Foraging Fields for the European Turtle Dove

Developing and testing management measures for a disappearing species

2021 – 2024

INCLUSIEF NEDERLANDSE SAMENVATTING ÉN **AANBEVELINGEN**

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Foraging Fields for the European Turtle Dove

This final project report is an analysis of all the data collected in 2021, 2022 and 2023.

It marks the end of the 3-year project "Foraging Fields for the European Turtle Dove".

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Contents

SAMENVATTING 1

CHAPTER 1: Introduction 11

1.1 Background 11

1.2 Project aims 14

CHAPTER 2: Methods 15

2.1 Study areas 15

2.2 Field location and set up 16

2.3 Seed mixes 18

2.5 Vegetation monitoring 24

2.6 Assessing plot suitability 26

2.7 Turtle dove monitoring 27

CHAPTER 3: Results 32

3.1 Test plot performance 32

3.2 Turtle dove use of test plots 42

3.3 Alternative foraging sites 56

CHAPTER 4: Discussion 61

4.1 Were the foraging fields used? 61

4.2 Creating and managing foraging fields 67

4.3 Foraging site selection 72

CHAPTER 5: Conclusions 76

CHAPTER 6: Further Research Needs 78

CHAPTER 7: Recommendations for foraging fields 79

References 83

Appendices 85

Appendix 1: Details of participating fields 85

Appendix 2: Seed mix composition 87

Appendix 3: Overview of test plot participation 88

Appendix 4: Sowing method 2021 - 2023 90

Appendix 5: Management plan used in 2023 (Dutch) 91

Appendix 6: Management strategy summary 93

Appendix 7: Suitability criteria 94

Appendix 8: GPS tag and harness information 95

Appendix 9: Seed mix species height and seeding date ... 96
Appendix 10: Test plot photo pages ... 97
Appendix 11: Camera trap total of daily maximum ... 121
Appendix 12: Dove information ... 123
Appendix 13: Dove (raw) data collection summary ... 123
Appendix 14: Turtle dove visits to test plots ... 124
Appendix 15: Home ranges, territories and nests ... 125
Appendix 16: National Land Use Classification 3.2 (NLUD) ... 129
Appendix 17: Land use classification for turtle doves ... 130
Appendix 18: Map of identified foraging sites ... 131
Appendix 19: Management ... 132

SAMENVATTING

Zomertortels broeden in kleinschalige, halfopen landschappen met verspreide houtopstanden zoals bosranden, hagen en struwelen. In de jaren zeventig herbergde Nederland naar schatting 35.000 – 50.000 broedparen, maar sindsdien is de populatie ingestort en raakten grote delen van het land hun zomertortels kwijt. Belangrijke oorzaken daarvan zijn onder andere habitatdegradatie in de broedgebieden en intensieve jacht in Zuid-Europa. Tegenwoordig herbergt Nederland nog maar 600 – 900 broedparen. Ook in de ons omringende landen en in zuidelijk Europa is de soort (sterk) afgenomen.

Vanwege de internationaal bestaande zorgen over de zomertortel is er in mei 2018 door de EU een zogenaamd Single Species Action Plan vastgesteld. Het doel van dit actieplan is om de achteruitgang van de zomertortel een halt toe te roepen. In het plan wordt een lange reeks van acties benoemd die de zomertortel ten goede moeten komen, waaronder verbetering van broed- en overwinteringsgebieden, regulering van jacht, onderzoek, bewustzijnsbevordering en internationale samenwerking. Eén van de acties uit het plan is het behouden of creëren van onkruidrijke en dus ook zadenrijke plekken waar zomertortels succesvol naar voedsel kunnen zoeken (Actie 1.2.1.1).

Het voedsel van de zomertortel bestaat nagenoeg volledig uit zaden. Dit voedsel wordt gezocht op zadenrijke plekken met ijle en lage (pionier)vegetaties en veel kale grond. Uit in de jaren negentig uitgevoerd Engels onderzoek blijkt dat er grote veranderingen zijn opgetreden in het soort van plaatsen waar zomertortels naar voedsel zoeken. 'Vroeger', dat wil zeggen, vóór de tijd van landbouwintensivering, zochten zomertortels in Engeland vroeg in het broedseizoen (april-juni) naar voedsel in klaverakkers en hooilanden, die toen nog veelvuldig in het Engelse landschap voorkwamen. Deze klaverakkers en hooilanden waren rijk aan onkruiden en er waren volop zaden van grassen in aanwezig. In de tweede helft van het broedseizoen (juli-september) foerageerden zomertortels vooral op percelen met tarweschoven en in onkruidrijke akkers waar erwten waren geteeld. Het voedsel bestond in die tijd voor meer dan 90% uit onkruidzaden. Door modernisering van landbouwmethoden is dit soort habitats grotendeels uit het landschap verdwenen. Tegenwoordig zijn zomertortels voor voedsel afhankelijker geworden van plekken die 'toevallig' door mensen zijn gecreëerd. Denk hierbij aan graanopslagplaatsen, rommelige boerenerven en plekken waar vee wordt gevoerd en gemorst graan als voedsel beschikbaar is. Later in het broedseizoen maken tortels in Engeland ook gebruik van stoppels van graan- en koolzaadakkers. Als gevolg van de veranderde foerageerlocaties is in Engeland ook de samenstelling van het dieet sterk veranderd. Waar 'vroeger' onkruidzaden meer dan 90% van het dieet uitmaakten, maken nu granen en koolzaad circa 60% van het dieet uit.

Het bovenstaande werd min of meer bevestigd in in 2019-20 in de Zak van Zuid-Beveland uitgevoerd onderzoek met gezenderde tortels. Uit dit onderzoek bleek dat zomertortels voor voedsel afhankelijk waren van specifieke en marginale plekken, zoals wegbermen, onverharde paden en randen en overhoekjes bij akkers en in boomgaarden. Net als in het Engelse onderzoek werden vroeg in het voorjaar ook plekken bezocht waar door menselijk handelen 'toevallig' zaden

beschikbaar waren, zoals boerderijerven met voersilos of erven waar erfkippen werden gehouden en gevoerd.

Het is aannemelijk dat zomertortels tegenwoordig meer moeite hebben met het vinden van voldoende voedsel dan voorheen. Dit speelt vooral in de eerste helft van het broedseizoen wanneer het aanbod aan zaden van onkruiden en landbouwgewassen laag is. Waar 'vroeger' altijd wel ergens onkruidrijke plekken in het leefgebied van zomertortels aanwezig waren, zijn ze nu voor voedsel aangewezen op specifieke en niet talrijk voorhanden zijnde plekken, zoals wegbermen, boerenerven, veevoeropslagplaatsen en buitenrennen voor pluimvee. Volgens opnieuw Engels onderzoek speelt een gebrek aan voedsel vermoedelijk een rol bij de aldaar waargenomen afname van de reproductie, veroorzaakt door een verminderd aantal broedpogingen per paar per jaar en dus ook minder uitgevlogen jongen per paar per jaar.

Het aanleggen van speciaal op de zomertortel afgestemde 'voedselveldjes' in de buurt van territoria kan bijdragen aan een vergroting van het voedselaanbod voor zomertortels. Deze voedselveldjes moeten daarvoor een drie voorwaarden voldoen: de vegetatie mag niet te hoog en te dicht zijn, het aandeel kale grond moet 30 – 70% bedragen en er moeten zo lang mogelijk zoveel mogelijk zaden beschikbaar zijn. Om dit te bereiken worden in de veldjes mengsels ingezaaid, deels van plantensoorten die al vroeg in het jaar tot zaadzetting komen. Het beheer van de veldjes is gericht op het creëren van de door zomertortels geprefereerde open en ijle vegetatiestructuur.

In het kader van Operation Turtle Dove wordt in Engeland met dergelijke voedselveldjes geëxperimenteerd. Hoewel er een verband bestaat tussen lokale talrijkheid van tortels en de aanwezigheid van onkruidrijke habitats, is de daadwerkelijke bijdrage van deze voedselveldjes aan de voedselvoorziening van zomertortels tot op heden niet bekend. Anders gezegd, het is niet bekend in welke mate Engelse zomertortels van de aangelegde voedselveldjes gebruik maken en welke bijdrage ze leveren aan de voedselvoorziening van zomertortels. Om in deze kennisleemte te voorzien, is in 2021 in Zeeland een driejarig onderzoek gestart naar de betekenis van speciaal voor zomertortels aangelegde voedselveldjes. Doelen van het onderzoek waren:

- Bepaling van voor voedselveldjes geschikte zaadmengsels waarin gedurende het gehele broedseizoen zaden voor tortels aanwezig en beschikbaar zijn;
- Bepaling van het effect van voorjaarsinzaai versus najaarsinzaai op geschiktheid van voedselveldjes voor zomertortels;
- Ervaring opdoen met beheer gericht op het creëren en handhaven van een voor zomertortels geschikte vegetatiestructuur in de voedselveldjes;
- Onderzoeken in welke mate lokaal aanwezige zomertortels gebruik maken van de aangelegde voedselveldjes;
- Onderzoeken wat het relatieve belang van de aangelegde voedselveldjes is ten opzichte van andere in het landschap beschikbare voedselbronnen voor zomertortels.

Materiaal en methoden

De studie werd uitgevoerd in twee onderzoeksgebieden op Walcheren in de provincie Zeeland. Eén onderzoeksgebied was het gebied tussen Westkapelle en Zoutelande, het andere lag rondom Oostkapelle. Beide studiegebieden waren ongeveer 550 ha groot. In het voorjaar van 2021 zijn in beide onderzoeksgebieden speciaal op de zomertortel afgestemde voedselveldjes aangelegd. Streven was om in beide onderzoeksgebieden acht voedselveldjes van elk 0.25 hectare aan te leggen. Bij de selectie van de locaties van de aan te leggen voedselveldjes is zoveel mogelijk rekening gehouden met de locaties van territoriale zomertortels in het voorgaande jaar en hun actieradius bij het zoeken naar voedsel. Daarnaast is gestreefd naar enige ruimtelijke spreiding van de voedselveldjes binnen de beide onderzoeksgebieden. Elk veldje werd in twee delen opgesplitst. Op de ene helft werd in het voorjaar eenmalig een mengsel ingezaaid, op de andere helft in het najaar. Beide helften werden gescheiden door een strook met ongeschikt foerageerhabitat. Vooraf was de verwachting dat de veldjes zich na eenmalige inzaai gedurende de hele onderzoeksperiode 2021 t/m 2023 in stand zouden houden. De ingezaaide mengsels bestonden zoveel mogelijk uit inheemse plantensoorten aangevuld met enkele cultuurgewassen. Bij aanvang waren belangrijke soorten in de mengsels onder andere raapzaad, koolzaad, rode klaver, hopklaver, voederwikke, gele mosterd en enkele grassoorten. Het eerste onderzoekjaar was een pilotjaar. Dit pilotjaar werd gebruikt om de voedselveldjes zich te laten ontwikkelen tot onkruidrijke veldjes waarin veel zaden beschikbaar zijn en om ervaring op te doen met het beheer ervan.

De experimentele voedselveldjes werden gedurende elk groeiseizoen (mei-half september) eens per twee weken bezocht voor een visuele beoordeling van de geschiktheid voor zomertortels in termen van vegetatiehoogte- en dichtheid en het percentage kale grond. Na deze veldbezoeken werd de toestand van elk veldje binnen het projectteam besproken en werd een beslissing genomen over het gewenste beheer. Als beheer nodig was, werd contact opgenomen met de grondeigenaar met het verzoek om het beheer uit te voeren. Dit beheer kon bestaan uit diverse bewerkingen, zoals maaien, schoffelen, frezen of schijveneggen.

