holes of burrow-nesting species. Ground nesting in sparsely vegetated area, presumably the predominant nest placement type along the studied Drava riverbed, is usually only briefly mentioned as uncommon (Bauer *et al.* 2005, Maumary *et al.* 2007) and mainly confined to gravel bars (Glutz von Blotzheim & Bauer 1985). In a small proportion of ground nests found in dedicated studies, these were usually placed in holes, in dense herbaceous vegetation or well-sheltered by plant cover (woody or grass tussock). Nests in more or less open areas as recorded in the study area (see Appendix 5c) were rarely reported (Leinonen 1974, Mason & Lyczynski 1980). However, field observations and occupancy of breeding locations indicate that the White Wagtail readily selects more advanced succession stages there as well.

The Slovenian lowland part of the Drava River is among the most important areas for all riverbed breeding bird species of conservation concern in the country (Denac *et al.* 2011). Linear densities of the Little Ringed Plover breeding pairs calculated for the good years (2006, 2014–2017) are higher than recorded on most comparable sections in Central Europe, where these only rarely exceed 1 p/km, mostly on wide, natural or restored stretches of large rivers (Božič & Denac 2010, Arlettaz *et al.* 2012, Schmidt 2016). On the other hand, densities of Common Sandpiper were similar to the prevailing situation (Theiss *et al.* 1992, Frühauf & Dvorak 1996, Schödl 2006, Schmidt & Zuna-Kratky 2009, Božič & Denac 2010, Schmid *et al.* 2010, Schmidt 2016). Densities in the lower part of the study area exceeded 1 p/km, a value characteristic of high-quality sections on a diverse array of rivers, only in the first two years (Božič & Denac 2010, Arlettaz *et al.* 2012). However, exceptional densities along vast natural river corridors can surpass this value for both species by several-fold (e.g. Reich 1994, Elas & Meissner 2014). The Kingfisher densities of well below 1 p/km found in the study area (c. one pair on 2–3 km of the studied riverbed on average) are typical of the rivers in Central Europe (Božič & Denac 2010).

Our findings have some important conservation implications that should be considered in future management decisions tackling the lowland part of the Drava riverbed. The large carrying capacity of the study area for Little Ringed Plover under suitable conditions was clearly demonstrated. However, most of the time this carrying capacity is reduced substantially due to suppressed natural disturbance regime resulting in a relatively small amount of available breeding habitat (see Catlin *et al.* 2016, Ziegler *et al.* 2017). Therefore, the ultimate goal would be to alter the prevailing regime towards one more similar to the natural disturbance flow regime (i.e. magnitude, frequency, seasonal timing, predictability, and/or duration of high-flow events) that would maintain a sufficient area of suitable habitat, supported by moderate management interventions. The evidence gathered suggests that synchronization of management with high-flow events, an outcome that occurs only on fairly rare occasions under currently existing river management and electric power generation practices, is probably the most feasible and cost-effective method to achieve good results in our situation. However, this estimate relies only on observed effects of these on population size and disregards the demographic aspects of the species. Plovers breeding in dynamic alluvial habitats exhibit behavioural adaptations to natural disturbances, including extreme floods, e.g. they increase their dispersal rates and reproductive output following high-flow events, with major influence of these on dynamics and the persistence of individual populations (Catlin *et al.* 2016). A metapopulation viability analysis found that peak population persistence and abundance of sand bar-breeding plover species would occur at a four-year return interval of high-flow events (Ziegler *et al.* 2017). Furthermore, dedicated studies indicate that neither artificially constructed or managed gravel bars cannot appropriately substitute natural river dynamics due to lower demographic parameters on these and/or rapid vegetation encroachment (Catlin *et al.* 2011 & 2015, Hunt *et al.* 2018), the latter experienced at our managed sites as well. Important features of flood-created alluvial habitats were lower nesting densities over substantially increased areas of sandbar, and decreased nest and chick predation (Hunt *et al.* 2018). Based on these observations, future management efforts in the Drava riverbed should also incorporate the following: (1) regular bankfull discharges achieved by planned release of water over dams during extended periods without natural high-flow events; (2) implementation of river restoration measures that would enable bank erosion during high-flow events and consequent formation of new gravel bars through provision of gravel sediment (limited under existing conditions), such as removal of dysfunctional/unnecessary rock ripraps; (3) large-scale (most of the gravel bars included) and complete removal of woody vegetation on regular basis, and synchronized with occurrence of high-flow events that would promote flood-assisted formation of extensive open and/or sparsely vegetated shingle areas.

