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PREPOZNAVANJE IN EVIDENTIRANJE MEJIC: PREVERJANJE RAZLIČNIH METOD NA PILOTNEM OBMOČJU LJUBLJANSKEGA BARJA

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Izvleček

Mejice so manj (pre)poznan element v kulturni pokrajini. V Sloveniji je v uradno evidenco vključenih 4522 mejic v skupni dolžini 458,5 km. Zaradi različnih dejavnikov se njihovo število in kakovost zmanjšujeta. Ker gre za pokrajinsko rastlinsko prvino, ki se v prostoru hitro spreminja, je za njeno ohranjanje in upravljanje pomembno ustrezno prepoznavanje in evidentiranje. Preverili smo več postopkov prepoznavanja mejic. Z uporabo lidarsko zajetih podatkov smo razvili dva pristopa in ju ovrednotili z vidika njune nadaljnje uporabnosti. Ugotovili smo, da je za učinkovito prepoznavanje in evidentiranje mejic pomembna ustrezna kombinacija metod, tudi geografsko terensko delo. Za ohranjanje mejic bodo, poleg metodološko ustreznega in ažurnega evidentiranja, odločilni medsektorsko usklajeni ukrepi ter ciljno ozaveščanje kmetov in širše javnosti o raznovrstnih funkcijah mejic v kulturni kmetijski pokrajini.

Ključne besede: krajinska prvina, mejice, lidarsko zajeti podatki, operacija Ohranjanje mejic, Ljubljansko barje

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1 UVOD

Zmanjševanje pokrajinske pestrosti in neustrezno upravljanje s posameznimi sestavinami pokrajine sta med pomembnimi dejavniki izgube biotske raznovrstnosti v večini držav Evropske unije in Sloveniji. Krajinske značilnosti (izraz krajinske značilnosti ali prvine uporabljamo na mestih, kjer povzemamo besedilo uradnih dokumentov, sicer uporabljamo izraz pokrajinske značilnosti) namreč povečujejo možnost ohranjanja biotske raznovrstnosti predvsem kmetijskih ekosistemov (Resolucija o Nacionalnem programu …, 2020). Številne, za kmetijsko pridelavo vitalne ekosistemske storitve (kot npr. opraševanje, naravno zatiranje škodljivcev v kmetijstvu, zmanjševanje negativnih vplivov vetra, suše ipd.), so neposredno in močno odvisne od ustrezne zastopanosti pokrajinskih značilnosti v (kmetijski) kulturni pokrajini (Stališče stičišča SVARUN, 2020).

Pri obravnavanju (po)krajinskih značilnosti v prispevku sledimo opredelitvi krajinskih značilnosti v ciljnem raziskovalnem projektu (Golobič in sod., 2015), kjer so razvrščene v štiri skupine in vključujejo geomorfološke in rastlinske krajinske prvine (grbinaste travnike, kraške kotanje, balvane, terase ipd.), rastlinske krajinske prvine (gozdne zaplate, mejice, obvodna vegetacija, vlažni travniki ipd.), vodne krajinske prvine (lokalna zamočvirjenja, nizka in visoka barja, jarki) in grajene objekte (suhozidi).

Manjša pokrajinska pestrost je največkrat posledica sprememb v uporabi (sodobnih) kmetijskih tehnologij, velike racionalizacije proizvodnih stroškov, modernizacije in intenzifikacije kmetijske proizvodnje. Sočasno na območjih z manj ugodnimi naravnimi razmerami za kmetijsko pridelavo prihaja do opuščanja rabe in zaraščanja kmetijske pokrajine. K spremembam prispevajo tudi povsem administrativni razlogi, ki so vezani na pogoje upravičenosti podpor kmetijskim gospodarstvom, ter posledično prizadevanja kmetov za povečanje upravičenih kmetijskih površin, saj pokrajinske značilnosti večinoma niso priznane kot upravičena raba za prejemanje podpor iz naslova ukrepov kmetijske politike (Golobič in sod., 2015; Stališče stičišča SVARUN, 2020). Zmanjševanje, ponekod pa celo izginjanje pokrajinskih značilnosti je povezano tudi z urbanizacijo in fragmentacijo prostora, turizmom in rekreacijo, razrastom invazivnih (tujerodnih) rastlinskih vrst in podnebnimi spremembami.

Okoljska vizija zadnje Resolucije o nacionalnem programu varstva okolja za obdobje 2020–2030 je ohranjena narava in zdravo okolje v Sloveniji in zunaj nje, kar omogoča in bo omogočalo kakovostno življenje zdajšnjim in prihodnjim generacijam. Tudi tu v okviru varovanja, ohranjanja in izboljševanja naravnega kapitala Slovenije med cilji naslavljajo ohranjanje tistih pokrajinskih značilnosti, ki so pomembne za biotsko raznovrstnost. V resoluciji ugotavljajo, da so krajinska pestrost in krajinske značilnosti pretežno odvisne od naravnih procesov in socialno-ekonomskih razmer (Resolucija o Nacionalnem programu …, 2020). V Sloveniji zaradi raznolikih geografskih razmer in dolge tradicije kultiviranja zemljišč (še) prevladuje mozaična pokrajina, katere sestavni deli so drobne strukture (vodotoki in drugi vodni pojavi, posamezno drevje ali skupine dreves, žive meje, mejice, suhozidi, drevoredi), ekstenzivne kmetijske površine (npr. malo gnojeni ali negnojeni travniki in pašniki), mozaični preplet njiv z različnimi kulturami in gozdovi, s katerimi trajnostno gospodarijo. T. i. »poenostavljanje krajine«, ki smo mu priča marsikje v Sloveniji, vodi v izginjanje naravnih struktur in kulturnih elementov, zmanjšuje mozaičnost ter s tem tudi krajinsko pestrost in biotsko raznovrstnost (Resolucija o Nacionalnem programu …, 2020).

Za varstvo omenjenih pokrajinskih značilnosti je treba torej ohranjati lastnosti, zaradi katerih so deli pokrajine ali njeni elementi opredeljeni kot pokrajinska značilnost. Tu je odločilnega pomena spremljanje in usmerjanje posegov v prostor (Lampič, Kušar, Zavodnik Lamovšek, 2017).

Mejice so opredeljene kot »rastlinska krajinska prvina« (Golobič in sod., 2015). Sestavlja jih linijsko lesnato rastlinstvo (drevesa in grmovje), ki pa je lahko podvrženo številnim in hitrim spremembam. Če se za mejice ustrezno ne skrbi, stalno spreminjajo svojo dolžino in obliko. Ker gre za linijske strukture pretežno grmovne zarasti, se jih razmeroma enostavno tudi poseka. Mejice se po drugi strani tudi hitro zaraščajo, najpogosteje na tistih delih kmetijskega zemljišča, ki ga kmet zaradi slabše kakovosti, težje dostopnosti in drugih vzrokov preneha obdelovati.

Posebno pozornost smo v prispevku namenili prepoznavanju in evidentiranju mejic s pomočjo digitalnih ortofoto in lidarskih posnetkov. Njihova največja pomanjkljivost je ažurnost, saj so bili lidarsko zajeti podatki za celotno Slovenijo zajeti le enkrat, medtem ko se digitalne ortofoto posnetke posodablja na dve do štiri leta.

Za učinkovitejše ohranjanje posameznih pokrajinskih prvin (npr. grbinastih travnikov, mejic idr.), ki v kombinaciji z ostalimi sestavinami ustvarjajo pokrajinske značilnosti, je potrebno zagotavljanje podatkovnih zbirk, ki temeljijo na ustreznih načinih evidentiranja posameznih pokrajinskih prvin. Odsotnost monitoringov tako ovira sam sistem spremljanja pojava, nadzor in ustrezno ukrepanje ob negativnih procesih. Ta pomanjkljivost je bila prepoznana tudi na ravni izvajanja kmetijske politike, kjer sta v Skupnem strateškem načrtu 2023–2027 posebej izpostavljena izboljševanje ter razširitev različnih prostorskih slojev za izvedbo naravovarstvenih podintervencij, ki se bodo nanašale na mejice, mokrišča in občutljivo trajno travinje na območjih Natura 2020 idr. (MKGP, 2021).

2 TEORETIČNA IZHODIŠČA

Mejice so kot pomemben element v prostoru prepoznane širom po svetu. Strokovno utemeljena in z raziskavami dobro podprta je njihova obravnava v državah Zahodne Evrope in Severne Amerike (npr. Allende Álvarez, Gómez Mediavilla, López Estébanez, 2021; Allende Álvarez in sod., 2021; Graham in sod., 2018; Litza in sod., 2022). V Združenem kraljestvu jih npr. ciljno varujejo s posebnim Predpisom o varovanju mejic (The hedgerow regulations, 1997). Zaradi obsežnih in hitrih sprememb v prostoru (intenziviranje kmetijstva, uporaba sodobne tehnologije, širjenje urbaniziranih površin, spremembe politike upravljanja kmetijskih zemljišč) pa se na svetovni ravni soočamo z njihovim postopnim izginjanjem (Baudry, Bunce, Burel, 2000; Burel, Baudry, 1990; Molnarova, 2008) in tako ohranjanje mejic postaja vse večji izziv.

Obravnava mejic tudi terminološko še ni poenotena. V tuji literaturi se najpogosteje pojavljata dva pojma: živa meja (ang. *hedge*) in mejica (ang. *hedgerow*), vendar je njuna uporaba nekonsistentna. Živa meja predstavlja lesno komponento mejne zarasti, medtem ko mejice (*hedgerow*) vključujejo tudi zeliščno komponento in kanal ob mejici (Forman, Baudry, 1984). Ker v Sloveniji nimamo enega uveljavljenega termina, se uporabljajo poimenovanja, kot so živice, omejki ali živa meja. Terminološke zagate so se nekoliko razrešile z uvedbo operacije Ohranjanje mejic, ki se izvaja v okviru Kmetijsko okoljskih in podnebnih ukrepov (KOPOP) Skupne kmetijske politike (SKP). S to operacijo se je v kmetijskem in naravovarstvenem sektorju uveljavila oznaka mejica (MKGP, 2019).

Do razhajanj prihaja tudi pri opredelitvi minimalne dolžine mejic. V raziskavi smo izhajali iz definicije Ministrstva za kmetijstvo, gozdarstvo in prehrano (MKGP), ki mejice označuje kot vsaj 10 metrov dolge in pri krošnji največ 20 metrov široke strnjene in samostojne linije lesne vegetacije, ki morajo biti široke več kot dva metra (MKGP, 2019).

Obravnava mejic ter njihovo ustrezno upravljanje sta pomembna zaradi številnih in med seboj dopolnjujočih funkcij, ki jih mejice opravljajo. Predstavljajo prehranjevalni habitat za številne živali, kar je še posebnega pomena v intenzivno obdelani kmetijski pokrajini. So pomembni migracijski in preletni koridorji, ki med seboj povezujejo različne ekosisteme. Pomembno je, da so mejice sestavljene iz raznovrstnih avtohtonih vrst s tako razvito grmovno plastjo, ki omogoča dostop svetlobe do najnižjih plasti (Dondina in sod., 2016; Garratt in sod., 2017; Heath in sod., 2017). Mejice zmanjšujejo vplive vetra, suše, neurij in toče, kontrolirajo vodni tok ter zadržijo izpiranje hranil iz kmetijskih zemljišč v vodotoke. Na eni strani omejujejo širjenje za kmetijstvo škodljivih organizmov (MKGP, 2021), po drugi služijo kot zatočišče živalim, tako divjim kot pašnim. Velik pomen mejic v kmetijski pokrajini je v njihovem preprečevanju vetrne erozije (Earnshaw, 2004; MKGP, 2021). Kakovost zaščite je odvisna od velikosti drevja; tako je učinek vetrne zaščite 56 metrov za dvometrskim grmom in 560 metrov za 20-metrsko mejico (Forman, Baudry, 1984). Med pomembnimi ekosistemskimi storitvami je tudi uravnavanje lokalnega podnebja, saj se na območju mejic in v njihovi okolici vzpostavi posebna mikroklima (MKGP, 2021). Na območju mejic so višje vsebnosti vode in organskega ogljika v prsti, kar prispeva k višji produktivnosti zemljišč (Sanchez in sod., 2010). Mejice predstavljajo tudi vir surovin, med katerimi je najpomembnejši les, ki je imel pomembno vlogo predvsem v preteklosti in v deželah, kjer primanjkuje gozdnih površin (Burel, Baudry, 1990). Ima pa prisotnost mejic tudi nekatere negativne učinke, saj lahko mejice privabljajo nekatere škodljive žuželke ter ptice, ki škodujejo posevkom na bližnjih njivah (Farmers and hedgerow management, 2019), s povzročanjem sence pa vplivajo na količino pridelka (Oreszczyn, Lane, 2000).