Het gebruik van de voedselveldjes door zomertortels is in kaart gebracht door middel van drie elkaar aanvullende meetmethoden: veldobservaties, cameravallen en tortels uitgerust met dataloggers. Veldobservaties en cameravallen werden al met ingang van het pilotjaar ingezet, tortels met dataloggers alleen in de jaren 2022 en 2023. De kans dat één of meer zomertortels tijdens een veldbezoek in een voedselveldje aanwezig waren, was bij voorbaat niet zo groot (lage trefkans). Om dit probleem te ondervangen werden per veldje ook twee cameravallen ingezet. De inzet van cameravallen vergrootte de kans om zomertortels vast te stellen op de voedselveldjes, omdat ze 24/7 de activiteit van dieren in de voedselveldjes registreerden. Een belangrijke beperking van de cameravallen was echter dat ze maar een beperkt deel (maximaal 20%) van de voedselveldjes overzien. De via veldobservaties of cameravallen eventueel vastgestelde aanwezigheid van zomertortels op voedselveldjes is een duidelijke indicatie dat die voldoen als foerageergebied, maar vormt op zichzelf nog geen bewijs dat zomertortels de voedselveldjes verkiezen boven andere foerageerlocaties. Om meer inzicht in te krijgen in het relatieve belang van voedselveldjes, werden in 2022 en 2023 in beide studiegebieden twee zomertortels met een datalogger uitgerust (2 jaar x 2 onderzoeksgebieden x 2 tortels per gebied per jaar: 8 tortels in totaal). Deze dataloggers registreerden met een regelmatig interval de positie van de vogels met een nauwkeurigheid van 15 meter. De posities werden intern opgeslagen in de zender en vervolgens op afstand uitgelezen door een zogenaamd '*base station*' welke permanent in het veld aanwezig was. Daarvoor was wel een vereiste dat de gezenderde vogels binnen het bereik van het *base station* kwamen, ofwel binnen een tot maximaal 5 km. De dataloggers verzamelden locatiegegevens volgens een dag- en nachtschema. Het dagschema liep van 6.00 tot 22.00 uur. Mits de batterij volledig was opgeladen werd in dit tijdbestek elke 30 minuten één positie vastgelegd, bij een lagere batterijstatus elk uur of zelfs elke vier uur. Om batterijcapaciteit 's nachts zoveel mogelijk te sparen was de gegevensverzameling tijdens het nachtschema beperkt tot één positie per 2 uur of per 4 uur. Dit werd voldoende geacht om aan te geven waar duiven overnachtten. Alle vastgelegde posities van een zendervogel over een heel seizoen geven een gedetailleerd inzicht in het ruimtegebruik van de betreffende vogel, inclusief de locaties waar deze foerageert.

Resultaten

Voedselveldjes en beheer

In het voorjaar van 2021 zijn vier voedselveldjes in het onderzoeksgebied 'Oostkapelle' gestart en twee in het onderzoeksgebied 'Westkapelle' (Tabel 1). In het voorjaar van 2022 zijn nog twee voedselveldjes toegevoegd in Oostkapelle en één in Westkapelle. Eén veldje in het onderzoeksgebied 'Westkapelle' is na het groeiseizoen van 2022 - wegens een probleem met almaar terugkerende goudsbloem - voortijdig uit het onderzoek gehaald, de andere veldjes hebben tot en met 2023 in het veld gelegen.

In het pilotjaar is op het 'voorjaarsdeel' van elk voedselveldje een mengsel ingezaaid. Het mengsel werd in rijen gezaaid met een rijenafstand van 50 cm en een zaaidichtheid van 10 kg per ha. In juni bleken de voedselveldjes te hoog en te dicht te groeien. Oorzaken waren enkele hoog opgroeiende *Brassica* soorten in het mengsel (mosterd, koolzaad) en een te hoge zaaidichtheid. In het najaar van 2021 zijn de najaarsdelen van de voedselveldjes ingezaaid. Voor deze najaarsinzaai zijn zowel mengsel (*Brassica* soorten weggelaten) als zaaimethode (na elke 3 rijen werd een strook van 2 meter niet ingezaaid) als zaaidichtheid (verlaagd naar 7.5 kg per ha) aangepast. Ondanks dat door misverstanden in de communicatie de voorgeschreven methode in de praktijk niet overal werd gevolgd, hadden de verminderde zaaidichtheid, het kleinere aantal ingezaaide rijen en de gewijzigde mengselsamenstelling een positieve uitwerking op de vegetatiestructuur in het volgende voorjaar. Toch groeiden ook deze veldjes, met dominant aanwezig vooral rode klaver, wikke en kamille, in de loop van het voorjaar van 2022 te hoog en te dicht op.

Bij de inzaai van enkele aanvullende voedselveldjes (veldjes G, H en I) in het voorjaar en najaar van 2022 is dezelfde zaaimethode gebruikt als in het najaar van 2021, die dit keer ook in de praktijk werd opgevolgd. De gebruikte zaaidichtheid in het voorjaar was 7.5 kg per ha, in het najaar was dit 5 kg per ha. In het voorjaarsmengsel werden de aandelen van enkele grassen en rode klaver verlaagd, waardoor het aandeel van enkele laagblijvende soorten (akkerviool, boekweit, rolklavers) navenant toenam. Ook werd het laagblijvende en vroeg bloeiende winterpostelein aan het mengsel toegevoegd. Uit het najaarsmengsel van 2022 werden de grassen volledig verwijderd, zodat het mengsel volledig bestond uit laagblijvende een- en meerjarige kruiden.

Alle gebruikte mengsels overziende waren de laagblijvende soorten daarin vooral akkerviool, winterpostelein, spurrie, hopklaver en kleine klaver. De (te) hoog opgroeiende soorten waren koolzaad, raapzaad, gele mosterd, wilde rogge en voederwikke, met de kanttekening dat laatgenoemde soort eerder kruipt en klimt in plaats van eigenstandig omhoog groeit. Van de vijf hoog groeiende soorten is voederwikke de enige die in de in de loop der tijd aangepaste mengsels behouden bleef, alhoewel het procentuele aandeel ervan gaandeweg aanzienlijk is verlaagd.

Beheer van de voedselveldjes

In het pilotjaar is in de voedselveldjes geëxperimenteerd met schoffelen, maaien, klepelen, eggen en frezen. In alle veldjes werd in het eerste groeiseizoen schoffelen tussen de rijen toegepast. Schoffelen verwijderde de spontane onkruiden tussen de rijen en zorgde ervoor dat het ingezaaide mengsel de kans kreeg om te ontkiemen en concurrenten de baas te blijven. Schoffelen was echter alleen een korte periode na inzaai een optie, namelijk zolang de vegetatie nog laag was. Om later in het seizoen toch voldoende kale grond en een gelaagde vegetatiestructuur te krijgen werd in het pilotjaar maaien en klepelmaaien ingezet. Hierbij werden stroken van 3 meter breed tot grondniveau gemaaid, met aan weerszijden eveneens 3 meter brede stroken die tot 15-20 cm werden gemaaid. Hoewel dit tijdelijk resulteerde in een open en gevarieerde vegetatiestructuur met een verscheidenheid aan soorten, werd de vegetatie al snel weer te hoog om geschikt te zijn voor zomertortels, waardoor binnen 2 weken alweer beheer nodig was. Daarom werd al in het pilotjaar overgestapt op eggen en ondiep frezen. Dit gebeurde in opeenvolgende beheerrondes alternerend in de lengterichting en in de breedterichting. Deze werkwijze resulteerde erin dat er in elk veldje plekken met oude/hoge vegetatie met rijpend zaad aanwezig waren, plekken met nieuwe groei en plekken zonder vegetatie. Na met wisselend succes experimenteren met maaien, eggen en frezen in het pilotjaar, werd besloten dat ondiep eggen of frezen de beste opties waren voor het verkrijgen van voldoende openheid en kale grond, omdat het ervoor zorgde dat de bewerkte stroken langer (> 3 weken) open en kaal bleven.

In 2021 en 2022 is ook geëxperimenteerd met verschillende breedtes van kale stroken. Aanvankelijk waren die kale stroken te smal, wat leidde tot een ‘tunneleffect’, waarbij de ingezaaide rijen aan weerszijden van de kale stroken een ‘muur’ van vegetatie vormden. Dit resulteerde in een vegetatiestructuur die ongeschikt werd geacht voor zomertortels. De breedte van de kale stroken werd daarom vergroot tot 2-3 meter, afgewisseld met smallere begroeide stroken van 1 meter breed. Dit leek de beste verhouding om een meer open vegetatiestructuur in de veldjes te krijgen. Een neveneffect van het door eggen of frezen vergroten van het percentage kale grond tot 60-70% was dat het ongeveer vier weken duurde voordat opnieuw beheer nodig was. Grondeigenaren hoefden daarom minder vaak gevraagd te worden om in de voedselveldjes beheer uit te voeren.

Geschiktheid van voedselveldjes voor zomertortels

De geschiktheid van voedselveldjes voor zomertortels is bepaald op basis van drie criteria: het percentage kale grond, de hoogte van de vegetatie en de aanwezigheid van zaden. Elk van deze criteria is elk jaar om de twee weken in de voedselveldjes gemeten. Op basis van deze metingen in combinatie met foto’s van de veldjes werd een veldje beoordeeld als geschikt, gedeeltelijk geschikt of ongeschikt. Veranderingen in de (on)geschiktheid van voedselveldjes in de loop van de tijd zijn weergegeven in 'geschiktheidsdiagrammen'. Figuur 10 & 11 zijn voorbeelden van dergelijke geschiktheidsdiagrammen voor het voorjaarsdeel van veldje G en veldje B, met een uitleg waarom beide veldjes op enig moment als geschikt, gedeeltelijk geschikt dan wel ongeschikt werden beoordeeld. Dergelijke geschiktheidsdiagrammen zijn gemaakt voor alle veldjes.

In de praktijk varieerde de geschiktheid van de veldjes sterk. Sommige veldjes boden gedurende een flink deel van het seizoen ogenschijnlijk geschikt foerageergebied, vooral ook als er op tijd beheer was uitgevoerd. Andere veldjes werden een groot deel van het seizoen als ongeschikt beoordeeld. Redenen daarvoor liepen uiteen van niet of te laat uitgevoerd beheer tot problemen met duist, kweek en goudsbloem als voorgaande teelt die de kop op bleef steken en het ingezaaid mengsel volledig wegdrukte. De belangrijkste bevindingen voor wat betreft de geschiktheid van de voedselveldjes voor zomertortels zijn de volgende:

1. In het eerste jaar produceerden de in het voorjaar ingezaaide veldjes pas zaden vanaf juni. Dat betekent dat deze veldjes in het eerste jaar op zijn vroegst vanaf half juni geschikt foerageerhabitat kunnen bieden. In de herfstveldjes waren al in mei zaden aanwezig, wat betekende dat deze velden al geschikt waren zodra er in het voorjaar voor het eerst beheer was uitgevoerd. Na het eerste jaar was er weinig verschil tussen voorjaars- en najaarsveldjes: als ze vroeg in mei worden beheerd, kunnen beiden al vroeg in het seizoen geschikt foerageergebied voor zomertortels bieden.

2. De beschikbaarheid van zaden is meestal niet de beperkende factor voor de geschiktheid van een veldje, maar de aanwezigheid van voldoende kale grond. Zodra kale stroken door de vegetatie waren geëgd, boden de veldjes in alle gevallen ogenschijnlijk geschikt foerageergebied.

3. Zoals uit de geschiktheidsdiagrammen blijkt, is tijdig beheer essentieel voor het handhaven van de geschiktheid van percelen voor zomertortels. Na beheer kon een voedselveldje wekenlang achtereen geschikt foerageerhabitat voor tortels bieden. Maar ook: te lange tijd tussen beheermomenten zorgde ervoor dat veldjes snel overwoekerden en ongeschikt raakten.