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6. Povzetek

Med letoma 2006 in 2017 smo na 38,9 km dolgem odseku nižinskega dela struge Drave s spremenjenim pretočnim režimom zaradi hidroelektrarn med Mariborom in Zavrčem opravili vsakoletni popis gnezdilk, ki so indikatorske vrste naravnih rek. V štirih letih raziskave smo popisali tudi prodišča s kombinirano analizo ortofoto posnetkov in fotografij s terena. Vpliv upravljanja s prodišči smo preučili na 20 lokacijah. Mali deževnik *Charadrius dubius* se je pojavljal na 39,8 % vseh prodišč, vendar jih je bila večina zasedena le po nekaj let z enim samim gnezdečim parom. Nizkim številkam med letoma 2009 in 2012 (< 30 parov) je sledil strm porast populacije do maksimuma 66–73 parov (1,7–1,9 para/km) od leta 2014 naprej. To populacijsko dinamiko smo pripisali izostanku velikih pretokov (>500 m^3/s) in posledičnemu zaraščanju struge v prvem delu raziskovalnega obdobja, porast v drugem delu pa nastanku številnih prodišč (površina 20,6 ha v letih 2009/10 in 37,8 ha leta 2014) po izredni poplavi v zgodnjem novembru 2012, pojavljanju velikih pretokov med naslednjimi gnezditvenimi sezonami in odstranjevanju lesne vegetacije. Gnezditvena populacija malega martinca *Actitis hypoleucos* je bila majhna in stabilna (< 20 parov) po začetnem upadu, spremembe v površini habitatov rečne struge nanjo niso imele vpliva in ni odražala splošnih sprememb v površini habitatov rečne struge. V nasprotju s celotnim območjem se je število gnezdečih parov na upravljanih prodiščih močno povečalo. Najvišje število parov je bilo doseženo do štirih let po začetku upravljanja, saj je na glavnini območij šele tedaj nastal optimalen habitatni mozaik zgodnjih sukcesijskih stadijev in prodnate podlage. Vrsta je bila splošno razširjena le na spodnjem odseku Drave. Vodomec *Alceo atthis* je bil splošno razširjen vzdolž struge z razmeroma majhno gostoto (približno en par na 2–3 km rečne struge), verjetno zaradi omejene erozije bregov in posledičnega pomanjkanja primernih gnezdišč. Populacija je ostala stabilna, ugotavljali pa smo vpliv ostrih zim na številčnost v posameznih letih. Večina gnezditvenih rovov je bila izkopana v erodiranih bregovih vzdolž glavne struge (77,8 %), manjši del pa v podobnem habitatu na manjših pritokih Drave (14,8 %). Redna gnezditev breguljke *Riparia riparia* po letu 2012 (do 259 parov, večinoma na eni lokaciji vsako leto) je bila skoraj izključno posledica vsakoletne priprave umetnih gnezdišč. Od začetka monitoring te vrste leta 2013 smo spremljali razmeroma veliko populacijo bele pastirice *Motacilla alba* na prodiščih, kjer gnezdi na tleh na skromno poraščenih delih. To je nenavadno, upoštevajoč njene prevladujoče gnezditvene navade v Evropi.