Mejice prispevajo k pokrajinski pestrosti kulturne pokrajine in razbijajo njeno monotonost (Golobič in sod., 2015), pogosto pa razmejujejo posestva različnih lastnikov (Baudry, Bunce, Burel, 2000). Imajo torej velik estetski pomen, o katerem se redko piše in je o njem narejenih malo študij, a je pomemben dejavnik ohranjanja mejic (Burel, Baudry, 1990).

V Sloveniji so mejice ena izmed pokrajinskih prvin, pomembnih za ohranjanje biotske raznovrstnosti, ki so bile opredeljene v projektu Opredelitev krajinske pestrosti in značilnosti, pomembnih za ohranjanje biotske raznovrstnosti (Golobič in sod., 2015). Med krajinske prvine štejemo še npr. vodne jarke, suhozide, obvodno vegetacijo, grbinaste travnike idr. Na kmetijskih zemljiščih so te prvine ključnega pomena za ohranjanje številnih rastlinskih ter živalskih vrst, imajo pa tudi veliko drugih koristnih funkcij za človeka in samo pokrajino (Golobič in sod., 2015). Eden od ciljev Skupne kmetijske politike po letu 2020 je okrepiti prispevek kmetijstva k varstvu biotske raznovrstnosti s pomočjo varovanja pestrosti pokrajinskih prvin (Biodiversty and farmland landscapes, 2020). Skupna usmeritev za vse navedene prvine je njihovo ohranjanje predvsem v intenzivno obdelani kmetijski pokrajini in ekstenzivna raba njihove neposredne okolice. Za te prvine v Sloveniji nimamo ustreznih podatkovnih podlag za spremljanje stanja ali pa poenotenega sistema njihovega varovanja (Golobič in sod., 2015).

Slika 1: Dobro strukturirane mejice zaradi zastopanosti vseh treh slojev rastlinstva (dreves, grmovja in zelišč) opravljajo največ funkcij (Vipavska dolina) (foto: A. Kastelic).

Kakovost opravljanja različnih funkcij mejic pa je odvisna predvsem od njihove strukture. Zato so se številni avtorji (Boutin in sod., 2002; Burel, Baudry, 1990; Garratt in sod., 2017) v svojih raziskavah mejic lotili njihove tipologije (npr. Allende Álvarez, Gómez Mediavilla, López Estébanez, 2021; Allende Álvarez in sod., 2021). Strinjajo se, da so najbolj kakovostne tiste mejice, ki so večvrstne, goste, sestavljene iz dreves in grmovja ter se prepletajo z drugimi mejicami, tako da sestavljajo sistem oziroma mrežo mejic (Boutin in sod., 2002; Baudry, Bunce, Burel, 2000; Forman, Baudry, 1984; Hedgerow survey handbook ..., 2007).

Za potrebe naše raziskave smo izdelali lastno, slovenskim razmeram prilagojeno tipologijo mejic (Kastelic, 2019). Končna tipologija vključuje pet tipov mejic:

1. Strukturirane mejice so tiste, ki vključujejo vse tri plasti rastlinstva: drevesno, grmovno in zeliščno. So vertikalno povezane in nudijo različne habitate za številne živalske vrste, zato so z naravovarstvenega vidika najbolj kakovostne.
2. Grmovne mejice so sestavljene iz grmovne in zeliščne zarasti. Grmovna zarast je gosta, ustvarja vertikalno povezanost in je težko prehodna.
3. Polstrukturirane mejice so sestavljene iz drevesne, grmovne in zeliščne zarasti. Razlika med strukturiranim in polstrukturiranim tipom je, da je pri slednjem grmovna zarast redkejša, nižja in je zato mejica bolj prehodna.
4. Drevesne mejice sestavljajo drevesa in zeliščna zarast.
5. Kombinirane mejice so daljše mejice, v katerih se izmenjata najmanj dva tipa mejice. Njihove lastnosti so odvisne od tipov, ki jo sestavljajo.

Slika 2: Kombinirane mejice (kombinacija grmovne in drevesne plasti) so na Ljubljanskem barju prisotne v večjem številu (foto: A. Kastelic).

Z vidika opravljanja funkcij (za človeka, živalstvo in pokrajino) so najustreznejše strukturirane mejice, ki so sestavljene iz vseh treh slojev, sledijo grmovne in polstrukturirane mejice, medtem ko so drevesne mejice za opravljanje npr. naravovarstvenih funkcij manj primerne.

Slika 3: Strukturirane mejice na Ljubljanskem barju opravljajo še posebej pomembne naravovarstvene funkcije, saj se nahajajo med intenzivnimi kmetijskimi površinami (foto: A. Kastelic).

Slika 4: Drevesne mejice tvorijo drevesa in zeliščna zarast. Na sliki je primer drevesne mejice na Ljubljanskem barju, ki zaradi intenzivnega izsekavanja in čiščenja ter drugih rab izgublja svoje funkcije (foto: B. Lampič).

3 PRISOTNOST IN PREPOZNAVNOST MEJIC V SLOVENIJI

Mejice v Sloveniji so prisotne na območju celotne države, prihaja pa do precejšnjih pokrajinskih razlik. Na Krasu so npr. nastajale ob suhozidovju (Šmid Hribar, 2008), medtem ko so na Goričkem z mejicami omejevali pašnike (Domanjko, Malačič, 2009). O njihovi biološki funkciji je bilo napisanih nekaj diplomskih del, Janez Božič pa je že leta 1969 napisal delo Protivetrni nasadi (vetrobrani) v nižinskih predelih Slovenije (Premrl, Turk, 2013). Posledično o stanju mejic v Sloveniji vemo razmeroma malo, nekoliko bolj sistematično pa se spremlja tiste mejice, ki so vključene v kmetijsko operacijo Ohranjanje mejic.

Operacija Ohranjanje mejic je ena izmed operacij ukrepa KOPOP (kmetijsko--okoljska-podnebna plačila) v PRP (2014–2020, kot podinetervencija se bo izvajala tudi v programskem obdobju 2023–2027). Podpira vzdrževanje in ohranjanje mejic na različnih vrstah rabe kmetijskih zemljišč in pomeni ohranjanje enega izmed pomembnih elementov kmetijske kulturne pokrajine. Operacija se izvaja vse od leta 2017, kmet pa se ob vstopu v operacijo zaveže za izvajanje vsaj za pet let. Višina plačila za izvajanje operacije znaša 1,60 EUR za tekoči meter letno (MKGP, 2019). Pri vzdrževanju mejic je treba poskrbeti za njihovo redčenje, odstranjevati suhe veje in jih obrezovati. Plačila so namenjena izpadu dohodka kmeta (ponekod zmanjšan pridelek v senci, težja obdelava) in za dodatno delo, vezano na vzdrževanje mejic (Čus, 2019; Žvikart, 2019). Najpomembnejše je njihovo obrezovanje (na dve leti), vendar ne v času gnezdenju ptic (med 1. marcem in 30. septembrom) (MKGP, 2019).

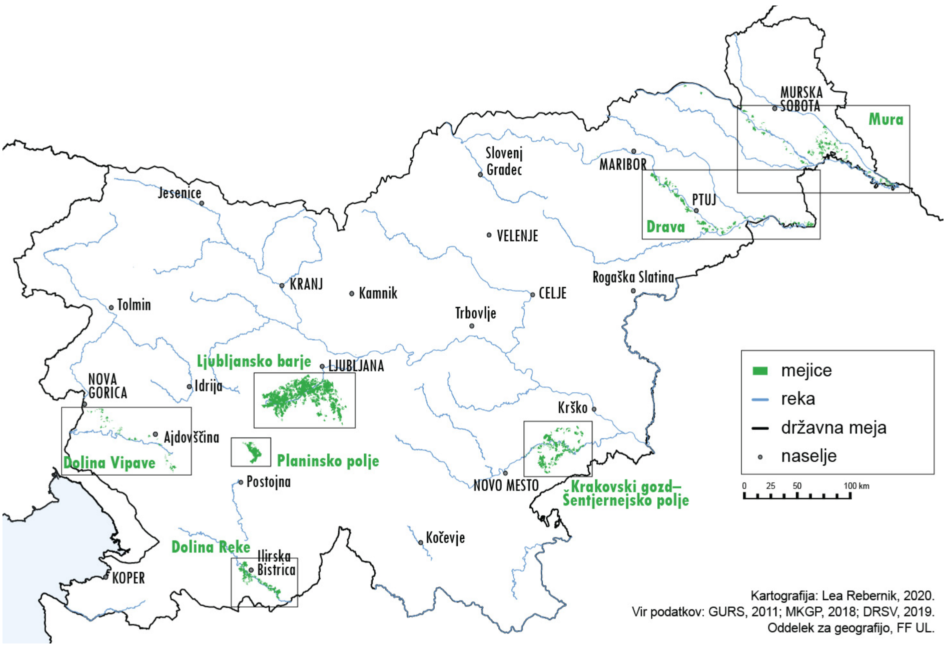
Preglednica 1: Število in dolžina mejic, vključenih v operacijo Ohranjanje mejic na sedmih območjih Natura 2000.

Območje Natura 2000	Število mejic	Skupna dolžina (m)	Najdaljša mejica (m)	Najkrajša mejica (m)	Povprečna dolžina (m)
Krakovski gozd – Šentjernejsko polje	404	44.875	792	11	111
dolina Reke	383	27.833	421	10	73
dolina Vipave	123	8.783	328	15	71
Planinsko polje	298	27.368	586	13	92
Ljubljansko barje	2.720	290.876	1.254	11	107
Drava	286	32.793	691	14	115
Mura	308	26.030	545	15	85
Skupaj	4.522	458.558	1.254	10	101

Vir podatkov: MKPG, 2018b.

Operacija Ohranjanje mejic se je v letu 2019 izvajala na sedmih območjih Nature 2000 (Krakovski gozd - Šentjernejsko polje, dolina Reke, dolina Vipave, Planinsko polje, Ljubljansko polje, Drava, Mura) (MKGP, 2019). V operacijo so vključena območja, kjer mejicam najbolj grozi izginotje (Živikart, 2019). Vseh mejic v operaciji je 4522, njihova skupna dolžina pa znaša 458.558 metrov. Povprečna dolžina mejice je 101 meter, najdaljša meri kar 1254 metrov, najkrajša pa 10 m (MKGP, 2018b).

Slika 5: Prikaz območij izvajanja operacije Ohranjanje mejic v Sloveniji.



V letu 2018 so se v operacijo Ohranjanje mejic vključila 104 kmetijska gospodarstva (KMG), ki so skupaj vzdrževala 134 kilometrov mejic. V okviru operacije jim je bilo izplačanih okoli 214.400 EUR. Od tega je bila večina (kar 90 %) prijavljenih kmetov z Ljubljanskega barja, medtem ko je število v operacijo vključenih KMG na drugih območjih skromno (Čus, 2019). Razlogi za velike razlike v številu prijavljenih kmetov med območji so v številu in dolžini mejic. Na Ljubljanskem barju jih je največ, so najdaljše in so širše prisoten element v kulturni pokrajini. Na odločitev za vstop v operacijo pomembno vpliva odnos kmeta do mejice, razumevanje same operacije ter (predvsem) aktivnost in prizadevanje kmetijskih svetovalcev (Živikart, 2019; Čuš, 2019).