4. Eggen en frezen levert aanzienlijk betere resultaten op dan maaien.

Gebruik van voedselveldjes door zomertortels

In de jaren 2021-23 werden in totaal 25 bezoeken van zomertortels aan voedselveldjes geregistreerd. Hiervan zijn er 13 geregistreerd via cameravallen, 11 via de zendervogels en één tijdens de veldbezoeken (Appendix 14). Alle registraties hadden betrekking op slechts drie velden (C, E, G), waarbij 15 van de 25 registraties afkomstig zijn van veld G in juli 2023. De enige veldwaarneming van een zomertortel tijdens de veldbezoeken vond plaats in 2021 in veldje C kort na inzaai. Van de 13 registraties met cameravallen waren er vier in 2021, één in 2022 en acht in 2023. Van de 11 registraties van zendervogels vonden er drie plaats in 2022 en acht in 2023. Alle geregistreerde bezoeken van zendervogels aan voedselveldjes hadden betrekking op veld G. Bij zendervogel Ina is sprake van meerdere bezoeken aan veld G op één dag. Vier van de vijf registraties in 2021 vonden plaats in de tweede helft van mei op veld C (Appendix 14). Omdat dit veldje toen nog maar kort was ingezaaid en er nog geen zaden aanwezig waren, hielden deze registraties geen verband met de kwaliteit van het voedselveldje zelf.

In 2022 en 2023 werden meerdere bezoeken geregistreerd aan veld G, wat suggereert dat de combinatie van locatie en geschiktheid als foerageerhabitat hier ‘klopte’. In 2022 hebben drie van de vier registraties in veld G afkomstig betrekking op zenderduif Paulina. Uit haar zendergegevens weten we dat ze rond half augustus op 150 m afstand een nest met bijna uitgevlogen jongen had. In 2023 zijn acht registraties in veld G in de periode 9-12 juli van zenderduif Ina. Op dat moment was Ina op een afstand van circa 850 m net begonnen aan een tweede nest na het mislukken van een eerste nest. Hoewel de cameravalgegevens geen individuele identificatie mogelijk maken, is de kans groot dat ook de cameraval-registraties in veld G betrekking hadden op Paulina en Ina of hun partners. De waarnemingen van Paulina en Ina op voedselveldje G, beide met min of meer nabijgelegen nesten, suggereren dat de afstand tot nestplekken een belangrijke factor zou kunnen zijn die het wel of niet benutten van voedselveldjes door de zendertortels bepaalt. Toch zijn er ook veldjes die niet bezocht werden, maar waar zich wel één of soms zelfs twee territoria van zendertortels op minder dan 1 km afstand bevonden. Behalve voor veld G gold dit ook voor de veldjes A, C en F. Dit wijst erop dat afstand tussen voedselveldje en nestplaats niet de enige verklaring is voor het al dan niet gebruiken van een voedselveldje.

Het overgrote deel van de registraties (17 van 20) in veld G vond plaats in de week volgend op beheer. Dit illustreert hoe cruciaal het beheer van de veldjes is voor instandhouding van een geschikte vegetatiestructuur en voor het beschikbaar maken van zaden. Het is verder opmerkelijk dat veld G in 2023 vooral bezocht werd in een vrije kort tijdsbestek in juli en niet in de maanden mei, juni en augustus. Dit ondanks het feit dat het veld ook in die maanden als geschikt werd beoordeeld.

Andere foerageerlocaties

Als de tortels maar weinig gebruik hebben gemaakt van de voedselveldjes, rijst de vraag waar tortels dan wel naar voedsel hebben gezocht. Hiertoe is specifiek gekeken naar de foerageerlocaties van de gezenderde tortels. Deze zijn bepaald door allereerst de dataset te verfijnen en alle datapunten in bomen, heggen en op gebouwen en alle ’s nachts verkregen datapunten buiten beschouwing te laten. In de resterende set datapunten werden vervolgens de foerageerlocaties bepaald als clusters van punten met hetzelfde landgebruik, geregistreerd bij meerdere gelegenheden (>5 datapunten) en verspreid over meerdere dagen (>2 dagen). In totaal konden op deze wijze circa 10-15 foerageerlocaties per zendertortel worden vastgesteld. Opgeteld over beide jaren en alle zendertortels tezamen gaat het om 83 foerageerlocaties. Vervolgens werden deze foerageerlocaties gekoppeld aan het landgebruik op de foerageerlocaties. De indeling in landgebruikscategorieën werd gebaseerd op de in het Engeland gebruikte categorieën, maar is aangepast naar voor zomertortels relevante landgebruikskenmerken. Uiteindelijk werden 15 landgebruikscategorieën onderscheiden. Figuur 21 geeft de verdeling van de 83 foerageerlocaties over de 15 landgebruikscategorieën weer. Figuur 23 geeft voor elke landgebruikscategorie aan op welke dagen van het jaar er coördinaten van zendertortels in werden geregistreerd. Het grootste aantal foerageerlocaties had betrekking op landbouwgewassen (*n*=23; 28%). In afnemende volgorde van belangrijkheid waren andere veel gebruikte foerageerlocaties boerderijcampings (*n*=15; 18%), boerderijerven (*n*=11; 13%), duinen (*n*=9; 11%) en vakantieparken (*n*=4; 5%) (Figuur 21). Foerageerlocaties in gewassen had in driekwart van de gevallen betrekking op geoogste gewassen (stoppels), vooral van tarwe. Boerderijerven, boerderijcampings, duinen en landelijk gelegen (volks)tuinen werden gedurende het gehele broedseizoen geregeld bezocht, maar boerderijcampings en duinen werden veel vaker bezocht (Figuur 23). Gewassen en vakantieparken werden aan het begin en einde van het broedseizoen maar weinig bezocht, maar bijna dagelijks in augustus respectievelijk juli en augustus. Boerderijcampings en sommige van de vakantieparken op Walcheren doen enigszins denken aan het kleinschalige landschap dat de voorkeur geniet van zomertortels. Hier zijn onder andere aanwezig parkeerplaatsen, onkruidrijke bermen en speeltuinen, zones met ijle, grazige vegetaties, hagen, bomen en struikgewas en klaverrijke gazons. Boerderijcampings werden gedurende het hele broedseizoen bijna dagelijks gebruikt om te foerageren, wat suggereert dat ze een stabiele bron van voedsel boden. Dit zou kunnen verklaren waarom boerderijcampings en vakantieparken ondanks de aanwezigheid van vakantiegangers zo 'populair' zijn bij tortels. Vier verschillende zendertortels bezochten twee verschillende pluimveebedrijven. Van één van deze bedrijven is bekend dat er op het erf bedrijf wordt bijgevoerd. Ook is hier een mestsilo aanwezig waar droge pluimveemest van het bedrijf wordt opgeslagen en waarvan bekend is dat deze silo veelvuldig wordt bezocht door zomertortels. De tortels komen hier af op de restanten van pluimveevoer dat in de mest aanwezig is. In 2022 bezochten drie verschillende zendertortels vier melkveehouderijbedrijven. Net als bij de pluimveebedrijven waren datapunten op deze locaties geclusterd rond specifieke delen van de boerderijen, waaronder onkruidrijke erfhoeken, zones met gemorst kuilvoer en open sleufsilo's met ingekuilde maïs. Het is verder opvallend dat de zendertortels relatief weinig gebruik hebben gemaakt van de aanwezige drie bijvoerplekken. Anekdotische informatie wijst erop dat tortels vooral in de eerste helft van het broedseizoen (mei, juni) van de bijvoerplekken gebruik maken en dat dit daarna afneemt. In juni was het niet ongewoon om dagelijks meerdere duiven samen te zien foerageren, terwijl bezoeken van tortels aan bijvoerplekken in de loop van juli sporadischer werden. Mogelijk is het gebruik van bijvoerplekken door zendertortels deels gemist, omdat de zendertortels pas na circa 10 juni en in sommige gevallen nog wat later – overigens op bijvoerplekken – konden worden gevangen en gezenderd.

Een van de redenen waarom tortels relatief weinig van de voedselveldjes gebruik hebben gemaakt is vermoedelijk gelegen in het feit dat die een deel van de tijd ongeschikt zijn geweest voor foeragerende zomertortels. Dit speelde vooral in het eerste (pilot)jaar van het onderzoek. De vraag is of de uitkomsten anders zouden zijn geweest als we van begin af aan het beheer van de voedselveldjes onder de knie hadden. Tegelijkertijd is het ook zo dat er voedselveldjes waren die een groot deel van de tijd geschikt werden geacht voor foeragerende zomertortels, maar waar desondanks geen tortels werden geregistreerd. Dit betreft specifiek veld C in 2022 en de velden A en E in zowel 2022 als 2023. Veld E was in beide jaren 'het beste veldje', met voor het grootste deel van het broedseizoen ogenschijnlijk geschikt foerageerhabitat. Mogelijk zijn er ook andere en vooralsnog onbegrepen factoren in het spel die een rol spelen bij het al dan niet gebruiken van de voedselveldjes door tortels. Hiertoe behoren de aanwezigheid van predatoren en locatiespecifieke landschapskenmerken rondom elk voedselveldje. Een andere mogelijkheid is dat er voldoende alternatieve voedselbronnen in de omgeving aanwezig waren, waardoor er minder noodzaak was om de voedselveldjes te bezoeken. Het veelvuldig gebruik van boerenerven en campings, waar ogenschijnlijk in overhoekjes volop grassen en onkruiden aanwezig zijn, wijst hier op. Verder is vermeldenswaardig dat veld G af en toe werd bezocht, ondanks dat er 'naast de deur' in een tuin specifiek tortels worden bijgevoerd. In 2022 is zendertortel Paulina 18 keer foeragerend in deze tuin geregistreerd, terwijl ze maar drie keer is geregistreerd in veld G. Zendertortel Ina daarentegen werd in 2023 nooit in de tuin geregistreerd, maar wel acht keer op veld G. De redenen voor deze opmerkelijke verschillen tussen individuele vogels zijn onduidelijk, maar het geeft wel aan dat voedselveldjes ook in de aanwezigheid van 'makkelijk voedsel' nog steeds een rol kunnen spelen in de voedselvoorziening van zomertortels.

Conclusies

In dit onderzoek is aanzienlijke vooruitgang geboekt bij het bepalen van voor voedselveldjes geschikte zaadmengsels en effectieve methoden voor inzaai en beheer van die voedselveldjes. Hoewel de voedselveldjes diverse soorten zaadetende vogels en andere dieren hebben aangetrokken, is het gebruik ervan door zomertortels beperkt gebleven. Voor een deel kan dit worden verklaard door een voor tortels ongeschikte vegetatiestructuur in de voedselveldjes gedurende een deel van de tijd. Uit het onderzoek kunnen de volgende conclusies getrokken worden:

- Het is mogelijk om voedselveldjes aan te leggen die voldoen voor tortels en die bijdragen aan hun voedselvoorziening.
- Voedselveldjes zoals getest in dit onderzoek bleken niet de eerste keuze van tortels.
- Er is potentieel voor verdere verbetering van het beheer van voedselveldjes.
- Voedselveldjes hebben potentieel om tijdens het broedseizoen een stabiele voedselbron te bieden, als aanvulling op bestaande voedselopties.
- Beheer van de voedselveldjes in een landbouwcontext vereist flexibiliteit die verder gaat dan een gestandaardiseerde aanpak.
- Verder onderzoek naar alternatieve methoden voor aanleg en beheer van voedselveldjes en andere stabiele alternatieve voedselbronnen, ook buiten de landbouw, is nodig. Daarbij dient ook de invloed van de afstand van voedselveldjes tot nesten en territoria en de invloed van andere landschapskenmerken op het gebruik van voedselveldjes meegenomen te worden. De voorkeuren voor landgebruik die de zendertortels hebben laten zien kunnen daarbij als leidraad fungeren. Hun constante aanwezigheid op kleine campings maakt het bijvoorbeeld de moeite waard om foerageerstroken op juist deze locaties te realiseren.

Vanwege bovenstaande vragen rondom beheer en effectiviteit van voedselveldjes zijn deze nog niet klaar voor opschaling in de praktijk.

Verder bracht dit onderzoek ook een aantal interessante inzichten in het gedrag van tortels aan het licht. Tortels maken gedurende het seizoen gebruik van een verscheidenheid aan voedselbronnen. Zelfs in het geval dat speciaal aangelegde voedselveldjes een belangrijke voedselbron zouden vormen, dan nog zullen tortels ook andere foerageerlocaties benutten. Daarbij worden de voorkeuren van tortels voor foerageerlocaties gestuurd door de beschikbaarheid van voedsel, met een voorkeur voor boerenerven in het vroege voorjaar en voor stoppels van geoogste gewassen vanaf het midden van de zomer. Kleinschalige terreinen met menselijke activiteit en verhardingen worden bepaald niet gemeden door tortels, maar als deze locaties worden gebruikt, zijn ze altijd landelijk gelegen en zijn er altijd bomen, hagen en grazige, niet-intensief beheerde vegetaties aanwezig. De op Walcheren aanwezige boerderijcampings lijken bijzonder aantrekkelijk voor tortels en bieden waarschijnlijk een betrouwbare bron van voedsel gedurende het hele broedseizoen.