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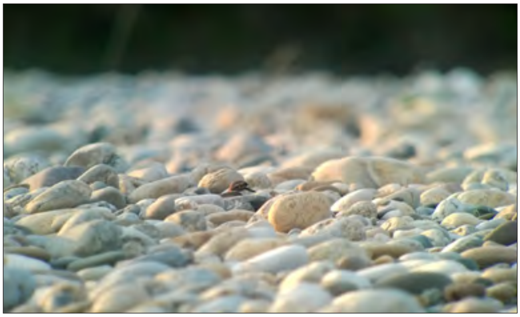
APPENDIX 1 / DODATEK 1

Breeding habitat of Little Ringed Plover *Charadrius dubius* in studied area of the Drava River. Presented here is the entire range of nest sites selected by the species in the study area, from completely bare shingle, varying among sites in sediment grain size and surface area (a–e) to gravel bars overgrowing with herbaceous and early stages of woody vegetation (f–l). In all cases, the actually occupied nest sites with confirmed breeding (nests found) are depicted. Photos: T. Basle (b), L. Božič (a, c–l)

Gnezditveni habitat malega deževnika *Charadrius dubius* na raziskovanem območju reke Drave. Predstavljen je celoten razpon gnezdišč, ki jih na območju raziskave izbira vrsta, od popolnoma golega proda, ki se med območji razlikuje v velikosti zrn sedimenta in površini (a–e), do prodišč, zaraščajočih se z zelmi in zgodnjimi fazami lesne vegetacije (f–l). V vseh primerih so prikazana dejansko zasedena gnezdišča s potrjenim gnezdenjem (najdena gnezda). Foto: T. Basle (b), L. Božič (a, c–l)

(a)

(b)



(c)

(d)

(e)

(f)

Nadaljevanje dodatka 1 / Continuation of Appendix 1

(g)

(h)

(i)

(j)

(k)

(l)

APPENDIX 2 / DODATEK 2

Breeding habitat of Common Sandpiper *Actitis hypoleucos* in studied area of the Drava River. Presented are different nest sites of the species on the study area, from mostly unvegetated gravel bars (a-c) to areas with predominant dense herbaceous vegetation (d-f). On the former sites, nests are situated next to solitary herbs or under stranded large woody debris, while on the latter sites they are placed along edges, close to more open areas. In all cases, the actually occupied nest sites with confirmed breeding (nests found) are depicted. Photos: L. Božič

Gnezditveni habitat malega martinca *Actitis hypoleucos* na raziskovanem območju reke Drave. Predstavljena so različna gnezdišča vrste na območju raziskave, od večinoma neporaslih prodišč (a-c) do območij s prevladujočo gosto zarastjo zeli (d-f). Na prvih gnezda ležijo ob posameznih zelnatih rastlinah ali pod naplavljenimi debli, medtem ko so na slednjih nameščena vzdolž robov, v bližini bolj odprtih predelov. V vseh primerih so prikazana dejansko zasedena gnezdišča s potrjenim gnezdenjem (najdena gnezda). Foto: L. Božič

(a)

(b)

(c)

(d)

(e)

(f)

APPENDIX 3 / DODATEK 3

Kingfisher *Alcedo atthis* nest sites in studied area of the Drava River: (a) long natural section of concave river bank, (b) freshly eroded river bank with exposed vertical surface of suitable alluvial soil, (c) partly overgrown high river bank, (d) river bank with rather thin layer of suitable soil, (e) river bank completely obscured by overhanging vegetation, (f) the longest occupied nest site in the study area formed by bank erosion at location of damaged old rock riprap, (g) mouth area of small stream, (h) nest hole excavated low above water in a small suitable surface of a stream mouth, (i) river terrace edge 15 m above the river, (j) unusual nest site in a sloping edge of river island with nest hole only 30 cm above water. Photos: L. Božič (a–e, g–j), D. Denac (f)