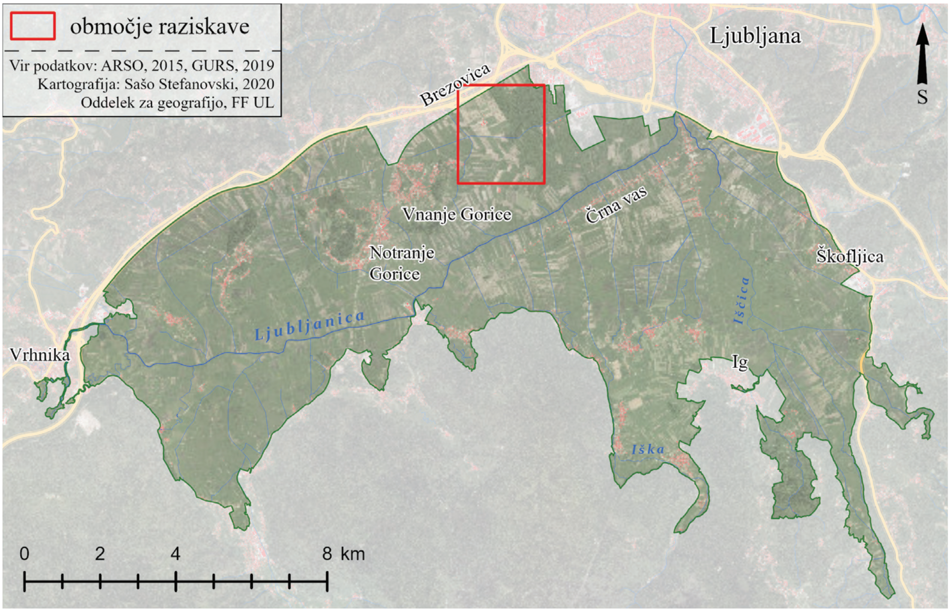
Operacija Ohranjanje mejic ščiti in ohranja 4.522 mejic na sedmih območjih Nature 2000 (MKGP, 2018b). Te mejice so (bolj) varne pred posekom, pri preostalih pa še vedno redno prihaja do izsekavanja ali krčenja, saj je njihovo varovanje, tudi na območju Krajinskega parka Ljubljansko barje, s trenutnimi zakonskimi podlagami težko izvedljivo. Še bolj pa je zaskrbljujoče dejstvo, da nimamo podatkov in informacij, kaj se dogaja z mejicami na preostalem območju Slovenije. Nimamo nobenega podatka o njihovem številu, dolžini, strukturi in aktualnih procesih. Če neustrezna ravnanja zasledimo na bolj varovanih območjih izvajanja operacije lahko predvidevamo, da so drugod razmere še slabše. Tako npr. na območju Krajinskega parka Ljubljansko barje ugotavljajo, da so bili z izsekavanjem (torej uničenjem) mejic kršeni predpisi s področja varstva narave. Sočasno pa je kmet, po odstranitvi mejic, lahko brez ovir zemljišče (travinje) vpisal v zbirno vlogo kot njivo ter prejel kmetijska plačila. Sistem pravil in kmetijskih predpisov v Sloveniji očitno deluje na način, da omogoča izplačevanje evropskih kmetijskih plačil tudi za ravnanja, ki pomenijo krnitev narave in kršitev naravovarstvenih predpisov (Jančar, 2018).

4 LJUBLJANSKO BARJE KOT PILOTNO OBMOČJE

Za nadaljnje delo smo izbrali pilotno območje Ljubljansko barje, kamor smo usmerili vse nadaljnje korake raziskave, skupaj s terenskim popisom mejic. Ljubljansko barje leži v osrednji Sloveniji na južnem delu Ljubljanske kotline in obsega 120 kvadratnih kilometrov (Pavšič, 2008). Zanj je značilna mozaična pokrajina, preplet njiv, barjanskih travnikov, pašnikov, kanalov, vodotokov in mejic, ki so eden izmed pomembnejših gradnikov pokrajine (Strokovne podlage za ustanovitev …, 2007). Glavna ovira za razvoj kmetijstva sta zamočvirjenost in talna voda; kljub temu so leta 2017 obdelovali 82 % površin. Na skoraj polovici njiv je kot kulturna rastlina zastopana (silažna) koruza, kar predstavlja nevarnost, da Ljubljansko barje postane monotona monokulturna pokrajina. Velikost kmetij na Ljubljanskem barju je glede na slovenske razmere nadpovprečna (12,72 ha) (Kmetijstvo na Ljubljanskem barju, 2019).

Mejice so na Ljubljanskem barju tradicionalni pokrajinski element. Njihova razširjenost v preteklosti je bila še večja, predvsem ob kanalih. Bile so pomemben vir surovin (les), označevale so meje parcel različnih lastnikov, danes pa te funkcije izgubljajo. Gostota in sestava mejic se znotraj Ljubljanskega barja precej razlikujeta. Tako je v zarasti mejic na obrobju več vrb, pri mejicah v notranjosti pa prevladujejo jelše. Veliko drevesne in grmovne zarasti so posekali ob čiščenju pri vzpostavitvi grafičnih enot rabe kmetijskega gospodarstva (GERK-ov). Z intenziviranjem kmetijstva so tako za marsikaterega kmeta postale moteči element. Na Ljubljanskem barju je v operacijo Ohranjanje mejic več kmetov vključenih na zahodnem delu, na vzhodnem delu pa je njihovo število manjše. Večina kmetov v Operaciji ima preko 2000 metrov mejic, dva kmeta pa celo po 10 kilometrov mejic (Pečjak, 2019).

Slika 6: Območje raziskave na severnem delu Ljubljanskega barja.



Izbrano pilotno območje znotraj Ljubljanskega barja je veliko dva kvadratna kilometra in leži na območju Nature 2000, znotraj Krajinskega parka Ljubljansko barje. Krajinski park s svojimi varstvenimi režimi mejice varuje pred sekanjem in vzdrževalnimi deli med 15. marcem in 30. septembrom (Uredba o Krajinskem parku ..., 2008), v praksi pa se pojavljajo težave z nadzorovanjem upoštevanja predpisov iz uredbe (Japelj, 2019). Na pilotnem območju prevladujejo njive (54 %) in barjanski travniki (20 %) (MKGP, 2018a), med mejicami pa so prevladujoče strukturirane in grmovne, ki jih prepoznavamo kot najbolj kakovostna tipa (Kastelic, 2019).

Slika 7: Značilna polstrukturirana mejica med travniki na Ljubljanskem barju (foto: A. Kastelic).

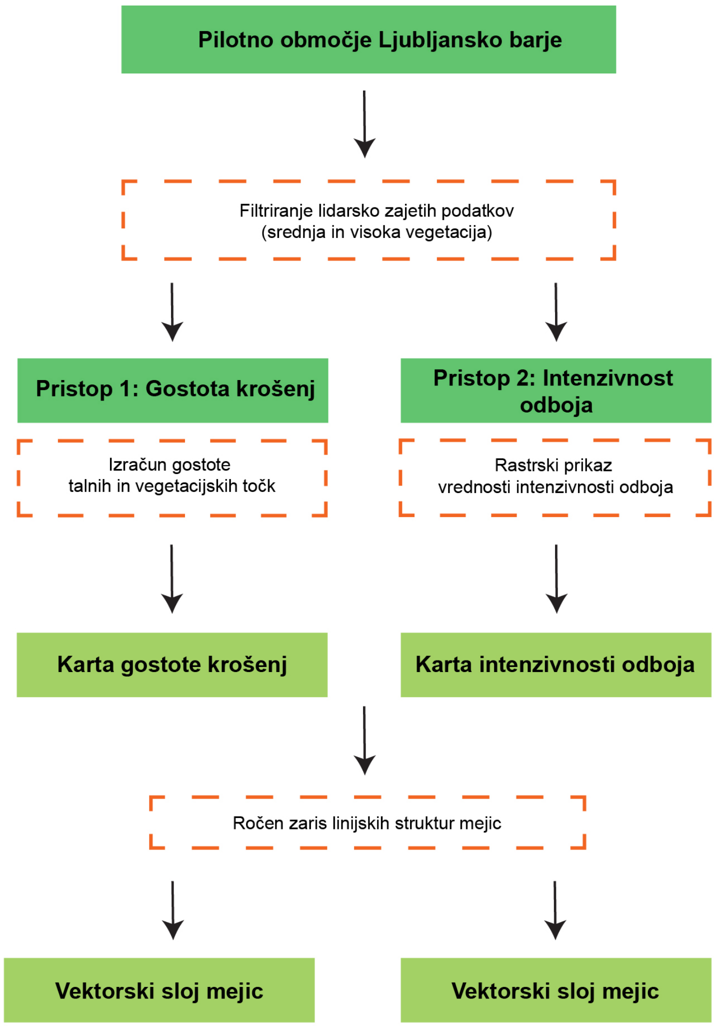
5 METODE

Zavod RS za varstvo narave (ZRSVN) je po pooblastilu MKGP leta 2016 pripravil prvi evidenčni sloj mejic v Sloveniji (Bucik in sod., 2017). Sloj je bil izdelan na podlagi digitalnih ortofoto posnetkov iz leta 2014, kjer so aerofotografije transformirane iz centralne v ortogonalno projekcijo in so mersko primerljive s kartami (Zbirke prostorskih podatkov, 2019). Zaradi implementacije operacije Ohranjanje mejic v okviru KOPOP je bil sloj pripravljen v kratkem času. Prepoznavanje mejic je temeljilo na uporabi starejših ortofoto posnetkov, zato je bila kakovost prvega evidenčnega sloja ponekod slabša, saj so bile mejice evidentirane površno ali pa je prišlo do napak zaradi sprememb v dejanski rabi oziroma odstranitvi mejic. Sloj mejic 2018 je bil dopolnjen in izboljšan na podlagi novejših ortofoto posnetkov (iz leta 2017) ter terenskih poročil (Čuš, 2019; Žvikart, 2019). Oba uradna sloja mejic (2016 in 2018) smo preverili na terenu tudi za potrebe raziskave in ugotovili številne nepravilnosti. S preliminarnim terenskim delom smo leta 2017 na severovzhodnem delu Ljubljanskega barja ugotovili razlike med dejanskim stanjem v prostoru in evidenčnim slojem mejic 2016 na kar 62 % mejic (izbranega območja). Ob ponovnem terenskem preverjanju v letu 2019 (preverjali smo sloj mejic 2018) je bilo zaznanih manj razlik (Kastelic, 2019). Pokazala se je ključna vloga terenskega preverjanja stanja mejic pa tudi njegova zahtevnost in zamudnost (Bucik in sod., 2017; Kastelic, 2019).

Ker se prepoznavanje in evidentiranje mejic neposredno s pomočjo ortofoto posnetkov ter terenskim delom nista izkazala za optimalni rešitvi pri evidentiranju mejic, smo mejice identificirali še na podlagi lidarsko zajetih podatkov. Uporabili smo posnetke s portala E-vode, za katerega skrbi ARSO. Metodo smo preverili na manjšem pilotnem območju (ki je bilo predstavljeno predhodno), kjer so mejice zastopane v večjem številu, hkrati pa je dovolj blizu Ljubljane. Lasersko skeniranje za Ljubljansko barje je bilo izvedeno v letih 2014 in 2015 z ločljivostjo 10 točk na m^2 (Izvedba laserskega skeniranja …, 2015).

Pilotno območje dveh kvadratnih kilometrov, ki leži na severu Ljubljanskega barja, vključuje različne tipe mejic, heterogena pa je tudi raba tal. Osnovni sloj lidarsko zajetih podatkov je bil filtriran na sloj LAS DATASET. Filtrirali smo ga na srednjo in visoko vegetacijo, saj to ustreza kriterijem mejice. Zaradi iskanja najboljšega načina evidentiranja mejic z uporabo lidarsko zajetih podatkov sta bila preizkušena dva pristopa: pristop 1 oz. gostota krošenj ter pristop 2 oz. intenzivnost odboja.

Slika 8: Shematični prikaz uporabljenih metodoloških pristopov z lidarsko zajetimi podatki.