CHAPTER 1: Introduction

1.1 Background

Despite increasing uptake of agricultural management schemes to benefit farmland birds, European turtle doves (*Streptopelia turtur*, European turtle dove) are still disappearing from our landscape. Since the 1970s, their population has plummeted across West Europe; the Netherlands has seen a 97% population decline. They are now a vulnerable Red List species.

The European Commission supported the development of the International Single Species Action Plan for the European Turtle Dove (Fisher *et al*, 2018). It identified key contributors to their population decline and outlined a series of actions that countries will need to undertake to protect the species. The need for National Conservation Strategies and agri-environment measures that benefit European turtle doves (Action 1.2.1) was considered an 'essential' and 'immediate' Action. Other Actions highlighted the need to "improve our knowledge of turtle-dove habitat selection and dietary needs" (Action 7.4.1).

> "Put in place and further develop national agri-environment packages that create or maintain seed-rich habitats within the species' current *or recent range*. This may include bespoke seed packages that provide specific plant species that turtle-dove are known to feed on. "
>
> **Action 1.2.1.1**
> **International Single Species Action Plan for the European Turtle Dove**

Research in the UK indicates that food shortages caused by habitat loss could be one of the main drivers in the decline of European turtle doves. As exclusive seed-eaters, their diet was historically dominated by the seeds of agricultural weeds such as *Fumaria officinalis* (Murton et al, 1964; Browne & Aebischer, 2003). Small-scale agricultural landscapes were full of field borders and hedges, making it rich in flowering weeds and nesting opportunities. Recent advancements in farming efficiency across Europe have included greater weed and pest control, larger field size, the loss of field edges, and the removal of hedges and scrub (Figure 1). The small-scale landscapes rich with feeding and nesting opportunities have become increasingly scarce and have caused difficulties for many farmland birds relying on them.

Research in 2003 (Browne & Aebischer, 2003) revealed a dietary shift in European Turtle Doves, from wild seeds to cultivated-seeds, the timing of which coincides with this recent loss of natural, seed rich habitats and arable plants (Storkey, Meyer, Still, & Leuschner, 2012). Browne & Aebischer (2004) suggest that this dietary shift might be linked to decreased food availability during the breeding season, as a result of these agricultural changes.

In the Netherlands, a recent demographic analysis of the Turtle Dove population revealed that a reduced number of clutches per breeding season is a primary driver of the decline, which is associated with a large-scale degradation of foraging habitat (De Vries *et al*, 2022). This is in line with findings from studies in the UK. It this appears that the key to improving the situation on the Western European breeding grounds for Turtle Doves is to ensure the provisioning of foraging habitat of sufficient quality.

1959 Kruiningenpolder, Zeeland 2019

Fig. 1. Arial photos of Kruiningen Polder in Zeeland, the Netherlands, taken in 1959 and 2019 illustrate the landscape changes that have taken place in Zeeland.

Fig. 1. Luchtfoto's van de Kruiningenpolder in Zeeland, Nederland, gemaakt in 1959 en 2019, tonen de landschapsveranderingen die in Zeeland hebben plaatsgevonden.

The provisioning of seed for turtle doves in the UK is currently encouraged by Operation Turtle Dove by suggesting either the planting of a bespoke seed mix or by allowing natural regeneration of non-agricultural vegetation (often considered 'weeds' in agriculture). Rotational cutting and scarifying of plots are used to maintain a low and open vegetation structure, and the aim is to have seed available in May, when the doves return from their wintering grounds. In addition, experimental measures are currently being tested to further improve the existing recommendations, with GPS-tracking research on individual birds started in 2021.

Given the similarities between British and Dutch climate and agricultural advancements, we expect food shortages to be a similar issue in the Netherlands. This theory is strongly supported by research carried out in the Zak van Zuid-Beveland, Zeeland in 2019 – 2020, in which the daily movements of five European Turtle Doves were followed in detail using telemetry (Vreugdenhil-Rowlands, 2021). Foraging site selection appeared to reflect seed availability. Upon their return from Africa in the spring, the doves foraged in areas where human actions coincidentally increased seed availability, such as a grass seed factory, small holdings, poultry runs and farmyards with open feed silos. These foraging areas were gradually replaced in June/July by marginal, weed-rich areas such as roadsides, unpaved paths and edges and corners of fields and orchards. With the start of harvest, the turtle doves abandoned these areas in favour of newly harvested cereal fields or fields of other crops such as poppy seed.

Furthermore, the research showed that they appeared not to use any existing field borders (such as those created through Dutch agri-environmental scheme "agricultural nature and landscape management" (ANLb) measures). Turtle dove foraging habitat is typically characterised by a sparse, low and open vegetation structure, rich in seeds that are available throughout the breeding season. The vegetation of existing measures appears too tall and dense for turtle doves. Consequently, a new field measure needs to be developed to provide suitable foraging habitat, or else an existing ANLb measure must be adjusted to meet turtle dove requirements.

Many Dutch field borders can be rather tall and dense

Suitable foraging habitat: low, sparse vegetation

1.2 Project aims

The two primary aims of this project were (1) to identify an agri-environmental measure providing suitable foraging habitat for European turtle doves and gain experience with its management, and (2) to investigate their effectiveness in supporting European turtle doves.

This research should lead to concrete management recommendations regarding the establishment and management of feed plots for turtle doves, which could be taken up in the Dutch agri-environment system (ANLb), on condition that there is proof that these feed plots support turtle doves. In this way, effective management measures can be rolled out nationally in areas where turtle doves still breed, increasing their food availability and ultimately contributing to halting the decline of turtle doves in the Netherlands.

To achieve these goals, we formulated the following objectives:

- Test bespoke seed mixes to identify the most suitable combination of species to provide ripe seed in test plots throughout the breeding season.
- Investigate the impact of different sowing moments (spring sowing vs autumn sowing) in providing suitable foraging habitat.
- Test management methods to create and maintain a vegetation structure suitable for turtle doves.
- Investigate the extent of test plot use by local turtle doves.
- Compare the use of test plots relative to alternative sources of food.

The first year of this project (2021) was a pilot year. By the end of 2021 the aim was to have:

- The first landowners 'on board'.
- Fine-tuned an initial bespoke seed mix.
- A method for field management.
- A protocol for effectively monitoring field success in terms of suitability for and actual use by turtle doves.

In the second and third years, we aimed to have foraging plots (autumn and spring sown) operational and being monitored, and the daily movements of eight European turtle doves being mapped using telemetry (four doves in both years), in order to build up a picture of their foraging habitats and preferences.

CHAPTER 2: Methods

2.1 Study areas

With the turtle dove population in the Netherlands being rather fragmented, the province of Zeeland provided a suitable location for this research project, being one of the remaining strongholds for the population. It's estimated that 19% (115 - 175 breeding pairs) of the remaining Dutch turtle dove population is currently found in Zeeland (Sovon Vogelonderzoek Nederland, 2018-2020).

This research was carried out in two study areas on Walcheren: one in the west between Westkapelle and Zoutelande, and the other in the north between Oostkapelle and Serooskerke (Figure 2). One of the considerations when selecting appropriate study areas was to ensure that test plots had the best chance of being appropriately situated. Vreugdenhil-Rowlands (2021) found that turtle doves were flying up to 5 km away to forage, and suggested that doves with active nests might be foraging much closer to home (predominantly within 1 km). With this in mind, and combined with the low population density of turtle doves on Walcheren, the study areas were selected based on turtle dove territories in 2020. Both study areas were approximately 550 ha, and the aim was to spread the test plots as evenly as possible across the study areas.

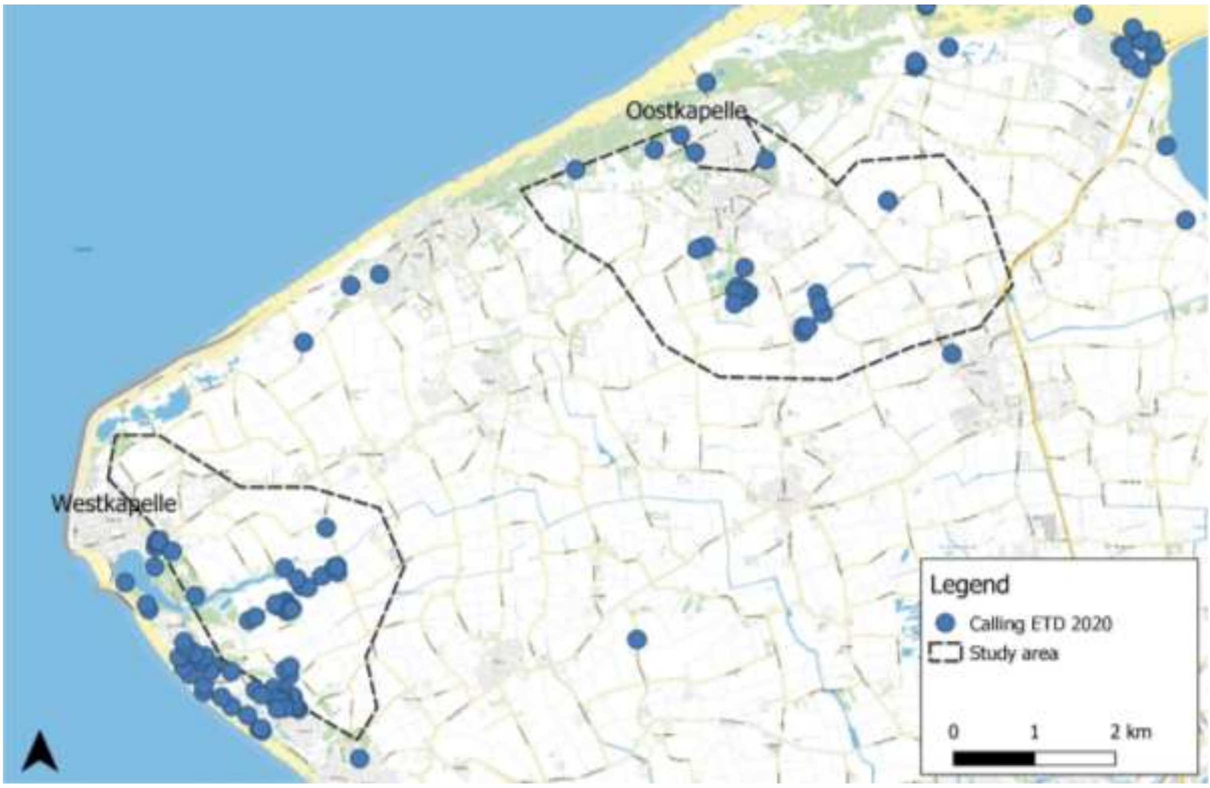


Fig. 2. Study areas Westkapelle and Oostkapelle: based on records of singing turtle doves recorded on waarneming.nl in 2020.

Fig. 2. Onderzoeksgebieden Westkapelle en Oostkapelle: gebaseerd op waarnemingen van zingende zomertortels geregistreerd op waarneming.nl in 2020.

2.2 Field location and set up

In spring 2021, five landowners joined the research project, providing four fields in Oostkapelle and two fields in Westkapelle (Table 1, Figures 4 and 5). Three more fields were added to the study in 2022, two in Oostkapelle and one in Westkapelle. In 2023, one field in Westkapelle was taken out of the project. Fields were accepted into the project based on their size, and their proximity to suitable nesting habitat, water and territorial turtle doves in 2020.

Table 1. Summary of participating fields.
Tabel 1. Overzicht van de deelnemende velden.