Gnezdišča vodomca *Alcedo atthis* na raziskovanem območju reke Drave: (2) dolg naraven odsek zunanjega rečnega brega, (b) sveže erodiran rečni breg z izpostavljeno navpično površino, primerne obrečne prsti, (c) delno zaraščen visok rečni breg, (d) rečni breg z dokaj ozko plastjo ustrezne prsti, (e) z visečo vegetacijo povsem zakrit rečni breg, (f) najdlje zasedeno gnezdišče, nastalo z erozijo brega na mestu, kjer je bil poškodovan star kamnomet, (g) območje ustja majhnega potoka, (h) gnezdilni rov, izkopan nizko nad vodo v majhni primerni površini ustja potoka, (i) ježa rečne terase 15 m nad reko, (j) neobičajno gnezdišče v poševnem robu rečnega otoka z gnezdilnim rovom le 30 cm nad vodo. Foto: L. Božič (a–e, g–j), D. Denac (f)

(a)

(b)

(c)

(d)

Nadaljevanje dodatka 3 / Continuation of Appendix 3

(e)

(f)

(g)

(h)

(i)

(j)

APPENDIX 4 / DODATEK 4

The Sand Martin *Riparia riparia* colonies in specially prepared natural banks in the Drava riverbed: (a) nest holes at location on the upper part of the study area managed between 2012 and 2016 (occupied in 2012–2015), (b) section of nesting wall on the lower part of the study area where management was carried out in the 2014–2017 period (occupied since 2016), (c) view of the entire stretch of natural river bank with the Sand Martin nest sites on the upper part of the study area at the beginning of breeding season. Photos: L. Božič

Kolonije breguljk *Riparia riparia* v posebej pripravljenih naravnih bregovih v strugi reke Drave: (a) gnezdilni rovi na lokaciji na zgornjem delu območja raziskave z upravljanjem med letoma 2012 in 2016 (zasedena 2012–2015), (b) odsek gnezdilne stene na spodnjem delu območja raziskave, kjer je upravljanje potekalo v obdobju 2014–2017 (zasedena od 2016), (c) pogled na celotno dolžino naravnega rečnega brega z gnezdišči breguljke na zgornjem delu v začetku gnezditvene sezone. Foto: L. Božič

(a)

(b)

(c)

APPENDIX 5 / DODATEK 5

The White Wagtail *Motacilla alba* nest sites in the study area of the Drava River: (a, b) tuft of herbaceous plants on partly overgrown part of the gravel bar, (c) rather open shingle area with nest unconcealed from above, (d) root system of large tree stranded on gravel bar, (e) natural river bank, (f) crevice between boulders in rock riprap. In all cases, the actually occupied nest sites with confirmed breeding are depicted. Photos: L. Božič

Gnezdišča bele pastirice *Motacilla alba* na raziskovanem območju reke Drave: (a, b) šop zelnatih rastlin na delno zaraščenem delu prodišča, (c) dokaj odprta prodnata površina, kjer gnezdo od zgoraj ni zakrito, (d) koreninski sistem velikega drevesa, naplavljenega na prodišču, (e) naravni rečni breg, (f) razpoka med skalami v kamnometu. V vseh primerih so prikazana dejansko zasedena gnezdišča s potrjenim gnezdenjem. Foto: L. Božič

(a)

(b)

(c)

(d)

(e)

(f)

APPENDIX 6 / DODATEK 6

Number of the Little Ringed Plover *Charadrius dubius* and Common Sandpiper *Actitis hypoleucos* breeding pairs and surface area of suitable shingle habitat on all managed gravel bars in two periods, 2013–2015 and 2016–2017. Initial and final situations for each period and year of data are given. Bold font denotes sites with management carried out in a given period. Gravel bars 35 (Starše), 37 and 700 (Krčevina pri Vurbergu), 49 (Hajdoše), 6000 (Dravci), 76 (Borl) and 82 (Mala vas) were managed within the LIVEDRAVA project.