Na sliki 8 sta prikazana dva različna načina obdelave lidarskih podatkov, rezultat pa sta dva različna prostorska prikaza mejic. Gostota krošenj ali pokrovnost je ocena razmerja med tlemi in vrhovi krošenj, kot je vidno iz zraka. Izračunali smo jo s pomočjo podatkov o gostoti talnih in vegetacijskih točk. Metoda je uporabna za meritve v naravi, kot je npr. izračun biomase in vegetacijskega pokrova (Estimating forest canopy density ..., 2019).

Intenzivnost odboja ali intenziteta pomeni jakost odbitega signala oziroma razmerje med jakostjo sprejete svetlobe na laserskem skenerju. Uporablja se kot pripomoček pri identificiranju elementov in kot nadomestek za letalske posnetke. Sama karta je rastrski prikaz vrednosti izmerjene intenzivnosti odboja. Zajema eno valovno dolžino, in sicer človeku nevidni bližnji infrardeči del spektra, ki je le malo večja od valovnih dolžin vidnega spektra, zato je prikaz precej podoben dojemanju vidne svetlobe. Lahko ločimo gosto posnete točke, kot so drevesa, hiše ali ceste, še posebej na površju, brez višinskih razlik. Težko je predvidevati končni razpon vrednosti, saj so končne vrednosti odvisne od več spremenljivk, različnih senzorjev in so brez merske enote (Švab Lenarčič, Oštir, 2015).

V zaključni fazi smo še ročno zarisali linijske strukture mejic in tako dobili dva vektorska sloja. Vse analize so bile opravljene s programskim orodjem ArcMap 10.7.

6 REZULTATI

Prepoznavanje mejic v prostoru s pomočjo različnih postopkov (1. terensko zajemanje (2017), 2. dva pristopa, temelječa na lidarsko zajetih podatkih, 3. dva evidenčna sloja mejic (MKGP 2016 in 2018)) je za pilotno območje na Ljubljanskem barju dalo različne rezultate (preglednica 2). To se odraža v številu in skupni dolžini mejic, ki se med vsemi postopki opazno razlikujejo.

Preglednica 2: Pilotno območje Ljubljanskega barja – evidentirano število in dolžina mejic z različnimi pristopi.

Postopki	Število mejic	Skupna dolžina mejic (m)
Evidenčni sloj mejic 2016	88	9.468
Terensko evidentiranje mejic 2017	122	11.427
Evidenčni sloj mejic 2018	101	10.536
Lidarsko zajeti podatki – gostota krošenj	127	13.978
Lidarsko zajeti podatki – intenzivnost odboja	130	12.788

Vir podatkov: Bucik in sod., 2017; MKGP, 2016; 2018b.

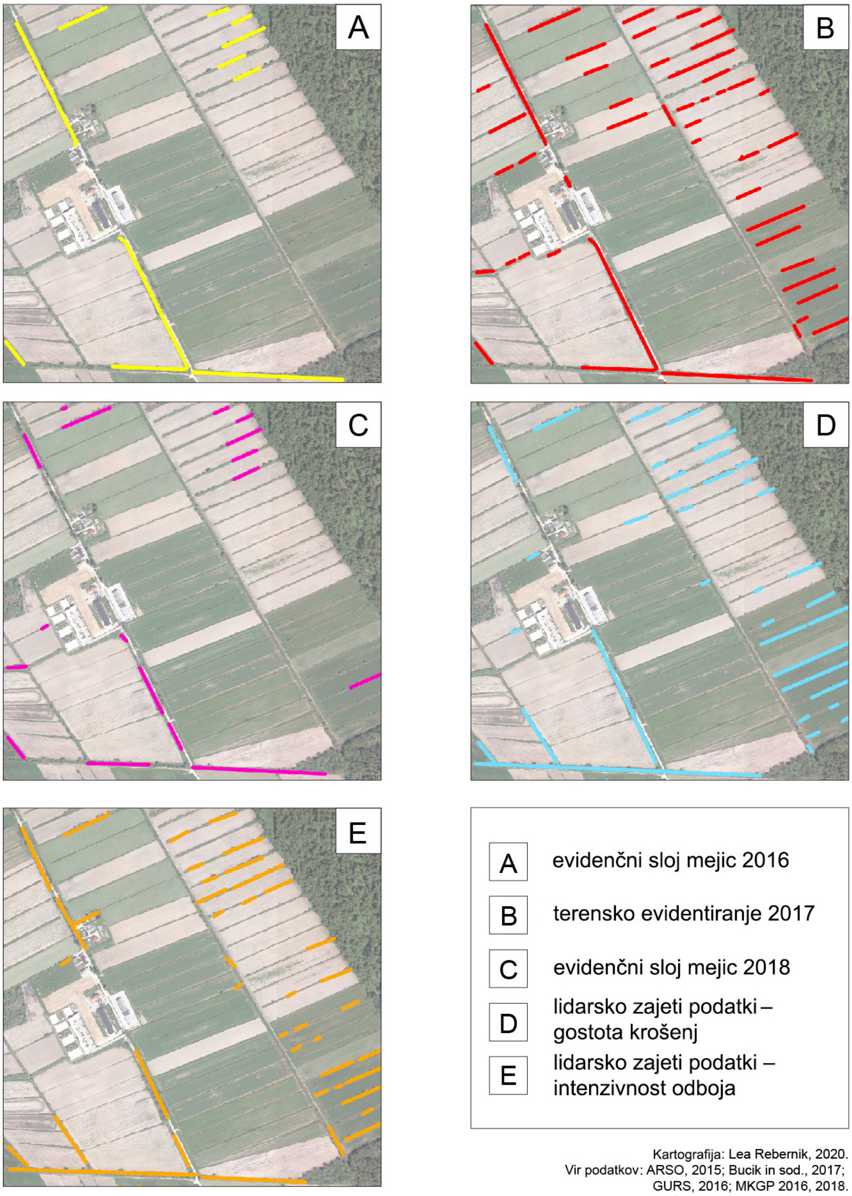
Analiza mejic iz obeh uradnih evidenčnih slojev mejic iz let 2016 in 2018 kaže, da je na obravnavanem pilotnem območju leta 2018 zabeleženo večje število in večja skupna dolžina mejic. Takšno stanje nas je presenetilo, saj se je v tem obdobju skupno število mejic na celotnem območju Ljubljanskega barja precej zmanjšalo, in sicer z 2952 na 2720. Manjša je bila tudi njihova skupna dolžina (za 50.000 m) (MKGP, 2016; 2018b). Ti podatki opozarjajo na vprašljivo primernost DOF posnetkov iz leta 2014, ki so bili uporabljeni za pripravo evidenčnega sloja mejic 2016.

Podrobneje smo se problema lotili na manjšem pilotnem območju, kjer je bilo leta 2016 v evidenčni sloj zajetih 88 mejic, dve leti kasneje pa 101 mejica. Vzrokov za takšne razlike je lahko več. Spremembe so vezane na območje s pretežno njivsko rabo. Analiza rabe tal v obeh letih kaže na opuščanje njiv in s tem na večje zaraščanje površin, kar lahko pripelje do nastanka novih mejic. K slabši natančnosti lahko prispeva že omenjeno prvo zajemanje mejic s starejših DOF posnetkov. Začetek izvajanja operacije Ohranjanje mejic (leta 2017) je vnesel spremembe v način upravljanja z mejicami, kar bi lahko vplivalo na njihov manjši posek. Glavne razlike med evidenčnim slojem in terenskim popisnim slojem so večinoma v grmovnih mejicah na njivskih površinah na vzhodnem delu območja. Grmovne mejice so namreč tip mejic, ki se najhitreje zaraste in verjetno zaradi tega še niso bile opazne na DOF posnetkih.

Glede na predstavljeno se rezultati evidenčnih slojev niso izkazali za optimalne, zato smo se odločili za razvoj dveh lastnih metodoloških pristopov, ki sta izvedena s pomočjo lidarsko zajetih podatkov in sta podrobneje opisana v metodološkem poglavju 5.

Karta gostota krošenj (D) nam prikazuje gostoto drevesnih in grmovnih krošenj. Mejice so bile vidne kot linijski prikazi krošenj. Pri evidentiranju mejic smo morali biti pozorni, da smo zajemali jasno vidne linijske zarasti, ki pa niso smele biti širše od dvajsetih metrov. Dve različni metodi (gostota krošenj in intenzivnost odboja), ki sta temeljili na lidarsko zajetih podatkih, sta dali različne rezultate. Razlog je v različnih stopnjah vidnosti in tudi v sami podobi mejic. Pri karti intenzivnosti odboja mejice predstavljajo pasovi, v katerih se ne prepozna oblik lesnate vegetacije, medtem ko lahko pri karti gostote krošenj prepoznamo krošnje, kar zagotavlja jasno vidnost tudi ožjih pasov vegetacije.

Slika 9: Prikaz in primerjava različnega obsega evidentiranih mejic, prepoznanih po različnih metodah (na izseku pilotnega območja Ljubljanskega barja).



Kartografija: Lea Rebernik, 2020.
Vir podatkov: ARSO, 2015; Bucik in sod., 2017;
GURS, 2016; MKGP 2016, 2018.
Oddelek za geografijo, FF UL.

Preglednica 3: Število evidentiranih mejic z različnimi metodološkimi pristopi na pilotnem območju Ljubljanskega barja.

Sloj mejic	Evidenčni sloj 2016	Evidenčni sloj 2018	Terensko evidentiranje 2017	Lidarsko zajeti podatki – gostota krošenj	Lidarsko zajeti podatki – intenzivnost odboja
Evidenčni sloj 2016		+13	+34	+39	+42
Evidenčni sloj 2018	−13		+21	+26	+29
Terensko evidentiranje 2017	−33	−21		+5	+8
Lidarsko zajeti podatki – gostota krošenj	−39	−26	−5		+3
Lidarsko zajeti podatki – intenzivnost odboja	−42	−29	−8	−3	

Vir podatkov: Bucik in sod., 2017; MKGP, 2016; 2018b.

Pri evidentiranju mejic na pilotnem območju Ljubljanskega barja je bilo prepoznanih najmanj mejic v obeh uradnih evidencah mejic (Evidenčni sloj 2016 in 2018). S terenskim popisovanjem mejic ter slojema mejic, ki smo jih izdelali na osnovi lidarsko zajetih podatkov, smo evidentirali več mejic. Tudi razlike med temi tremi sloji mejic so razmeroma majhne in zato sklepamo, da so ti ustreznejši.

Preglednica 4: Dolžine evidentiranih mejic (v metrih) z različnimi metodološkimi pristopi na Ljubljanskem barju.

Sloj mejic	Evidenčni sloj 2016	Evidenčni sloj 2018	Terensko evidentiranje 2017	Lidarsko zajeti podatki – gostota krošenj	Lidarsko zajeti podatki – intenzivnost odboja
Evidenčni sloj 2016		+1.068	+1.959	+4.510	+3.320
Evidenčni sloj 2018	−1.068		+891	+3.442	+2.252
Terensko evidentiranje	−1.959	−891		+2.551	+1.361
Lidarsko zajeti podatki – gostota krošenj	−4.510	−3.442	−2.551		−1.190
Lidarsko zajeti podatki – intenzivnost odboja	−3.320	−2.252	−1.361	+1.190	

Vir podatkov: Bucik in sod., 2017; MKGP, 2016; 2018b.

Zanimivo je, da se evidenčni sloj mejic 2018 tako po številu kot po skupni dolžini mejic manj razlikuje od sloja mejic, evidentiranih s pomočjo lidarsko zajetih podatkov, kot evidenčni sloj 2016. Tak rezultat deloma preseneča zaradi manjše časovne razlike med DOF posnetki (ki so osnova za evidenčni sloj 2016) in lidarskimi posnetki, ki so bili zajeti med letoma 2014 in 2015. Naši rezultati kažejo na slabšo natančnost uradnega evidenčnega sloja mejic 2016. Razlike med terenskim popisom in rezultati obeh lidarskih pristopov so manjše predvsem pri skupnem številu mejic, do razlik pa prihaja pri dolžini grmovnih mejic med njivami.