Field Code	Study Area	Growing seasons	Size (ha)
A	Westkapelle	2021 - 2023	0.27
B	Westkapelle	2021 - 2022	0.26
C	Oostkapelle	2021 - 2023	0.26
D	Oostkapelle	2021 - 2023	0.52
E	Oostkapelle	2021 - 2023	0.28
F	Oostkapelle	2021 - 2023	0.33
G	Oostkapelle	2022 – 2023	0.25
H	Oostkapelle	2022 – 2023	0.25
I	Westkapelle	2022 – 2023	0.60

The average field size was 0.34 ha (range: 0.25 – 0.6 ha) and field shape and size were dependent on the area available (full details in Appendix 1). Each field was divided in half, creating 2 smaller test plots – 1 plot for the spring sown seed mix; the other for the autumn sown seed mix (Figure 3). A 9m wide strip of characteristically unsuitable habitat for turtle doves (either overgrown or completely bare) divided the 2 plots. This strip was included as a way to compensate for GPS accuracy limitations of any tagged doves that should visit the fields: it allowed us to determine whether a dove visited the spring or autumn sown plot.

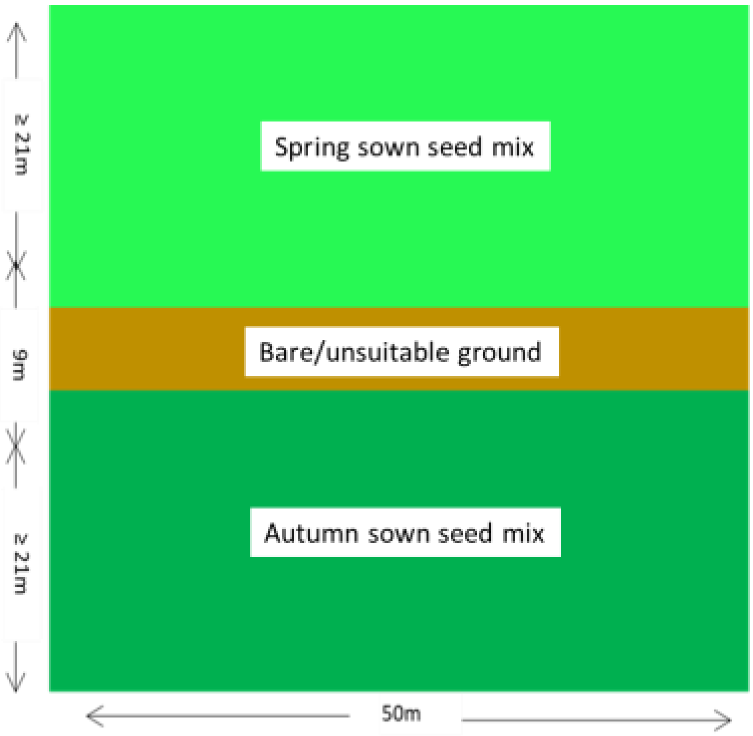


Fig. 3. Test field set up for a regular shaped field.
Fig. 3. Schematische indeling van de voedselveldjes.

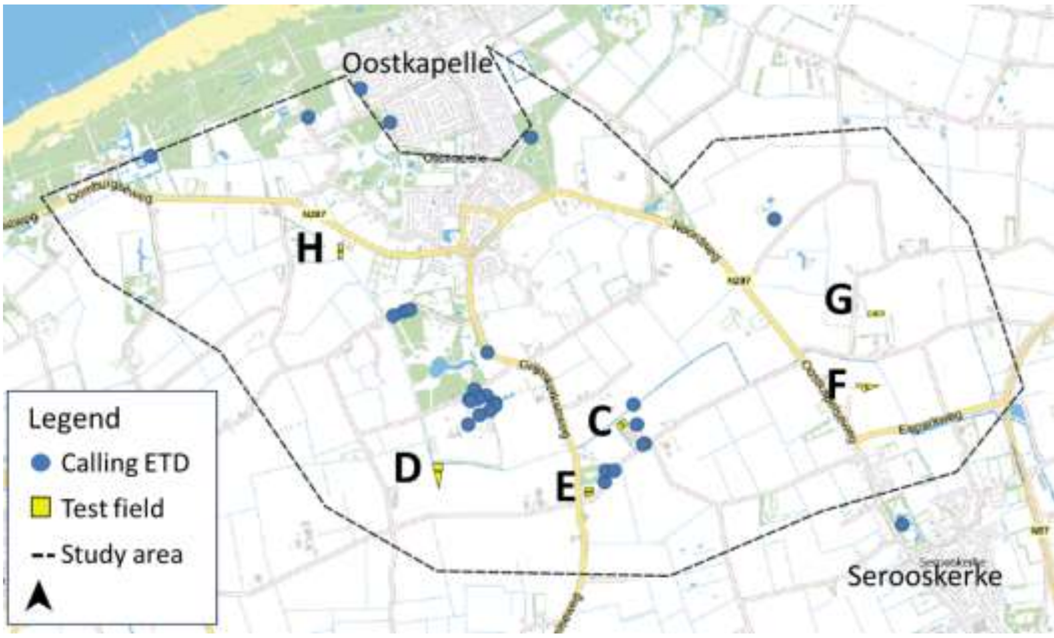


Fig. 4. Participating fields in Study Area Oostkapelle (territorial turtle doves recorded in 2020 indicated in blue).
Fig. 4. Deelnemende velden in het onderzoeksgebied Oostkapelle (territoriale zomertortels waargenomen in 2020 aangegeven in blauw).

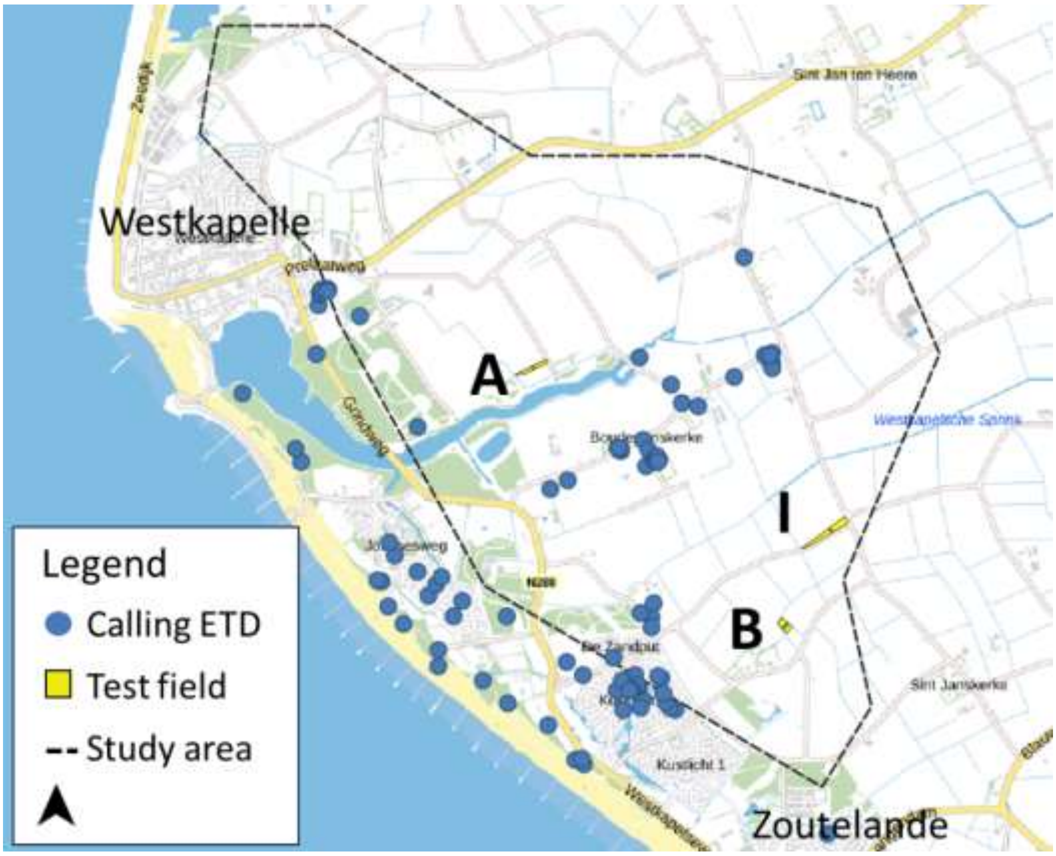


Fig. 5. Participating fields in Study Area Westkapelle (territorial turtle doves recorded in 2020 indicated in blue).
Fig. 5. Deelnemende velden in het onderzoeksgebied Westkapelle (territoriale zomertortels waargenomen in 2020 aangegeven in blauw).

2.3 Seed mixes

Based on previous turtle dove dietary research, a list of species was compiled and used as the basis for the first test seed mix. The seed mix included a combination of grass, herb and cultivated species, and was dominated by annual species that set seed and return each year.

The spring seed mix used in 2021 ('seed mix 1') was found to grow too high; hiding and stunting the growth of more suitable, lower growing herbs and grasses. This led to substantial changes in the seed mix used in the autumn mix sown that year. Subsequent changes in seed mix were comparatively minor. Details of each mix's performance and the changes made each year are detailed in the results chapter. A complete list of the four seed mixes used during the project can be found in Appendix 2.

Once sown, none of the test plots were re-sown with their original seed mixes between growing seasons: they were sown only once, and then followed through subsequent growing seasons until the end of the project. If a seed mix didn't take on a test plot, for whatever reason, the plot was scrapped for the season and resown with the new test mix in the following sowing round (as was the case with Field H autumn test plot, Field B spring and autumn, and Field I spring and autumn test plots).

Only one test plot containing seed mix 1 was so unsuitable at the end of 2022 (it's second growing season) that it was cleared in favour of resowing and testing a different seed mix: the Field E spring test plot was cleared and resown with seed mix 4 in autumn 2023. An overview of participating plots can be found in Appendix 3, with a summary of what was sown or what happened to each test plot throughout the project.

Landowners were asked to prepare the fields by creating a false seedbed in the month/s before sowing. This technique reduces the weed seed bank in the topsoil, thereby reducing competition against the bespoke seed mix.

Sowing was done using the same farm machinery which is used for the flower picking field edges initiative ('plukbloem randen') on Walcheren. This 3 m wide machine has a cultivator mechanism on the front, meaning that cultivation of the false seedbeds and sowing of the mix could be combined in one operation. Sowing pipes were spaced 50 cm apart at the back of the machine, and each is followed by a heavy 'roller' (Figure 6).

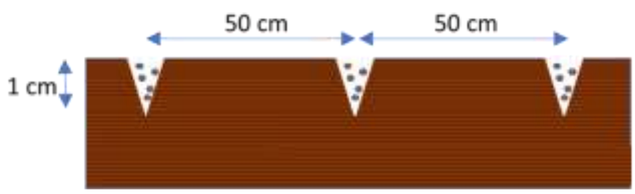


Fig. 6. Sowing method employed for flower picking fields on Walcheren.

Fig. 6. Inzaaimethode gebruikt bij plukbloemranden op Walcheren.

Spring 2021

During the pilot year, seed mix 1 was sown in early May, in rows spaced 50 cm apart, at a rate of 10 kg/ha (Figure 7). Due to an unusually wet spring, the seed mix had variable success: it either took very well (Fields C, D, F), or germinated slowly and sparsely and experienced stunted growth (Fields A and E). This was not a surprise; Fields A and E were the wettest of all participating fields.

Once growing, it was quickly apparent that this method and density, combined with a number of *Brassica* species in the seed mix, was unsuitable for turtle dove foraging habitat; fields became too dense, too quickly (photo below).

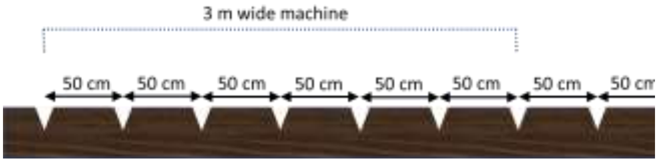


Fig. 7. Sowing method in spring 2021.
Fig. 7. Inzaaimethode voorjaar 2021.

Photo 1. Field A underwater in April 2021.
Foto 1. Veld A onder water, April 2021.