Število gnezdečih parov malega deževnika *Charadrius dubius* in malega martinca *Actitis hypoleucos* ter površina primernega prodnatega habitata na vseh upravljanih prodiščih v dveh obdobjih, 2013–2015 in 2016–2017. Za vsako obdobje sta predstavljena začetna in končna situacija ter leto podatka. Krepka pisava označuje območja, na katerih je v določenem obdobju potekalo upravljanje. Na prodiščih 35 (Starše), 37 in 700 (Krčevina pri Vurbergu), 49 (Hajdoše), 6000 (Dravci), 76 (Borl) in 82 (Mala vas) je bilo upravljanje opravljeno v okviru projekta LIVEDRAVA.

	Management period 1 / Obdobje upravljanja 1							
	Initial situation / Začetna				Final situation / Končna			
Gravel bar ID/ ID prodišča	CHADUB pairs / pari	ACTHYP pairs/ pari	Habitat (m^2)	Year/ Leto	CHADUB pairs / pari	ACTHYP pairs/ pari	Habitat (m^2)	Year/ Leto
0	1	0	7449	2013	**2**	0	**39828**	**2014**
401	0	0	6427	2013	1	1	7082	**2014**
402	0	0	0	2011	**1**	0	**5838**	**2013**
601	0	0	308	2013	**2**	0	**2092**	**2014**
602	0	0	0	2013	**1**	0	**5764**	**2014**
7	1	0	544	2011	**3**	0	**12032**	**2014**
901	0	0	0	2013	**1**	0	**2381**	**2014**
132	0	0	1836	2013	**2**	0	**9118**	**2014**
15	1	0	317	2011	**0**	0	**8513**	**2013**
18	0	0	238	2011	**1**	0	**12286**	**2013**
27	0	0	1210	2014	**0**	0	**4493**	**2015**
35	1	0	2540	2013	**3**	0	**8958**	**2014**
37	1	1	2617	2014	**4**	1	**16639**	**2015**
700	3	0	4020	2013	3	0	4016	2014
49	1	0	784	2014	**1**	0	**5459**	**2015**
512	0	0	0	2013	**2**	1	**3852**	**2014**
6000	2	1	3807	2014	**3**	1	8081	**2015**
76	1	0	3263	2013	**9**	2	**12642**	**2014**
3800	0	0	0	2013	0	0	403	2014
82	0	0	6910	2013	**10**	1	**43279**	**2014**
Total / Skupaj	12	2	42270		49	7	212756	

Gravel bar ID/ ID prodišča	Management period 2 / Obdobje upravljanja 2							
	Initial situation / Začetna				Final situation / Končna			
	CHADUB pairs / pari	ACTHYP pairs/ pari	Habitat (m^2)	Year/ Leto	CHADUB pairs / pari	ACTHYP pairs/ pari	Habitat (m^2)	Year/ Leto
0	1	1	6942	2016	**2**	**0**	**7982**	2017
401	1	0	1924	2016	**1**	**1**	**4441**	2017
402	0	0	852	2016	**1**	**1**	**22281**	2017
601	2	0	1248	2016	0	0	0	2017
602	0	0	1135	2016	**2**	**0**	**3767**	2017
7	2	0	298	2016	**2**	**0**	**7945**	2017
901	1	0	754	2016	0	0	0	2017
132	2	0	2330	2016	0	0	320	2017
15	0	0	1780	2016	0	0	0	2017
18	1	0	7279	2016	2	0	4815	2017
27	0	0	4021	2016	0	0	0	2017
35	2	0	1350	2016	**2**	**0**	**13516**	2017
37	3	0	6981	2016	**3**	**0**	**15264**	2017
700	2	1	3737	2016	**2**	**0**	**4574**	2017
49	0	0	1571	2016	0	0	671	2017
512	0	0	176	2016	0	0	0	2017
6000	2	1	5376	2016	2	1	5026	2017
76	7	2	7671	2016	**7**	**3**	**15400**	2017
3800	0	0	0	2015	**2**	**2**	**13487**	2016
82	7	2	37274	2016	**8**	**2**	**45715**	2017
Total / Skupaj	33	7	92699		36	10	165204	