Ugotavljamo, da se na različnih posnetkih mejice vizualno različno dobro zaznajo. To vpliva na razlike v njihovih dolžinah pri vseh slojih, ki smo jih zajeli digitalno. Med analiziranjem podatkov smo zaznali več razlik med lidarskimi in DOF posnetki. Te razlike tudi nakazujejo prednosti oziroma slabosti uporabe enih oziroma drugih podatkovnih slojev. Pomembna tehnična razlika je že v velikosti datotek. Velikost lidarskega posnetka, ki meri en kvadratni kilometer, je 101 MB, medtem ko je DOF slika, ki prikazuje območje petih kvadratnih kilometrov, velika približno 315 MB. Tudi prepoznavanje mejic je na lidarskih slojih težje kot na slojih DOF, saj slednji omogočajo lažje in hitrejše prepoznavanje linijskih struktur mejic. Po drugi strani pa je prednost lidarskih podatkov v tem, da jih je mogoče filtrirati, na ta način pa se na sliki lahko vidi samo srednja in visoka vegetacija, zato so linijske strukture bolj jasne in lažje prepoznavne kot na DOF posnetkih. Na lidarskih posnetkih tudi ni senc, ki se lahko pojavijo na posnetkih DOF in ovirajo vizualno prepoznavanje, hkrati pa je na lidarskih posnetkih laže zaznati vrzeli med mejicami. Omeniti še velja, da se pri evidentiranju mejic pri uporabi obeh posnetkov pojavlja problem prepoznavanja drevoredov in ostalih (linijskih) nasadov, ki ne sodijo med mejice.

7 ZAKLJUČEK

Operacija Ohranjanje mejic, ki se izvaja v okviru ukrepa KOPOP, predstavlja prvi sistemski poskus ohranjanja in vzdrževanja mejic v Sloveniji. Na sedmih območjih v Sloveniji (Krakovski gozd - Šentjernejsko polje, dolina Reke, dolina Vipave, Planinsko polje, Ljubljansko polje, Drava, Mura), kjer so mejice že opredeljene v evidenčnem sloju mejic, se je posledično med lastniki zemljišč, kmeti in kmetijskimi svetovalci začelo pogosteje naslavljati problematiko njihovega vzdrževanja in ohranjanja (Čuš, 2019; Žvikart, 2019). V novem programskem obdobju si lahko obetamo izboljševanje ter razširitev različnih prostorskih slojev za izvedbo naravovarstvenih podintervencij, kar bo v praksi pomenilo razširitev evidenčnega sloja mejic še na druga območja Slovenije (MKGP, 2021).

Zaradi prepoznanih težav naravovarstvenega in kmetijskega resorja, vezanih na kakovost in vzdrževanje uradne evidence mejic, iskanja učinkovitejših načinov popisovanja novih območij z mejicami in spremljanja njihovega vzdrževanja, smo se v raziskavi osredotočili na razvoj metod prepoznavanja in vzpostavljanja sloja mejic. Obstoječi sistem spremljanja in posodabljanja podatkov je pomanjkljiv in ne sledi dejanskim razmeram na terenu.

Naše podrobnejše raziskave na pilotnem območja Ljubljanskega barja med letoma 2017 in 2019 kažejo, da nobeden od treh preverjenih načinov prepoznavanja in evidentiranja mejic (z uporabo digitalnih ortofoto posnetkov, lidarsko zajetih podatkov, s terenskim delom) ni povsem ustrezen, vendar ima vsak pristop določene prednosti in slabosti. Ugotavljamo, da ažuren prostorski sloj mejic zahteva uporabo najnovejših dostopnih podatkov in različnih tehnik, kljub zamudnosti pa je treba metode kombinirati s terenskimi ogledi in popisom. Evidentiranje mejic z uporabo lidarsko zajetih podatkov poleg pristopov, predstavljenih v prispevku, ponuja še druge možne rešitve, vendar bi že s predstavljenimi (in preizkušenimi) metodami prepoznavanja in evidentiranja zagotovo lahko razširili evidenčni sloj mejic tudi na druga območja v Sloveniji.

Zaključimo lahko, da se prikazi mejic, izdelani po različnih metodoloških pristopih, ki smo jih izvedli na pilotnem območju Ljubljanskega barja, razlikujejo. Razlike bi se verjetno pokazale tudi na drugih območjih mejic v Sloveniji. Med postopki sicer ne prihaja do velikih razhajanj v številu in dolžinah mejic, so pa razlike pomembne zaradi dejstva, da se kmetijska plačila za operacijo Ohranjanje mejic nanašajo na dolžinski meter mejice. Plačilo je v programskem obdobju 2014–2020 znašalo 1,6 EUR za tekoči meter mejice, namenjeno pa je izravnavi stroškov kmeta, ki nastanejo zaradi njihovega urejanja in vzdrževanja (MKGP, 2019).

Ker o obsegu in kakovosti mejic izven evidenčnega sloja trenutno v Sloveniji nimamo podatkov, ukrepi za ohranjanje pa se v okviru Operacije mejic drugod ne morejo izvajati, upravičeno pričakujemo, da bodo zaradi teženj v kmetijstvu in drugih prostorskih pritiskov te prvine v prostoru še bolj ogrožene. Obstoječo evidenco mejic je treba nadgraditi tudi v vsebinskem smislu. Trenutno se spremljata le dolžina in sklenjenost mejic, ne pa tudi njihova kakovost. Poskusno smo atribute za spremljanje razširili že v okviru naše raziskave, in sicer z dodatnim podatkom o tipu mejic. Na podlagi terenske opredelitve tipa mejice lahko bolje ocenimo oziroma sklepamo na obseg in kakovost funkcij, ki jih določena mejica lahko opravlja. Zaradi prepoznane kakovosti funkcij mejic bi laže opredelili območja, kjer je njihovo varovanje še posebej pomembno, oziroma območja z manj kakovostnimi mejicami, ki bi jih bilo treba izboljšati.

Prispevek nakazuje nekatere rešitve v smeri nadgradnje obstoječega nacionalnega evidenčnega sloja mejic. Za ohranjanje in učinkovito varovanje mejic bodo, poleg metodološko ustrezno podprtega evidentiranja, odločilnega pomena ukrepi in usmeritve s področij kmetijstva, varstva narave in urejanja prostora. Predvsem pa je potrebno kontinuirano ozaveščanje kmetov, lastnikov zemljišč in širše javnosti o številnih funkcijah mejic v kulturni kmetijski pokrajini.

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IDENTIFICATION AND RECORDING OF HEDGEROWS: TESTING DIFFERENT METHODS IN A PILOT AREA OF THE LJUBLJANA MARSHES

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Abstract

Hedgerows are a less-known element in the cultural landscape. In Slovenia, 4522 hedgerows are officially registered, covering a total length of 458.5 km. Due to various factors, their number and quality are decreasing. As a landscape vegetation feature that changes rapidly, their proper identification and recording are paramount to their conservation and management. Using lidar-captured data, two approaches were developed and evaluated for future applicability. We found that a suitable combination of methods, including geographic fieldwork, is required for effective identification and recording of hedgerows. In addition to methodologically appropriate and up-to-date recording, cross-sectoral coordinated actions and targeted awareness-raising among farmers and the general public on the multiple functions of borders in the cultural agricultural landscape will be crucial for the conservation of hedgerows.

Keywords: landscape features, hedgerows, lidar-captured data, the Conservation of Hedgerows operation, the Ljubljana Marshes

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1 INTRODUCTION

The loss of landscape diversity and inadequate management of individual landscape components are among the major factors contributing to biodiversity loss in most EU countries and in Slovenia. Landscape features (the term landscape features or elements is used in places where the text of official documents is summarised) increase the potential for biodiversity conservation, particularly in agricultural ecosystems (Resolucija o Nacionalnem programu ..., 2020). Many ecosystem services vital for agricultural production (such as pollination, natural pest control in agriculture, mitigation of the negative impacts of wind, drought, etc.) are directly and strongly dependent on an adequate representation of landscape features in the (agricultural) cultural landscape (Stališče stičišča SVARUN, 2020).

In the treatment of landscape features, the paper follows the definition of landscape features in the target research project (Golobič et al., 2015), where they are divided into four groups: geomorphological and vegetation landscape elements (hilly meadows, karst hollows, boulders, terraces, etc.), vegetation landscape elements (forest patches, hedgerows, riparian vegetation, wet meadows, etc.), water landscape elements (local swamps, low-moor and high-moor, ditches) and built structures (dry stone walls).

Reduced landscape diversity is most often the result of changes in the use of (modern) agricultural technologies, major rationalisation of production costs, and modernisation and intensification of agricultural production. At the same time, in areas with less favourable natural conditions for agricultural production, there has been abandonment and overgrowth of agricultural landscapes. Purely administrative reasons linked to the eligibility conditions for farm support and, consequently, farmers' efforts to increase the eligible agricultural area are also contributing to the changes, as landscape features are largely not recognised as an eligible use for support under agricultural policy measures (Golobič et al., 2015; Stališče stičišča SVARUN, 2020). The decline and sometimes even disappearance of landscape features is also linked to urbanisation and fragmentation, tourism and recreation, the spread of invasive (non-native) plant species and climate change.

The environmental vision of the latest Resolution on the National Programme for Environmental Protection for 2020–2030 is preserved nature and a healthy environment in Slovenia and beyond, which enables and will enable a quality life for present and future generations. Here again, the objectives of protecting, preserving and enhancing Slovenia's natural capital include the conservation of landscape features that are important for biodiversity. The Resolution notes that landscape diversity and landscape features are largely dependent on natural processes and socio-economic conditions (Resolucija o Nacionalnem programu ..., 2020). In Slovenia, due to the diverse geographical conditions and the long tradition of land cultivation, a mosaic landscape is (still) predominant, with fine structures (watercourses and other water phenomena, individual trees or groups of trees, hedges, hedgerows, dry walls, tree avenues), extensive agricultural areas (e.g. low-fertilised or unfertilised meadows and pastures), a mosaic of arable fields with different crops and sustainably managed forests. The "simplification of the landscape", which is being witnessed in many parts of Slovenia, is leading to the disappearance of natural structures and cultural elements, reducing the mosaic nature and thus landscape diversity and biodiversity (Resolucija o Nacionalnem programu ...,2020).

The protection of these landscape features therefore requires the preservation of the characteristics that make parts of the landscape, or elements of it. Here, monitoring and guiding spatial interventions is crucial (Lampič, Kušar, Zavodnik Lamovšek, 2017).

Hedgerows are defined as a "landscape vegetation feature" (Golobič et al., 2015). They are composed of linear woody vegetation (trees and shrubs), which can be subject to numerous and rapid changes. If they are not properly managed, their length and shape change constantly. As they are linear structures of predominantly shrubby vegetation, they are also relatively easy to cut down. On the other hand, they also become overgrown quickly, most often on parts of farmland that the farmer has stopped cultivating due to poorer quality, less accessibility and other reasons.

In this paper, we have paid special attention to the identification and recording of hedgerows using digital orthophoto and lidar imagery. Their biggest drawback is their timeliness, as lidar data for the whole of Slovenia have been captured only once, while digital orthophotos are updated every two to four years.

In order to more effectively conserve the individual landscape features (e.g. hilly meadows, hedgerows, etc.), it is necessary to provide databases based on appropriate ways of recording these features. The absence of monitoring thus hampers the very system of monitoring the phenomenon, surveillance and appropriate action in the event of negative processes. This shortcoming has also been identified at the level of agricultural policy implementation, where the Joint Strategic Plan 2023–2027 specifically highlights the improvement and extension of the different spatial layers for the implementation of nature conservation sub-interventions, which will relate to hedgerows, wetlands, sensitive permanent grasslands in Natura 2020 sites, etc. (MAFF, 2021).

2 THEORETICAL STARTING POINTS

The hedgerow is recognised worldwide as an important landscape element. Their treatment in Western European and North American countries is well established and supported by research (e.g. Allende Álvarez, Gómez Mediavilla, López Estébanez, 2021; Allende Álvarez et al., 2021; Graham et al., 2018; Litza et al., 2022). In the UK, for example, they are protected in a targeted way through the Hedgerow Regulations (1997). However, due to large-scale and rapid spatial changes (intensification of agriculture, use of modern technology, expansion of urbanised areas, changes in farmland management policies), hedgerows are facing their gradual loss at a global scale (Baudry, Bunce, Burel, 2000; Burel, Baudry, 1990; Molnarova, 2008), and thus conservation of hedgerows is becoming increasingly challenging.