Photo 2. Field C spring plot on 1st July 2021 – too high and dense for foraging turtle doves.
Foto 2. Veld C voorjaarsveldje op 1 juli 2021 – te hoog en dicht voor foeragerende zomertortels.

Photo 3. Field E autumn sown plot, 09/05/2023. Seed mix 4 was sown in October 2022 and this photo shows that there has been recent hoeing on the unsown strips. The lack of suitable machinery to hoe between the sown rows here is clear; spontaneous weeds from the soil seed bank compete strongly with the sown seed mix, resulting in the broad green strips shown here.
Foto 3. Veld E najaarsveldje, 09-05-2023. Zaadmengsel 4 werd gezaaid in oktober 2022 en deze foto toont dat er recent geschoffeld is op de niet ingezaaide stroken. Het gebrek aan geschikte machines om tussen de ingezaaide rijen te wieden is duidelijk; spontane onkruiden uit de zaadbank in de bodem concurreren sterk met het ingezaaide zaadmengsel, wat resulteert in de brede groene stroken die hier te zien zijn.

Autumn 2021

For the following sowing moment, autumn 2021, sowing density was reduced to 7.5 kg/ha and the method adapted: 3 rows sown at 50 cm intervals, followed by an unsown 2 m strip (Figure 8).

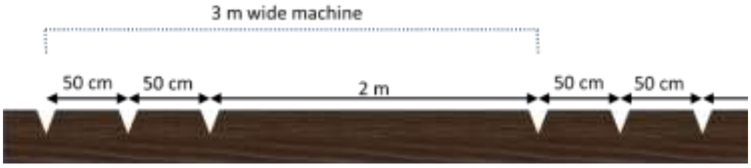


Fig. 8. Sowing method from autumn 2021.
Fig. 8. Inzaaimethode vanaf najaar 2021.

In practice, something went wrong with the communication and the autumn sown plots in 2021 presented an odd mix of sowing methods, with some being completely sown with rows spaced 1 m apart, and other plots displaying 4 rows spaced at 50 cm apart, followed by a bare/unsown strip of just 1 m. Despite these difficulties, the reduced density, fewer number of sown rows, and the changes made to the seed mix species (particularly the removal of *Brassica sp*) had a positive impact on the vegetation structure.

Spring and autumn 2022

In 2022, mixes 3 and 4 were both sown at a density of 7.5 kg/ha and 5 kg/ha respectively, using the same method as autumn 2021, this time also in practice (Photo 4). No fields were sown in 2023, as this was the last year of the project. Full details on the sowing method and density for each seed mix can be found in Appendix 4.

Photo 4. Field H spring sown test plot, 21/06/2022. Seed mix 3 was sown in March 2022 and this photo shows that there has been recent hoeing between the 3 sown rows as well as in the unsown strips.
Foto 4. Veld H voorjaarsveldje, 21-06-2022. Zaadmengsel 3 werd gezaaid in maart 2022 en deze foto toont dat er recent gewied is tussen de 3 gezaaide rijen en op de ongezaaide stroken.

2.4 Field management

The aim of managing the fields was to create a stratified vegetation structure on both test plots with plenty of bare ground (>40%) and seed producing plants from both the sown seed mix and from spontaneous weeds. The management should prevent the vegetation from becoming too tall and dense and ensure sufficient bare ground and a constant supply of fallen seed.

Before the start of this project, there were no clear guidelines for management of turtle dove foraging plots and few examples available. During the course of the project, certain techniques proved to be more effective in managing plots than others, leading to improved management of the test plots through a continuous process of trial and error.

The following techniques were tried: hoeing, mowing, flail mowing, harrowing and cultivating.

Hoeing *(Dutch: "schoffelen"/ "schoffelbalk")*: similar to a horsedrawn hoe or wheel hoe, "schoffelen" uses horizontal blades mounted together on a single frame to loosen the ground and cut weeds off at the root, causing them to dry out and die. In terms of sown seed, the area between sown rows is hewn as a way to remove any competing plants.

Mowing *(Dutch: "maaien")*: cutting down an area of vegetation to a particular height using a machine. Not suitable for particularly thick or dense vegetation.

Flail mowing *(Dutch: "klepelmaaien")*: Flail mowers differ from regular mowers in that they are designed to shred and cut much thicker vegetation (including brambles and shrubs). Vegetation is shredded by means of flails or blades attached to a rotating cylinder.

Harrowing *(Dutch: "eggen"/ "rotorkopeg")*: Rotary power harrows have multiple sets of vertical tines which till the soil horizontally (as opposed to turning the soil as a plough does). Harrows are used to break up large clods of earth and the depth of harrowing can be adjusted up to a depth of about 15 cm. They are also used to mix in crop residue and level ploughed ground.

Cultivating *(Dutch: "frezen"/ "grondfrees")*: A cultivator acts similar to a harrow, in that it is used to stir the soil horizontally, rather than turning it over (as in ploughing). It removes weeds and creates seedbeds for planting.

The strip between plots needed to be unattractive for turtle doves, to ensure that tagged doves would be unlikely to forage here. Additionally, farmers had the option to cultivate the ground when they considered it to be too overgrown with problematic 'weeds' going to seed and spreading into the surrounding crops. The strips were therefore either kept as bare as possible, through tilling or ploughing, or else allowed to grow dense vegetation.

Fields were visited every two weeks between May and mid-September to visually check on their apparent habitat suitability in terms of the percentage bare ground and the vegetation height and structure. Following field visits, the state of each test plot was discussed by researchers and the coordinating farmer, and a decision was made regarding management. If management was required, the land owner was contacted with the request and details regarding how management should happen.

During this project, the afore mentioned techniques were all tried and tested. Occasionally more drastic measures had to be taken, such as clearing a whole field and re-sowing it, or using chemicals to reduce or control certain tenacious weeds. A basic record of what management was carried out in each field was kept throughout the project.

In 2021 and 2022, management was carried out on the basis of a chain of command: test plots were visited, the visual state of each plot was discussed and, if management was required, landowners were contacted.

In 2023, landowners were given a pre-defined management plan to work to (Appendix 5). The idea was to give them more independence and the freedom to plan in management moments when they fitted alongside their existing agricultural work obligations. If successful, it would also be an indicator that a standardised management plan might be a viable option for creating foraging fields for turtle doves on a larger scale.

There were a number of advantages and disadvantages to both management approaches – each with its merits and disadvantages (summary in Appendix 6). The challenges experienced during this project are detailed further in the discussion.

2.5 Vegetation monitoring

In literature, it has been found that foraging turtle doves prefer feeding habitat which is open, sparsely vegetated, has plenty of bare ground, and has readily available seed. The typical characteristics of foraging sites have been found to have an average vegetation height of <20cm and an average of 60% bare ground (Browne and Aebischer 2003; Dunn *et al* 2015). Recommendations for the provision of turtle dove foraging habitat in the UK, through the Countryside Stewardship Agri-environment Agreement, aim to provide consistent seed availability and maintain 30 – 50% bare ground (Fisher et al, 2018), and Operation Turtle Dove recommends maintaining 30 – 60% bare ground on foraging plots, and either cultivating or else rotationally cutting vegetation to 5cm. For supplementary feeding stations, vegetation should be kept short (<15cm) and patchy. For this reason, vegetation data was collected on each factor (bare ground, vegetation height, and presence of seed) every two weeks, from May to August each year.

During the pilot year, 2021, vegetation height was measured by recording the vegetation height at ten random points on each test plot and taking the average. In subsequent years, the percentage method (below) was used in order to make results more comparable to the bare ground percentage recorded.

While the baseline methodology each year was the same, due to limited resources interns were taken on for the field season each year and given the task of vegetation monitoring in the test plots. For this reason, there are minor variations in the data collection method regarding frequency, level of detail, the number of quadrats at each plot, and the way in which seed availability was assessed. The data was made comparable across data collection years in order to assess field suitability throughout each growing season. The percentage of bare ground on each plot was averaged, and the presence (or percentage cover) of seed-bearing species was classed into three broad categories: a) seed is present, or seed-bearing species have 10-70% cover; b) seed is limited, or seed-bearing species cover 5 - 10 %; c) no seed, or seed-bearing species cover <5%. Where seed-bearing species covered more than 70% of the test plot, this indicated a decrease in habitat suitability; it indicates a plot with too little bare ground. These measurable variables were combined with field notes, photos and (where available) vegetation height to assess overall field suitability.

Method

During fortnightly visits to each test plot, a single 2 x 2 m quadrat was set up in an area that visually represented the plot. For example, if half the field appeared bare due to recent management, the quadrat should likewise contain 50% bare ground, or if a test plot had areas of particularly high or flower rich vegetation, this should be similarly represented in the quadrat.

In each quadrat the following was recorded as a percentage:

- Bare ground
- Vegetation <5 cm tall
- Vegetation 5-20 cm tall
- Vegetation 20-50 cm tall
- Vegetation > 50 cm tall
- Vegetation cover of each plant species within the sown seed mix*
- Vegetation cover of each non-sown plant species with a percentage of >5 %**
- Vegetation cover of grass species outside of the sown mix were grouped together as 'grasses'

*Where only 1 or 2 individuals were present, the percentage was taken as 0.5 %.
**Non-sown plants with a percentage cover <5 % were grouped together as 'other'.

In addition, for each species, the most advanced stage of development was noted – either green, in flower, presenting unripe seed, or presenting ripe seed.

2.6 Assessing plot suitability

Suitability diagrams for each plot, each growing season, were created in a way that combines the percentage bare ground, vegetation height and seed availability data, and uses expert judgement to assess the suitability of plots for foraging turtle doves over time.

Firstly, for all habitat surveys, *each* variable was assessed and scored for its suitability: either suitable (1), partially suitable (0.5) or unsuitable (0), using the criteria in Appendix 7. Given the scores for each of the three variables and supported by photos of how the field looked during each survey, a member of the research team combined the scores to an overall suitability score. This allowed more 'weight' to be given to the arguably more important variables of sufficient bare ground and the presence of seed.

Example 1) A plot with sufficient bare ground, but no available seed, was deemed unsuitable: foraging doves might visit but will be unable to find food.

Example 2) A plot with sufficient seed, but a dense vegetation and no bare ground, was deemed unsuitable: the seed is inaccessible to foraging doves.

Example 3) A recently managed plot with 70% bare ground, and plenty of fallen and/or accessible seed but where vegetation is strictly classified as 'too tall' for turtle doves, then the plot as a whole was still considered suitable: the large percentage of bare ground makes seed easily available to foraging doves, and the large quantity of bare ground creates the 'open' habitat preferred by foraging turtle doves.

Suitability diagrams show the changes in each plot's overall suitability score during the course of each growing season. Green indicates 'suitable' foraging habitat, orange indicate 'partially suitable' foraging habitat and red indicates 'unsuitable' foraging habitat for turtle doves.

2.7 Turtle dove monitoring

Three methods were used to monitor the use of test plots by turtle doves and other birds and animals: camera traps, field observations and GPS tagging.

Camera trap monitoring

To confirm turtle dove presence and use of test plots, camera trap monitoring was deployed. Camera trapping was also used to identify whether visits coincide with periods of 'optimal' foraging habitat on the test plots.

Browning camera traps (2021 Recon Force Elite HP4) were used as one of the monitoring methods aimed at identifying turtle doves on test plots. They were used from May to August each year of the project (Table 2). The advantage of this recording method is that it takes little time to set up and offers round the clock observations. There are however a few disadvantages to this method, some of which needed to be compensated for in the methodology. Namely, cameras provide only a partial view of the test plot, only capture foraging animals (not singing), and there's a high risk of photographing the same animal multiple times on a single day. There's also a high chance that smaller animals might not trigger the motion sensor on the camera.

In the pilot year growing season (2021) there were only 6 plots in use. Consequently, two cameras were placed on each plot, allowing for a higher intensity of monitoring in the pilot year. It also provided an opportunity to test camera range in relation to foraging bird species (distance/photo quality) and whether the fixed time intervals were a suitable method of data collection. In subsequent growing seasons, each test plot had a single camera recording animal activity.