APPENDIX 7 / DODATEK 7

Development of habitats on one of the most important gravel bars in studied area of the Drava River at Borl (ID No. 76, 46.37°N, 16.00°E) throughout the two management periods (all photos taken from bridge above the uppermost tip of the gravel bar at usual discharge except where noted): (a) situation before the start of management 1 – lower two thirds are completely overgrown with trees and bushes, 29 Aug 2013, (b) view after the conclusion of management 1, carried out in late Sep–first half of Oct, and several following high water events with max discharge 580 m^3/s, 12 Dec 2013, (c) the first breeding season after management 1, 29 May 2014, (d) autumn aspect after several high water events with max discharge 1063 m^3/s, 13 Oct 2014, (e) the second breeding season after management 1, 7 Jun 2015, (f) autumn situation without preceding large discharges, 8 Oct 2015, (g) almost completely submerged gravel bar at c. 320 m^3/s, 15 Oct 2015, (h) the third breeding season after management 1, 26 May 2016, (i) late autumn situation without preceding large discharges, just prior to the start of management 2, 15 Nov 2016, (j) gravel bar immediately after conclusion of management 2 that was not followed by any large discharge during the corresponding non-breeding period, 29 Nov 2016, (k) the first breeding season after management 2, 4 Jun 2017; series of available aerial photographs (orthophotos): (l) situation before the extreme 2012 flood and the start of management, 30 Apr 2010, (m) during the first breeding season after management 1, 20 May 2014, and (n) during the third breeding season after management 1, 21 Apr 2016; photos: A. Koren (a, b), L. Božič (c–k), The Surveying and Mapping Authority of the Republic of Slovenia (l–n).

Razvoj habitatov na enem izmed najpomembnejših prodišč na raziskovanem območju reke Drave pri Borlu (ID št. 76, 46.37°N, 16.00°E) v času dveh obdobij upravljanja (vse fotografije so bile narejene z mosta nad zgornjim koncem prodišča pri običajnih pretokih, razen kjer je navedeno drugače): (a) situacija pred začetkom upravljanja 1 – spodnji dve tretjini sta v celoti zaraščeni z drevesi in grmovjem, 29. 8. 2013, (b) pogled po zaključku upravljanja 1, opravljenega med koncem septembra in prvo polovico oktobra, in več sledečih visokovodnih dogodkih z največjim pretokom 580 m^3/s, 12. 12. 2013, (c) prva gnezditvena sezona po upravljanju 1, 29. 5. 2014, (d) jesenski vidik po več visokovodnih dogodkih z največjim pretokom 1063 m^3/s, 13. 10. 2014, (e) druga gnezditvena sezona po upravljanju 1, 7. 6. 2015, (f) jesenska situacija brez predhodnih velikih pretokov, 8. 10. 2015, (g) skoraj v celoti potopljeno prodišče pri c. 320 m^3/s, 15. 10. 2015, (h) tretja gnezditvena sezona po upravljanju 1, 26. 5. 2016, (i) poznojesenska situacija brez predhodnih velikih pretokov, tik pred začetkom upravljanja 2, 15. 11. 2016, (j) prodišče takoj po zaključku upravljanja 2, ki mu v pripadajočem negnezditvenem obdobju ni sledil noben velik pretok, 29. 11. 2016, (k) prva gnezditvena sezona po upravljanju 2, 4. 6. 2017; serija razpoložljivih aerofotografij (ortofotov): (l) situacija pred ekstremno poplavo leta 2012 in začetkom upravljanja, 30. 4. 2010, (m) med prvo gnezditveno sezono po upravljanju 1, 20. 5. 2014, (n) med tretjo gnezditveno sezono po upravljanju 1, 21. 4. 2016; foto: A. Koren (a, b), L. Božič (c–k), Geodetska uprava Republike Slovenije (l–n).

(a)

(b)

Nadaljevanje dodatka 7 / Continuation of Appendix 7

(c)

(d)

(e)

(f)

(g)

(h)

Nadaljevanje dodatka 7 / Continuation of Appendix 7

(i)

(j)

(k)

(l)

(m)

(n)