The treatment of hedgerows is also not yet uniform in terms of terminology. The two most commonly used terms in the foreign literature are *hedge* and *hedgerow*, but their use is inconsistent. Hedges represent the woody component of the boundary vegetation, whereas *hedgerows* include a herbaceous component and a canal adjacent to the hedgerow (Forman, Baudry, 1984). As there is no single established term in Slovenia, terms such as "živice", "omejki" and "živa meja" are used. Terminological conundrums have been somewhat resolved with the introduction of the Conservation of Hedgerows operation, which is part of the Agri-environmental-climate scheme (AECS) under the Common Agricultural Policy (CAP). This operation has established the term "hedgerow" (Slov. "mejica") in the agricultural and nature conservation sector (MAFF, 2019).

There are also discrepancies in the definition of the minimum length of hedgerows. In the survey, we used the definition of the Ministry of Agriculture, Forestry and Food (MAFF), which defines hedgerows as compact and independent lines of woody vegetation at least 10 metres long and no more than 20 metres wide at the canopy, which must be more than two metres wide (MAFF, 2019).

The importance of the management and proper treatment of hedgerows lies in the multiple and complementary functions that they provide. They provide foraging habitat for many animals, which is particularly important in intensively farmed landscapes. They are important migration and flyway corridors linking different ecosystems. An important fact is that hedgerows are composed of a diversity of native species with a shrub layer developed to allow light to reach the lowest layers (Dondina et al., 2016; Garratt et al., 2017; Heath et al., 2017). Hedgerows reduce the impacts of wind, drought, storms and hail, control water flow and delay nutrient leaching from farmland into watercourses. On the one hand, they limit the spread of organisms harmful to agriculture (MAFF, 2021), and on the other hand, they serve as a refuge for animals, both wild and grazing. The great importance of hedgerows in the agricultural landscape lies in their prevention of wind erosion (Earnshaw, 2004; MAFF, 2021). The quality of the protection depends on the size of the trees, so that the effect of windbreak is 56 metres for a two-metre shrub and 560 metres for a 20-metre thicket (Forman, Baudry, 1984). Another important ecosystem service is the regulation of the local climate, as a specific microclimate is established in and around hedgerows (MAFF, 2021). In the area of the hedgerows, soil water and organic carbon contents are higher, which contributes to higher land productivity (Sanchez et al., 2010). They are also a source of raw materials, the most important of which is timber, which has played an important role especially in the past and in countries where forest cover is scarce (Burel, Baudry, 1990). However, the presence of hedgerows also has some negative effects, as hedgerows can attract some harmful insects and birds that damage crops in nearby fields (Farmers and hedgerow management, 2019), and they affect crop yields by causing shade (Oreszczyn, Lane, 2000).

Hedgerows contribute to the landscape diversity of the cultural landscape and break up its monotony (Golobič et al., 2015), and they often demarcate properties of different owners (Baudry, Bunce, Burel, 2000). They therefore have a great aesthetic importance, which is rarely written about and few studies have been conducted on it, but is an important factor in the conservation of hedgerows (Burel, Baudry, 1990).

In Slovenia, hedgerows are one of the landscape features important for biodiversity conservation identified in the project Identification of landscape diversity and features important for biodiversity conservation (Golobič et al., 2015). Landscape features include, e.g., water ditches, dry walls, riparian vegetation, hilly meadows, etc. On agricultural land, these features are crucial for the conservation of many species of flora and fauna, but also have many other beneficial functions for people and the landscape itself (Golobič et al., 2015). One of the objectives of the post-2020 Common Agricultural Policy is to strengthen the contribution of agriculture to biodiversity conservation through the protection of the diversity of landscape features (Biodiversity and farmland landscapes, 2020). The common thread running through all these features is their conservation, particularly in intensively farmed landscapes, and extensive use of their immediate surroundings. Slovenia does not have adequate data to monitor the status of these elements or a unified system for their protection (Golobič et al., 2015).

Figure 1: Well-structured hedgerows perform the most functions due to the representation of all three layers of vegetation (trees, shrubs and herbs) (Vipava Valley) (photo: A. Kastelic).

The quality of the different functions of hedgerows depends mainly on their structure. For this reason, a number of authors (Boutin et al., 2002; Burel, Baudry, 1990; Garratt et al., 2017) have addressed the typology of hedgerows in their research (e.g. Allende Álvarez et al., 2021; Allende Álvarez, Gómez Mediavilla, López Estébanez, 2021). They agree that the best quality hedgerows are those that are multi-species, dense, composed of trees and shrubs, and intermingled with other hedgerows to form a system or network of hedgerows (Baudry, Bunce, Burel, 2000; Boutin et al., 2002; Forman, Baudry, 1984; Hedgerow Survey Handbook ..., 2007).

For the purposes of our research, we have developed our own typology of hedgerows, adapted to Slovenian conditions (Kastelic, 2019). The final typology includes five types of hedgerows:

1) Structured hedgerows are those that include all three layers of vegetation: trees, shrubs and herbs. They are vertically connected and provide a variety of habitats for many species, and are therefore of the highest quality from a nature conservation point of view.
2) Shrub hedgerows are made up of shrubs and herbs. Shrub vegetation is dense, creates vertical connectivity and is difficult to pass through.
3) Semi-structured hedgerows are made up of trees, shrubs and herbaceous vegetation. The difference between the structured and the semi-structured type is that in the latter the shrub cover is thinner, lower and therefore the hedgerow is more passable.
4) Tree hedgerows are made up of trees and herbaceous vegetation.
5) Combined hedgerows are longer hedgerows in which at least two types of hedgerow alternate. Their characteristics depend on the types that make it up.

Figure 2: Combined hedgerows (a combination of shrub and tree layers) are more abundant in the Ljubljana Marshes (photo: A. Kastelic).

In terms of function (for people, fauna and landscape), structured hedgerows, which are composed of all three layers, are the most suitable, followed by shrub hedgerows and semi-structured hedgerows, while tree hedgerows are less suitable for e.g. nature conservation functions.

Figure 3: Structured hedgerows in the Ljubljana Marshes have particularly important nature conservation functions, as they are located among intensive agricultural areas (photo: A. Kastelic).

Figure 4: Tree hedgerows are formed by trees and herbaceous vegetation. An example of a tree hedgerow in the Ljubljana Marshes, which is losing its function due to intensive clearing and cutting and other uses (photo: B. Lampič).

3 PRESENCE AND VISIBILITY OF HEDGEROWS IN SLOVENIA

Hedgerows are present throughout the country, but there are significant landscape differences. In the Karst, for example, they were created along drystacks (Šmid Hribar, 2008), while in Goričko they were used to border pastures (Domanjko, Malačič, 2009). Several theses have been written on their biological function, and Janez Božič wrote a publication on windbreaks in lowland areas of Slovenia as early as 1969 (Premrl, Turk, 2013). As a result, relatively little is known about the state of hedgerows in Slovenia, and those hedgerows that are included in the agricultural operation Conservation of Hedgerows are monitored in a slightly more systematic way.

The Conservation of Hedgerows operation is one of the operations of the AECS measure in the CAP (2014–2020, to be implemented as a sub-measure also in the programme period 2023–2027). It supports the maintenance and conservation of hedgerows in different types of agricultural land use and constitutes the preservation of one of the important elements of the agricultural landscape. The operation has been running since 2017 and the farmer commits to at least five years of operation when entering it. The amount of the payment for the implementation of the operation is EUR 1.60 per running metre per year (MAFF, 2019). The maintenance of the hedgerows must include thinning, removal of dead branches and pruning. Payments are made for the farmer's loss of income (in some cases reduced yields due to shade, more difficult cultivation) and for the extra work involved in maintaining the hedgerows (Čus, 2019; Žvikart, 2019). The most important is their pruning (every two years), but not during the bird nesting season (between 1 March and 30 September) (MAFF, 2019).

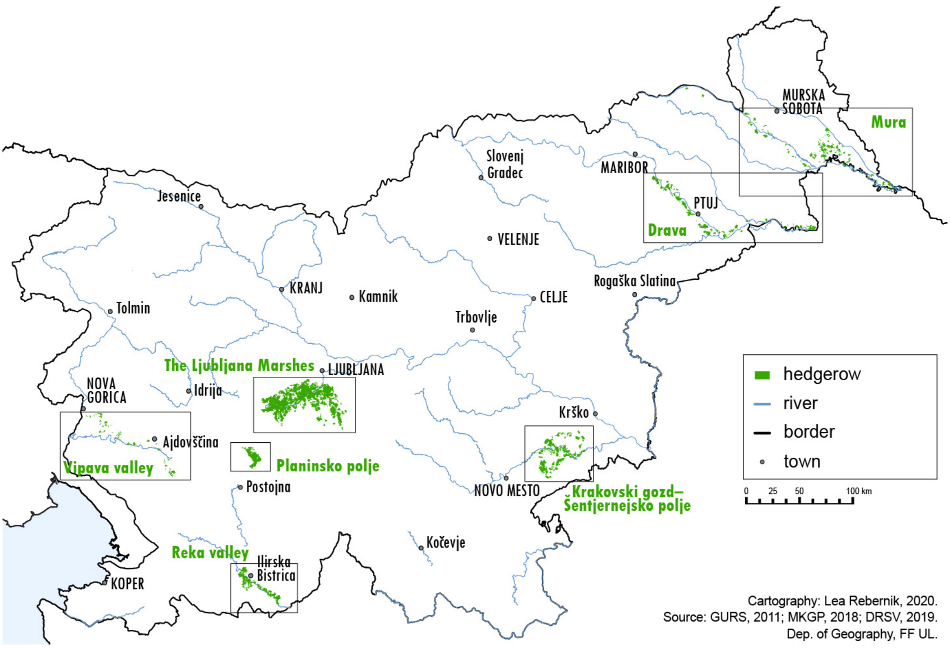
Table 1: Number and length of hedgerows included in the Conservation of Hedgerows operation in seven Natura 2000 sites.

Natura 2000 site	Number of hedgerows	Total length (m)	Longest hedgerow (m)	Shortest hedgerow (m)	Average length (m)
Krakovski gozd – Šentjernejsko polje	404	44.875	792	11	111
Reka valley	383	27.833	421	10	73
Vipava valley	123	8.783	328	15	71
Planinsko polje	298	27.368	586	13	92
The Ljubljana Marshes	2.720	290.876	1.254	11	107
Drava	286	32.793	691	14	115
Mura	308	26.030	545	15	85
Total	4.522	458.558	1.254	10	101

Source of data: MAFF, 2018b.

In 2019, the Conservation of Hedgerows operation was implemented in seven Natura 2000 sites (Krakovski gozd – Šentjernejsko polje, Reka valley, Vipava valley, Planinsko polje, Ljubljansko polje, Drava, Mura) (MAFF, 2019). The operation includes areas where the hedgerows are most at risk of disappearing (Živikart, 2019). The total number of hedgerows in the operation is 4,522 and their total length is 458,558 metres. The average length of a hedgerow is 101 metres, the longest is 1,254 metres and the shortest is 10 metres (MAFF, 2018b).

Figure 5: Map of the implementation areas of the Conservation of Hedgerows operation in Slovenia.



In 2018, 104 agricultural holdings took part in the Conservation of Hedgerows operation, maintaining a total of 134 kilometres of hedgerows. Around EUR 214,400 was paid to them as part of the operation. The majority of these, 90%, were farmers from the Ljubljana Marshes (Slov. Ljubljansko barje), while the number of farmers involved in the operation in other areas is modest (Čuš, 2019). The reasons for the large differences in the number of farmers registered between the areas are the number and length of the hedgerows. In the Ljubljana Marshes, they are the most numerous, the longest and a widely present element in the cultural landscape. The decision to join the operation is significantly influenced by the farmer's attitude towards the hedgerow, the understanding of the operation itself and (above all) the activity and efforts of the agricultural advisors (Čus, 2019; Živikart, 2019).