Each camera trap was set up on a pole, approx. 50 cm – 100 cm from the ground, to reduce the chance of the camera being triggered by, for example, a plant waving in the wind. Cameras were located on the edge of plots, to reduce the inconvenience to farmers managing the field, and in an open area, to maximise the chance of capturing foraging animals. They were also placed facing north, so as to minimise overexposure from the sun on resulting images.

All cameras were configured to take a photo every 5 minutes ('timelapse' function) during daylight. In addition to timelapse, they were also configured to take additional photos when the motion sensor was triggered. No anti-theft measures were taken. Where possible, cameras were situated at locations away/hidden from roads and footpaths, and were all clearly marked with contact details and reference to this research project.

Camera recording hours/days per plot varied for various reasons (number of cameras, empty batteries, camera malfunction, data entry error), but the average recording hours per plot per day was between 14 and 17 hours.

Table 2. Summary of camera trap running time each breeding season.
Tabel 2. Samenvatting van de looptijd van de cameravallen per broedseizoen.

Year	Recording hours	Recording days	Mean recording hours/day
2021	16498	1054	16 hours/day
2022	26403	1667	16 hours/day
2023	26315	1737	15 hours/day

All camera trap images were checked manually and a record was kept of when cameras were operational, to identify any data gaps caused by malfunction, setting resets or empty batteries. To avoid counting the same bird multiple times, the daily maximum for each species was recorded. I.e.) the maximum number of birds of that species recorded on a single photo on a single day. Where male and female birds were distinguishable within a species, this was taken into account.

While turtle doves were the primary aim of camera traps, all bird species were recorded, plus mammals of particular interest. This was important because the presence of seed eating species is a good indicator of seed availability, even in the absence of turtle doves.

Field observations

Test fields were visited a minimum of once every 2 weeks from May until August. The aim of these visits was to confirm turtle dove presence on test plots so as to identify whether visits coincide with periods of suitable foraging habitat on the plot. The visitation rate of fields varied depending on manpower, which needed to be compensated for in the analyses.

The advantage of field observations over camera traps is that the whole field can be observed at once, and there's limited risk of counting an individual multiple times. Additionally, activities other than foraging can be recorded (for example singing or resting). The biggest disadvantage of this method is that it's time consuming and the visitation rate, and therefore the detection probability of birds, is often low.

In 2021 and 2022, field observations were done by project fieldworkers and by volunteers from May to September. Observations were taken using binoculars and/or telescope, from a location causing as little disturbance as possible. Observations were typically 10 – 15 minutes per field and could be carried out at any time of day. In addition, where vegetation was too high for effective field observations, project field workers would follow up by walking once through the field when changing the cameras, and make a record of any birds that were flushed out. All turtle dove observations were recorded, along with their time, behaviour and location (which test plot they were visiting). Additionally, other species of interest were also recorded. Any turtle doves observed outside of the field were also noted and recorded into the national observation database waarneming.nl.

GPS monitoring

Part of this research included the tagging of 8 turtle doves with GPS datalogger transmitters from Microsensory (Model: GPSLR-M4.5). These tags log the dove's coordinates ('data fixes') at preset intervals and have an accuracy of ±5 m (n = 1668, across 3 different locations of varying vegetation density).

The primary aim of this was to investigate the use of test plots by turtle doves, and identify whether these visits coincided with periods when foraging habitat on the plots were considered suitable for turtle doves.

The secondary aim of using telemetry was to find out whether tagged doves were indeed foraging in the vicinity of the fields. In the case that few/no turtle doves were recorded in or near the test plots, one of the factors that needed to be addressed was whether the test plots were suitably situated within the home range or territory of the tagged turtle doves.

A third but equally important aim of this tracking study was to identify each individuals preferred food source as the breeding season progressed and consider the possible factors leading to their foraging site choice.

The tags weighed ca. 4.8 g and were attached using a full body harness of 2 mm teflon tape and a crimp ring (av. weight 0.72 g). Turtle doves also received a standard leg ring with a unique number (ca. 1.18 g). Additional information on the tags and harnesses used during this project can be found in Appendix 8. For this study, the generally accepted 5% rule (that transmitters should not weigh more than 5% of the subject's weight) was applied to the *collective weight* of all tagging components (ie. the tag, harness and metal ring combined). All doves were first ringed, measured, weighed and examined before tagging, to ensure they were in good general health and limit the risk of carrying additional weight.

'Data fixes' (coordinates) were collected at predetermined intervals, and stored on the tag until the bird came within range (up to 5 km) of a so called 'base station'. At this point, the data was transferred from the tag to the base station, and was uploaded to the internet where it became available to researchers.

The pre-set data collection intervals as requested from the supplier of the dataloggers can be seen in the table below (Table 3) and, once set, these settings cannot be altered. The tags were running on a daytime schedule between 6 am and 10 pm (04:00 0 20:00 UTC) which enabled maximum data collection when the battery was fully charged (1 data fix every 30 minutes). During the 'night' schedule, the data collection was to be minimal: enough to indicate where doves were sleeping, but limited so as not to drain the solar powered battery.

Table 3. Pre-set data collection interval.
Tabel 3. Vooraf ingestelde interval voor dataverzameling.

GPS (daytime)	GPS (night)
Schedule start: 4:00 UTC	Schedule start: 20:00 UTC
Schedule finish: 20:00 UTC	Schedule finish: 4:00 UTC
Interval – battery high: 30 mins	Interval – battery high: 2 hours
Interval – battery average: 1 hour	Interval – battery average: 2 hours
Interval – battery low: 4 hours	Interval – battery low: 4 hours

Once deployed, the pre-set settings of the data loggers appeared not to match what was requested. For example, turtle dove Paulina's tag switched off completely during the night, resulting in the complete absence of roost locations for her, while another dove's tag collected a data fix every 30 minutes at night. Other doves displayed a noticeably reduced data collection during the afternoon compared to the morning, with no obvious link to the battery level. The knock-on effect of this highly irregular data collection had to be taken into account during the analysis.

Compared to camera trap and field observations, rechargeable GPS dataloggers are able to regularly and accurately pinpoint their carrier's location. The advantage of this is that it builds up a detailed picture of where an individual dove goes during the day, and provides information on which foraging sites the dove prefers at any given time during the breeding season.

Downsides of this method are that it only provides information on its carrier, whose home range may not include any test plots or who may leave the area or die shortly after tagging. The tags recorded coordinates at preset intervals which, under favourable conditions, can collect a single data fix every 30 minutes. This means that any location the dove visits momentarily or irregularly has a chance of not being registered by the tag.

Since there was no additional information registered with each data fix (such as speed or temperature), the dove's activity (flying, loafing, nesting or foraging) had to be deduced using a combination of the full dataset, GIS maps, and current knowledge of turtle dove behaviour. Turtle doves are diurnal, so data fixes taken between x and x, during darkness, were presumed to be roosting locations. These data fixes can be expected to be located in areas of scrub, hedge or trees within the dove's territory (if they have one), and in close proximity to their nest (if present). Turtle doves are known to forage on the ground, and have no other reason to expose themselves to predation and danger other than to find food. For this reason, data fixes recorded on the ground were taken as foraging activity. The nests of turtle doves are in trees, scrub or overgrown hedges, and nesting activity could be distinguished from loafing and singing activity by taking the timing and duration of the dove’s presence in a single (suitable) bush or tree: incubation is performed by male and female doves and takes approximately 2 weeks. Following hatching, young doves are kept warm by one or other parent and are regularly fed over the next 2 – 3 weeks until they fledge. This is reflected in the tagged dove’s data fixes as a period of increasing activity, but where the individual routinely returns to the nest location. Singing and loafing activity, often done from the tops of taller bushes and trees, are indistinguishable within the data set. However, the assumption that turtle doves will need to spend relatively more time in and around their territory in order to ‘claim’ it, combined with field observations of singing doves, assist in the identification and confirmation of an individual’s territory.

For the purpose of identifying whether test plots were suitably situated in relation to foraging turtle doves, the home range and territory of each tagged dove were identified during the analysis. Vreugdenhil-Rowlands (2021) found that turtle doves were flying up to 5 km away to forage, and suggested that doves with active nests might be foraging much closer to home (predominantly within 1 km of their territory). For this reason, how many (tagged) turtle dove territories there were within a) a 5 km and b) a 1 km radius of each test plot were identified.

The term home range refers to the area where a turtle dove regularly lives and moves. For telemetry datasets, this range is typically defined by the outermost data points, excluding unrealistic outliers, and relative to the overall distribution of points. For flying birds, the land area within the furthest coordinates is considered fully accessible to them. Unlike territories, home range borders are not defended from others of the same species.

The term territory is used to refer to the area a turtle dove actively defends against others of its species. This contrasts with its home range, which is the broader area it uses daily for foraging. In other words, a dove's territory constitutes only a small portion of its home range.

CHAPTER 3: Results

3.1 Test plot performance

Seed mix - height/structure

Species composition and sowing density of each mixture was adapted with each sowing round. In the pilot year, the spring sown test plots containing seed mix 1 had a slow start to the growing season due to a particularly cold, wet spring. Once the weather warmed up, the seed mix quickly grew too tall and dense for turtle doves – in part due to the presence of tall, leafy *brassica* species (field mustard and rapeseed) in the seed mix. While turtle doves are known to eat these seeds, they are most readily available later in the growing season, following management/harvest, when the ripe seed falls on the ground. For these reasons, mustard and rapeseed were removed from subsequent mixes.

Seed mix 2, sown in autumn 2021, had its first growing season in 2022. Unlike 2021, 2022 was warm and dry and the seed mix germinated and grew very quickly. In the absence of mustard and rapeseed, the camomile/mayweed (either from the mix itself or from the soil seed bank), red clover and vetch were very prominent in these test fields. Once again, the fields were generally too tall and dense. Seed mix 2, sown at a lower density than seed mix 1, was still considered too dense, resulting in subsequent sowing rounds having a sowing density of 5 kg/ha.

Seed mix 3, sown in spring 2022, contained fewer grasses and further reductions to the mayweed and red clover. Additionally, the percentages of lower growing species such as field pansy, trefoil sp. and buckwheat were increased. Miners' lettuce was also added to seed mix 3, having been discovered present at many observed foraging locations in 2020 and 2021. As a low growing, early seeding herb it fitted well within the seed mix. Seed mix 3, sown in spring test plots performed rather well: while still requiring regular management to create bare ground/reduce average height, the general density of the vegetation appeared less than in previous test plots.

On all test plots, annual meadow grass (*Poa annua*) was present in the soil seed bank alongside a few other grass species. The grasses present in the seed mix were taller than the most frequently occurring annual meadow grass and produced ripe seed at a later date. Additionally, grasses tended to form denser clumps than herb species on the test plots and seemed to be increasing in percentage cover each growing season. For this reason, seed mix 4, the final mix used in this project, was comprised entirely of herb species.

Seed mix 4 was sown in autumn 2022 and had its first growing season in 2023. In addition to the removal of grasses, mayweed was also removed and further reductions in white and red clover were made. Consequently, increases were made to the percentage weight of trefoil *sp.* (such as black medick and lesser trefoil), miner's lettuce, field pansy, poppy and cornflower. Having had very limited success in growing on test fields, common fumitory was also removed in favour of other species.

The shortest species were field pansy, miner's lettuce, corn spurrey, black medick and lesser trefoil. The tallest growing species were rapeseed, field mustard, white mustard, wild rye and common vetch, the latter of which creeped and climbed rather than growing directly up. Common vetch was the only species of these five which was retained in our seed mix, though its percentage weight was significantly reduced by seed mix 4. A complete list of seed mix species used during this research, along with their height and earliest flowering periods can be found in Appendix 9.

Figure 9 provides an illustration of the average vegetation height of each seed mix during its first growing season. Particularly evident are:

- The notably slow start to seed mix 1's first growing season, followed by a sharp increase in vegetation height in late June as the *brassica* species experienced a growth spurt.
- The especially quick-growing start to seed mix 2's growing season; the combination of autumn sowing with a mild winter and spring.
- The height of seed mix 2 in July, caused by the combination of a mild spring followed by hot weather.
- Peaks in vegetation height in seed mixes 2 and 3 in July were caused by the hot, dry weather of 2022; leading to delayed management of these test plots.
- Seed mixes 2 and 4, both sown in autumn, had a head start in development once the growing season began. All autumn test plots had some vegetation cover and were already developing flowers and seeds as early as April.