The Conservation of Hedgerows operation is protecting and conserving 4,522 hedgerows in seven Natura 2000 sites (MAFF, 2018b). These hedgerows are (more) safe from clearing, while the remaining ones are still regularly cleared or deforested, as their protection, even in the area of the Ljubljana Marshes Landscape Park, is difficult to achieve with the current legal framework. Even more worrying is the fact that we have no data and no information on what is happening to hedgerows in the rest of Slovenia. We have no information on their number, length, structure and current processes. If inappropriate practices are observed in the more protected areas of the operation, we can assume that the situation is even worse elsewhere. For example, in the Ljubljana Marshes Landscape Park, the clearing (i.e. destruction) of hedgerows has been found to be in breach of nature protection regulations. At the same time, after the removal of the hedgerows, the farmer was able to register the land (grassland) as arable land and receive agricultural payments without hindrance. The system of rules and agricultural regulations in Slovenia seems to work in a way that allows European agricultural payments to also be paid for practices that constitute a violation of nature and nature conservation regulations (Jančar, 2018).

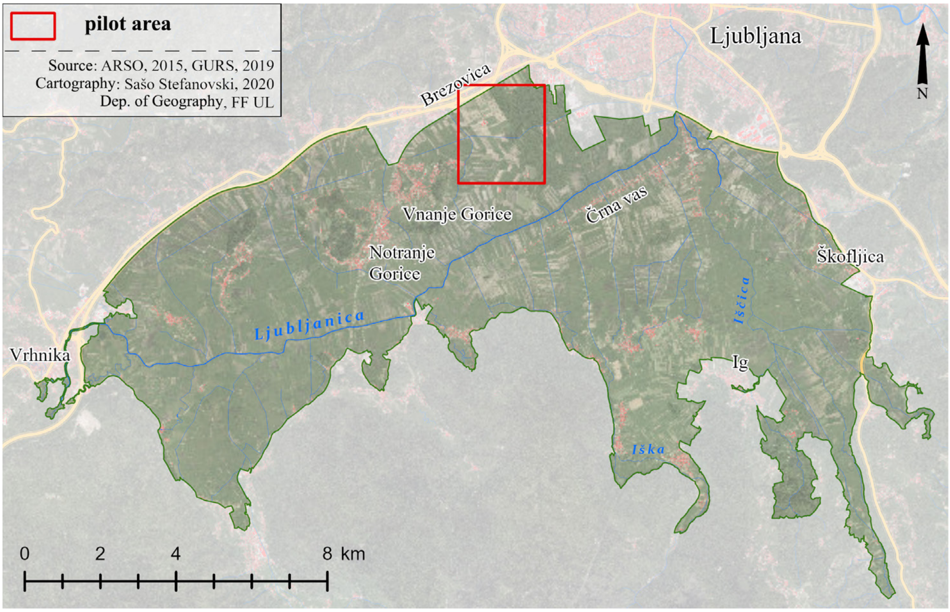
4 LJUBLJANA MARSHES AS A PILOT AREA

For further work, we selected the pilot area of the Ljubljana Marshes, where we focused all further steps of the survey, including the field inventory of hedgerows. The Ljubljana Marshes are located in central Slovenia in the southern part of the Ljubljana Basin and cover 120 square kilometres (Pavšič, 2008). It is characterised by a mosaic landscape, an interlacement of arable fields, marsh meadows, pastures, canals, watercourses and hedgerows, which are one of the most important building blocks of the landscape (Strokovne podlage za ustanovitev ..., 2007). The main constraints to agricultural development are waterlogging and soil water, yet 82% of the area was cultivated in 2017. Almost half of the arable land is cultivated with (silage) maize as a crop, which poses the risk of the Ljubljana Marshes becoming a monotonous monoculture landscape. The size of farms in the Ljubljana Marshes is above average (12.72ha) in relation to Slovenian conditions (Kmetijstvo na Ljubljanskem barju, 2019).

Hedgerows are a traditional landscape feature in the Ljubljana Marshes. In the past, they were even more widespread, especially along canals. They were an important source of raw materials (timber) and marked the boundaries of plots owned by different owners, but today they are losing these functions. The density and composition of hedgerows vary considerably within the Ljubljana Marshes. For example, the vegetation of the hedgerows on the periphery is dominated by willows, while the hedgerows in the interior are dominated by alders. Much of the tree and shrub cover was cleared during the establishment of graphic units of agricultural holdings use (GERKs). The intensification of agriculture has made them a nuisance for many farmers. In the

Ljubljana Marshes, more farmers are involved in the Conservation of Hedgerows operation in the western part of the area, while the number of farmers involved in the operation is smaller in the eastern part. Most of the farmers in the operation have over 2000 metres of hedgerows, and two farmers have as much as 10 kilometres of hedgerows (Pečjak, 2019).

Figure 6: Survey area in the northern part of the Ljubljana Marshes.



The selected pilot area within the Ljubljana Marshes is two square kilometres in size and lies in a Natura 2000 site within the Ljubljana Marshes Landscape Park. The Landscape Park's protection regimes protect the hedgerows from cutting and maintenance works between 15 March and 30 September (Uredba o Krajinskem parku ..., 2008), but in practice there are problems with monitoring compliance with the regulations set out in the Regulation (Japelj, 2019). The pilot area is dominated by arable fields (54%) and marshy hedgerows (20%) (MAFF, 2018a), while structured and shrubby types are predominant among the hedgerows, which are identified as the highest quality types (Kastelic, 2019).

Figure 7: A typical semi-structured hedgerow between meadows in the Ljubljana Marshes.

5 METHODS

In 2016, the Slovenian Nature Conservation Agency (ZRSVN), under the mandate of the Ministry of Agriculture and Rural Development, prepared the first inventory layer of hedgerows in Slovenia (Bucik et al., 2017). The layer was based on digital orthophotos from 2014, where aerial photographs are transformed from central to orthogonal projection and are dimensionally comparable to maps (Zbirke prostorskih ..., 2019). Due to the implementation of the Conservation of Hedgerows operation under the AECS, the layer was prepared in a short time and the identification of the hedgerows was based on the use of older orthophotos. Therefore, the quality of the first inventory layer was poorer in some places, as the hedgerows were recorded in a superficial way or there were errors due to changes in the actual use or removal of the hedgerows. The 2018 hedgerow layer has been updated and improved based on more recent orthophotos (from 2017) and field reports (Čuš, 2019; Žvikart, 2019). Both official boundary layers (2016 and 2018) were also field-checked for the purposes of the survey and a number of anomalies were found. Preliminary field work in 2017 in the north-eastern part of the Ljubljana Marshes recorded differences between the actual spatial situation and the 2016 hedgerow layer of record in 62% of the hedgerows (selected area). When the field verification was carried out again in 2019 (the 2018 hedgerow layer was verified), fewer differences were detected (Kastelic, 2019), demonstrating the key role of field verification of the status of hedgerows, as well as its complexity and time-consuming nature (Bucik et al., 2017; Kastelic, 2019).

As the identification and recording of hedgerows directly using orthophoto images and fieldwork did not prove to be optimal solutions for recording hedgerows, we identified hedgerows using lidar-captured data. We used imagery from the E-waters (Slov. E-vode) portal, which is maintained by Slovenian Environment Agency. We tested the method in a small pilot area (presented previously), where the hedgerows are more abundant and the location is close enough to Ljubljana. Laser scanning for the Ljubljana Marshes was carried out in 2014 and 2015, with a resolution of 10 pixels per m^2 (Izvedba laserskega ..., 2015).

The two-square-kilometre pilot area, located in the north of the Ljubljana Marshes, includes a variety of different types of grassland, and land use is heterogeneous. The base layer of lidar-captured data was filtered on the LAS DATASET layer and filtered on medium and high vegetation, as this corresponds to the criteria of a hedgerow. In order to find the best way to record the hedgerows using the lidar-captured data, two approaches were tested: approach 1 or canopy density, and approach 2 or reflection intensity.

Figure 8: Schematic representation of the methodological approaches used with lidar-captured data.

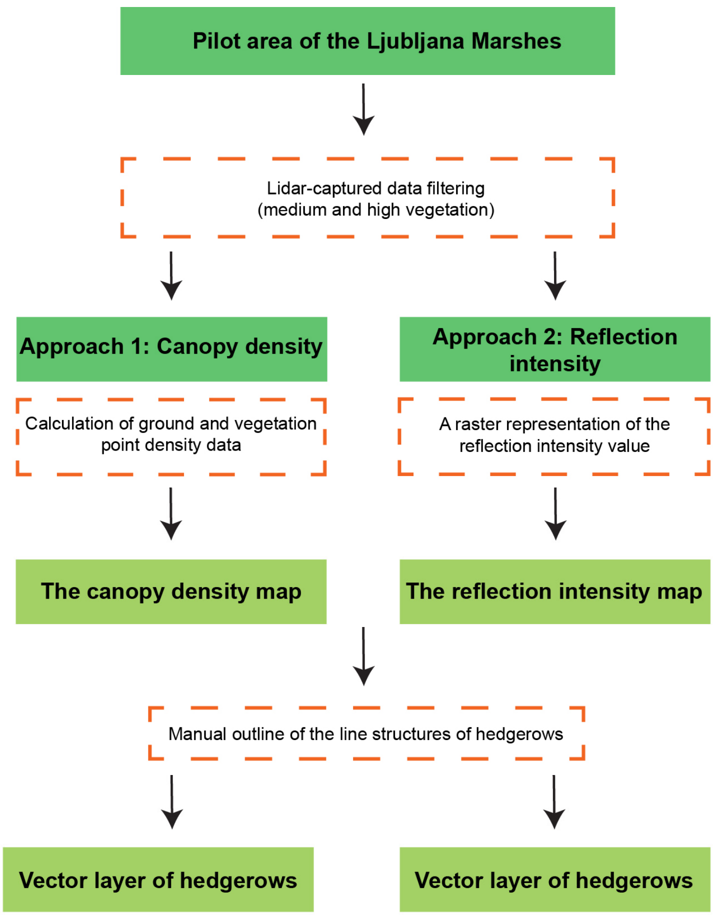


Figure 8 shows two different ways of processing the lidar data, resulting in two different spatial representations of the hedgerows. Canopy density or canopy cover is an estimate of the ratio of ground to canopy tops as seen from the air. It was calculated using ground and vegetation point density data. The method is useful for measurements in nature, such as calculating biomass and vegetation cover (Estimating forest canopy density ..., 2019).

Reflection intensity is the intensity of the reflected signal or the ratio of the intensity of the received light on the laser scanner. It is used as an aid in the identification of features and as a surrogate for aerial photographs. The map itself is a raster representation of the measured reflection intensity value. It covers one wavelength, namely the near-infrared part of the spectrum invisible to humans, which is only slightly larger than the wavelengths of the visible spectrum, so the display is quite similar to the perception of visible light. We can distinguish densely imaged points such as trees, houses, a road, especially at the surface, without height differences. It is difficult to predict the final range of values, as the final values depend on several variables, different sensors and are without a unit of measurement (Švab Lenarčič, Oštir, 2015).

In the final stage, the line structures of the hedgerows were drawn manually, resulting in two vector layers. All analyses were performed using ArcMap 10.7.

6 RESULTS

Identification of hedgerows using different procedures (1. field recording (2017), 2. two approaches based on lidar-captured data, 3. two MAFF hedgerow inventory layers (2016 and 2018)) yielded different results for the pilot area in the Ljubljana Marshes (Table 2). This is reflected in the number and total length of the hedgerows, which varies noticeably between all treatments.

Table 2: The Ljubljana Marshes pilot area – recorded number and length of hedgerows with different approaches.

Procedures	Number of hedgerows	Total length of hedgerows (m)
Hedgerow inventory layer 2016	88	9.468
Field recording of hedgerows 2017	122	11.427
Hedgerow inventory layer 2018	101	10.536
Lidar-captured data – Canopy density	127	13.978
Lidar-captured data – Reflection intensity	130	12.788

Source of data: Bucik et al., 2017; MAFF, 2016; 2018b.

An analysis of the hedgerows of the two official boundary inventory layers from 2016 and 2018 shows that the pilot area in 2018 recorded a higher number and total length of hedgerows. This situation surprised us, as the total number of hedgerows in the whole area of the Ljubljana Marshes decreased significantly during this period, from 2952 to 2720. The total length of the hedgerows also decreased (by 50,000 m) (MAFF, 2016; 2018b). These data point to the questionable suitability of the 2014 DOF imagery used to compile the 2016 hedgerow inventory layer.

We looked at the problem in more detail in a smaller pilot area, where 88 hedgerows were included in the inventory layer in 2016 and 101 two years later. There could be several reasons for these differences. The changes are linked to an area with predominantly arable land use. The analysis of land use in both years shows an abandonment of arable land and thus an increase in overgrowth, which may lead to the creation of new hedgerows. The previously mentioned first capture of hedgerows from older DOF images may contribute to the lower accuracy. The start of the implementation of the Conservation of Hedgerows operation (in 2017) has introduced changes in the way the hedgerows are managed, which could have an impact on their reduced clearing. The main differences between the inventory layer and the field inventory layer are mainly in the shrub hedgerows in the arable areas in the eastern part of the site. Shrub hedgerows are the type of hedgerow that grows most quickly and probably for this reason were not yet visible on the DOF imagery.

In view of the above, the results of the inventory layers did not prove to be optimal, and we decided to develop two methodological approaches of our own, implemented using lidar-captured data, which are described in more detail in the methodology section of Chapter 5.

The canopy density map (D) shows the density of tree and shrub canopies. The boxes were visible as line graphs of the canopy. When recording the hedgerows, care had to be taken to capture clearly visible linear vegetation, which could not be more than 20 metres wide. Two different methods (canopy density and reflection intensity) based on lidar-captured data gave different results. This is due to the different levels of visibility of the images. The difference also lies in the image of the hedgerows themselves. In the reflection intensity map, the hedgerows are represented by strips in which no woody vegetation forms can be discerned, whereas in the canopy density map, the canopy can be discerned, providing a clear view of even narrower strips of vegetation.

Figure 9: Illustration and comparison of the different extent of recorded hedgerows identified by the different methods (on a section of the Ljubljana Marshes pilot area).

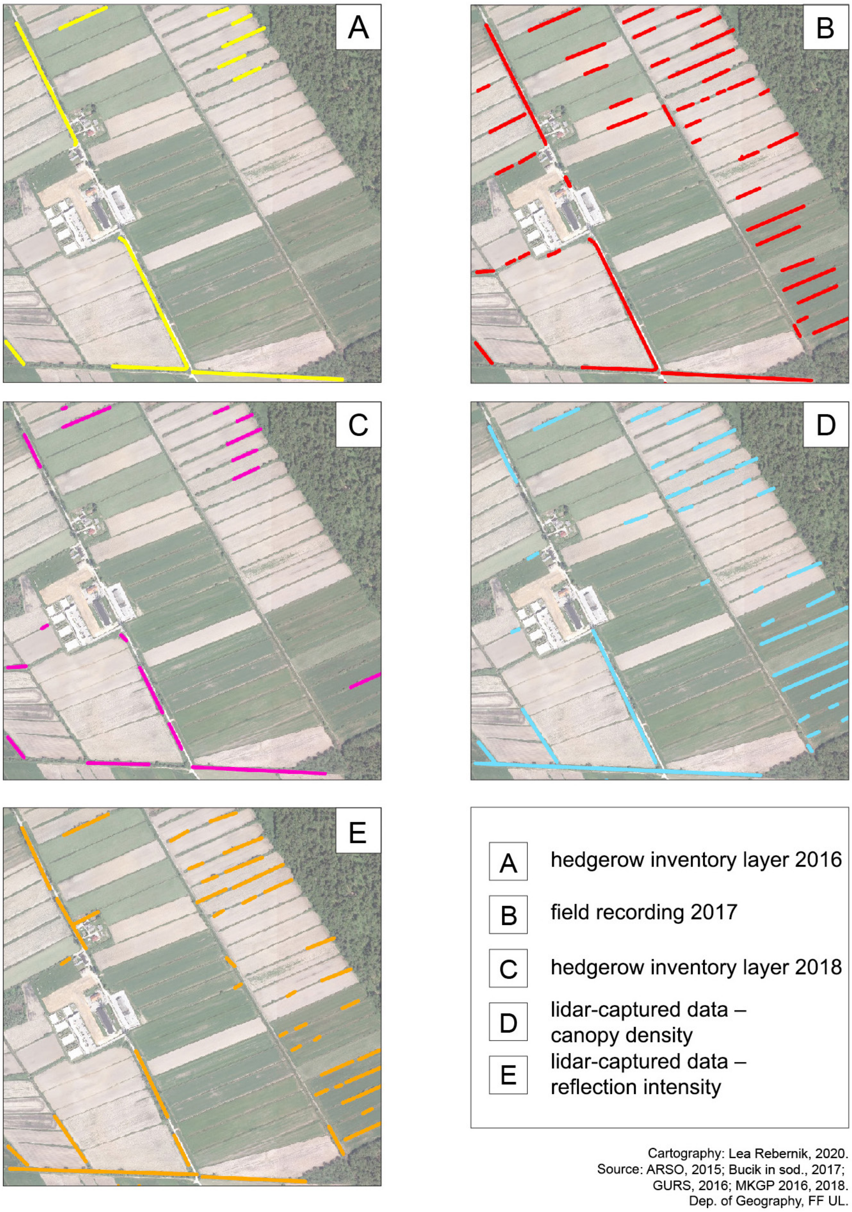


Table 3: Number of recorded hedgerows with different methodological approaches in the Ljubljana Marshes pilot area.

Hedgerow layer	Inventory layer 2016	Inventory layer 2018	Field recording 2017	Lidar-captured data – canopy density	Lidar-captured data – reflection intensity
Inventory layer 2016		+13	+34	+39	+42
Inventory layer 2018	−13		+21	+26	+29
Field recording 2017	−33	−21		+5	+8
Lidar-captured data – canopy density	−39	−26	−5		+3
Lidar-captured data – reflecti-on intensity	−42	−29	−8	−3	

Source of data: Bucik et al., 2017; MAFF, 2016; 2018b.

The least number of hedgerows were identified in the two official records of hedgerows (Inventory Layer 2016 and 2018) when recording the hedgerows in the Ljubljana Marshes pilot area. A larger number of more hedgerows were recorded through the field inventory of hedgerows and the two hedgerow layers that were created based on the lidar-captured data. The differences between these three hedgerow layers are also relatively small and we therefore conclude that these are more relevant.

Table 4: Lengths of recorded hedgerows (in metres) using different methodological approaches in the Ljubljana Marshes.

Hedgerow layer	Inventory layer 2016	Inventory layer 2018	Field recording 2017	Lidar-captured data – canopy density	Lidar-captured data – reflection intensity
Hedgerow layer		+1.068	+1.959	+4.510	+3.320
Inventory layer 2016	−1.068		+891	+3.442	+2.252
Inventory layer 2018	−1.959	−891		+2.551	+1.361
Field recording	−4.510	−3.442	−2.551		−1.190
Lidar-captured data – canopy density	−3.320	−2.252	−1.361	+1.190	
Lidar-captured data – reflection intensity					

Source of data: Bucik et al., 2017; MAFF, 2016; 2018b.

Interestingly, the 2018 hedgerow inventory layer, both in terms of number and total length of hedgerows, differs less from the lidar-captured hedgerows than the 2016 inventory layer. This result is partly surprising due to the smaller temporal difference between the DOF imagery (which is the basis for the 2016 inventory layer) and the lidar imagery that was captured between 2014 and 2015. Our results suggest that the accuracy of the official 2016 hedgerow inventory layer is lower. The differences between the field inventory and the results of the two lidar approaches are minor, especially for the total number of hedgerows, but there are differences for the length of shrub hedgerows between fields.

We find that different images show different visual perception of the hedgerows. This has an impact on the differences in their lengths in all the layers we captured digitally. During data analysis, we detected several differences between lidar and DOF images. These differences also indicate the advantages and disadvantages of using one data layer or the other. One important technical difference is the size of the files. A lidar image measuring one square kilometre is 101 MB in size, whereas a DOF image covering an area of five square kilometres is approximately 315 MB in size. Identifying boundaries is also more difficult on lidar layers than on DOF layers, as the latter make it easier and faster to identify the linear structures of the hedgerows. On the other hand, lidar data has the advantage that it can be filtered, so that only the middle and high vegetation can be seen in the image, making the linear structures clearer and easier to identify than in DOF images. The lidar images also lack the shadows that can appear in DOF images and hinder visual identification, while the lidar images make it easier to detect gaps between hedgerows. It is also worth mentioning that the identification of tree avenues and other (linear) plantations that do not belong to the hedgerow layer is a problem when recording hedgerows from both images.

7 CONCLUSION

The Conservation of Hedgerows operation, which is implemented within the framework of the AECS measure, represents the first systematic attempt to conserve and maintain hedgerows in Slovenia. In seven areas in Slovenia (Krakovski gozd – Šentjernejsko polje, Reka valley, Vipava valley, Planinsko polje, Ljubljansko polje, Drava, Mura), where hedgerows are already identified in the hedgerow inventory layer, the issue of their maintenance and conservation has consequently started to be addressed more frequently among landowners, farmers and agricultural advisors (Čuš, 2019; Žvikart, 2019). In the new programming period, we can look forward to improving and expanding the different spatial layers for the implementation of nature conservation sub-interventions, which in practice will mean the extension of the record layer of hedgerows to other areas of Slovenia (MAFF, 2021).

In view of the problems identified by the nature conservation and agricultural sectors, related to the quality and maintenance of the official records of hedgerows, the search for more efficient ways to inventory new areas of hedgerows and to monitor their maintenance, the study focused on the development of methods to identify and establish the hedgerow layer. The existing system of monitoring and updating data is flawed and does not keep pace with the actual situation on the ground.

Our more detailed research in the Ljubljana Marshes pilot area between 2017 and 2019 shows that none of the three tested methods of identifying and recording hedgerows (from digital orthophotos, lidar-captured data, fieldwork) is entirely appropriate, but each approach has certain advantages and disadvantages. We note that an up-to-date spatial layer of hedgerows requires the use of the latest available data and different techniques, and although time-consuming, the methods need to be combined with field visits and inventories. The recording of hedgerows using lidar-captured data, in addition to the approaches presented in the paper, offers other possible solutions, but the identification and recording methods already presented (and tested) could certainly be used to extend the recording layer of hedgerows to other areas in Slovenia.

In conclusion, the illustrations of the hedgerows produced according to the different methodological approaches that we have carried out in the pilot area of the Ljubljana Marshes differ. Differences are also likely to be found in other areas of hedgerows in Slovenia. Although there are no large differences in the number and length of the hedgerows between the procedures, the differences are important due to the fact that the agricultural payments for the Conservation of Hedgerows operation relate to the length of a hedgerow per linear metre. The payment in the 2014–2020 programming period was EUR 1.60 per linear metre of hedgerow and is intended to compensate the farmer for the costs incurred for their management and maintenance (MAFF, 2019).

As we currently have no data on the extent and quality of the hedgerows outside the inventory layer in Slovenia, and conservation measures cannot be implemented elsewhere under the hedgerow operation, it is reasonable to expect that agricultural trends and other spatial pressures will put these features at even greater risk. The existing inventory of hedgerows also needs to be upgraded in terms of content. At present, only the length and connectivity of the hedgerows are monitored, but not their quality. We have already experimentally extended the monitoring attributes in the context of our survey by adding information on the type of hedgerows. The field definition of the type of hedgerow can be used to better assess or infer the extent and quality of the functions that a particular hedgerow can perform. The identified quality of the functions of the hedgerows would make it easier to identify areas where their protection is particularly important or areas with poorer quality hedgerows that need to be improved.

The paper suggests some solutions towards upgrading the existing national hedgerow inventory layer. In addition to methodologically sound recording, measures and policies in the fields of agriculture, nature conservation and spatial planning will be crucial for the conservation and effective protection of hedgerows. Above all, there is a need for continuous awareness-raising among farmers, landowners and the general public about the role of the many functions of hedgerows in the cultural agricultural landscape.

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