The accompanying photos provide a snapshot of how the different seed mixes performed in their first growing season.

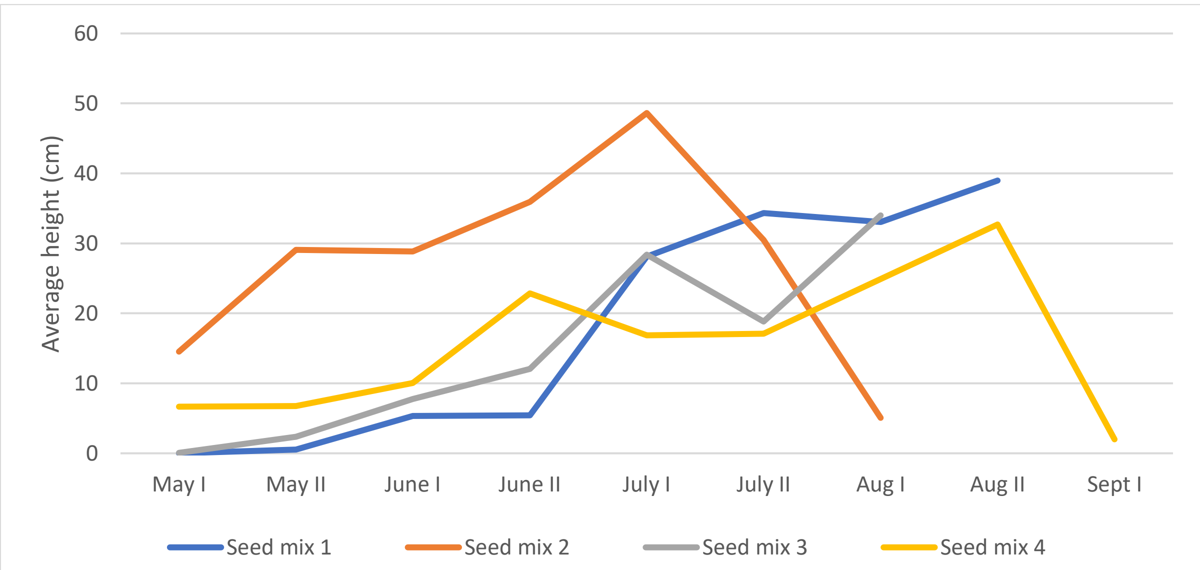


Fig. 9. Average height of each seed mix during its first growing season.
Fig. 9. Gemiddelde hoogte van elk zaadmengsel tijdens het eerste groeiseizoen.

Photo 5. Field A, Seed mix 1 (sown at 10 kg/ha) included brassicas which, in many fields quickly grew too tall and dense.

Photo 6a and 6b. Field G seed mix 2 (sown at 7.5 kg/ha), camomile and vetch are rather dominant.

Photo 7a and 7b. Field G seed mix 3 (sown at 5 kg/ha), generally lower and sparser vegetation.

Photo 8. Field E seed mix 4 (sown at 5 kg/ha), greater percentages of low growing species.

Foto 5. Veld A zaadmengsel 1 (ingezaaid op 10 kg/ha) bevatte koolgewassen die in veel velden snel te hoog en dicht groeiden.
Foto 6a en 6b. Veld G zaadmengsel 2 (ingezaaid op 7,5 kg/ha), kamille en veenbes zijn vrij dominant.
Foto 7a en 7b. Veld G zaadmengsel 3 (ingezaaid op 5 kg/ha), over het algemeen lagere en ijlere vegetatie.
Foto 8. Veld E zaadmengsel 4 (ingezaaid op 5 kg/ha), grotere percentages van laagblijvende soorten.

Seed mix – flowering times

Flowering species in the seed mixes in both 2022 *and* 2023 included field pansy, spurrey, vetch, black medick and other trefoil and clover species (Table 4). Additionally, field visits in mid-April both years revealed that some species were already flowering much earlier (including black medick, spurrey, miner's lettuce, Vesce de Narbonne), along with various species growing from the seed bank (including speedwell, mouse ear and shepherd's purse).

The latest flowering species sown on our plots included grasses (common and creeping bent, and cock's foot), buckwheat and mayweed. However, mayweed was often confused with spontaneous camomile growing in the plots so precise flowering times are unclear. While not as early as other species, it was noted that buckwheat and camomile/mayweed both flowered much earlier when they overwintered on the test plots i.e. they were sown in autumn, or else were in the second growing season of a spring sown seed mix. A complete list of species used during this research, along with their height and earliest flowering periods can be found in Appendix 9.

Some species performed notably poorly, including common fumitory and poppy. While observed in several test plots, these species were never seen in great numbers and didn't thrive in the same way that the spurrey, clover and trefoil species did.

Table 4. Seed mix species flowering by 15th May in 2022 and 2023.

Tabel 4. *Samenstelling van zaadmengsels die al bloeiden op 15 mei in 2022 en 2023.*

Species	2022	2023
Field pansy	√	√
Buckwheat	√	
Spurrey	√	√
Trefoil sp.		√
Black medick	√	√
Camelina	√	
Camomile	√	
Clover sp.		√
Cornflower	√	
Mustard sp.	√	
Rye	√	
Red clover	√	
Vesce de Narbonne	√	
Vetch	√	√

Photos 9. Flowering species in April 2022 incl. camelina, common fumitory and vetch.

Foto 9. Bloeiende soorten in april 2022, inclusief huttentut, gewone duivenkervel en wikke.

Photos 10. Flowering species in April 2023, incl. Miner's lettuce and spurrey.

Foto 10. Bloeiende soorten in april 2023, inclusief winterpostelein en spurrie.

Sowing moment and seed provision

Seed mixes 1 and 3 were sown in spring, while seed mixes 2 and 4 were autumn sown (Table 5). As expected, the seed mixes sown in spring did not start producing seed in their first growing season until mid-June at the earliest, while autumn sown fields did not experience this delay in their first growing season. In subsequent growing seasons there appeared to be little difference between autumn and spring sown fields regarding timing of seed formation.

Table 5. Seed mixes with respective sowing dates and first seed available date each growing season.
Tabel 5. Zaadmengsels met zaaidata en de datum waarop het eerste zaad beschikbaar was in elk groeiseizoen.

	Spring 2021 Seed mix 1	Autumn 2021 Seed mix 2	Spring 2022 Seed mix 3	Autumn 2022 Seed mix 4
Sowing Date	Week 4th May	Week 4th Oct	Week 28th Mar	Week 10th Oct
Growing season 1	16/6/2021	12/5/2022	20/6/2022	12/5/2023
Growing season 2	24/5/2022	5/6/2023	12/5/2023	-
Growing season 3	22/5/2023	-	-	-

Effect of management

Hoeing was used during the first growing season of all fields to great effect. It removed competing plants between the sown rows and, particularly in the case of spring sown plots, ensured the sown seed mix had the opportunity to germinate and outgrow its competitors. However, hoeing was only possible early on in the season while all vegetation was sufficiently low for this method. All other techniques came into play once hoeing was no longer an option.

Photo 11. Recently hoed rows in Field A autumn test plot.
Foto 11. Recent geschoffelde rijtjes in Veld A najaarsveld.

Flail mowing was selected over regular mowing for two reasons. Firstly, it could handle the, often thick, vegetation growing on the test plots. Secondly, shredding the vegetation led to it settling and breaking down quicker, creating a more suitable surface for doves to walk on.

In the pilot year flail-mowing was trialled as a means of creating bare ground together with a more stratified vegetation structure: 3 m wide strips were mown to ('bare') ground level through the plot, with a 3m wide strip mown to a height of 15-20 cm either side (see image left). While it temporarily created a nice open and varied vegetation structure, and led to a wide variety of mix species developing in each layer, the bare ground quickly regenerated and grew too high to be suitable for turtle doves, requiring further management within 2 weeks.

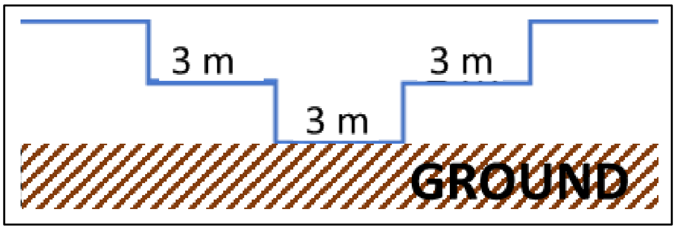


Photo 12. Flail mowing strategy diagram (top), and the stratified flail mowing result in Field D spring test plot, 2021.
Foto 12. Klepelmaaien methode (boven) en resultaat Veld D voorjaarsveld.

Power harrowing and cultivating were also tested. Once bare strips became vegetated and began growing too high, the plot was managed again, but with strips being harrowed/cultivated in a different direction, leaving stands of old/tall vegetation full of ripening seed, stands of new growth and strips of bare ground.

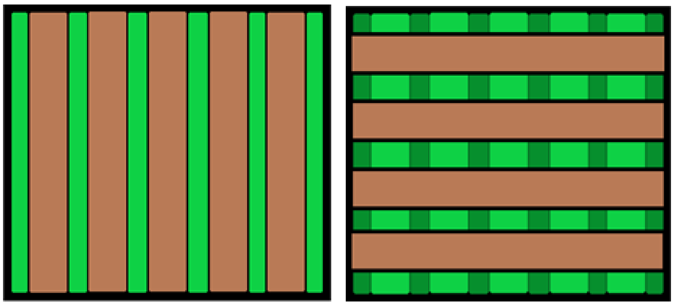


Photo 1. Power harrowing/cultivating strategy in management round 1 (left) and round 2 (right).
Foto 13. Eggen/frees methode in beheerronden 1 (links) en 2 (rechts).

After testing mowing, power harrowing and cultivating in 2021 it was decided that shallow (depth of 5 cm) power harrowing or cultivating bare strips were the better options for creating the bare ground, as it disturbed the root system and remained open and bare for longer (> 3 weeks).

In 2021 and 2022 bare strips of varying widths were experimented with. Earlier attempts using narrow management strips, combined with the higher sowing density used in the first plots, often resulted in a 'tunnel' effect: remaining vegetated areas created a 'wall' of vegetation either side of the bare strips. Where the remaining vegetation was too tall to support itself, it would collapse into the bare strips, quickly obscuring the bare ground altogether. The resulting habitat structure was visually unsuitable for a dove that prefers openness.

The best ratio of bare to vegetated strip width seemed to indicate that wider bare strips (2 – 3 m wide, depending on the available machinery) with narrower vegetated strips (1 m wide) were the most suitable for creating a more 'open' vegetation structure. This appeared to work on both high sowing density and low sowing density test plots.

The knock-on effect of increasing the plot's bare ground percentage to 60 – 70 % with each management round (by harrowing/cultivating) was that it took around 4 weeks before the bare ground began to grow to the point of needing further management. Landowners were therefore asked less frequently to manage the test plots. A summary of which management was applied, where and when, is provided in Table 6.

A photographic overview from a selection of different fields in different years can be found in Appendix 10. It illustrates the development and changes in vegetation throughout the season, showing the effects of management on the test plots.

Table 6. Summary of where and when different management techniques were used.
Tabel 6. Samenvatting van waar en wanneer verschillende beheertechnieken werden toegepast.

Technique	Purpose	Where	When
Hoeing	Removal of competing plants between sown rows of seed mix	All fields where sown rows were clearly visible	First growing season only
Mowing or flail mowing	Reducing vegetation height, either to create bare ground or simply to lower the vegetation	Fields B, D, F, I, H (in 2023)	During growing season (pilot year)
Harrowing	Creating bare ground	Fields A, C, E, G, H (in 2022)	During all growing seasons
Cultivating	Creating bare ground	Fields A, C, E, G, H, I	During all growing seasons

Suitability assessment

For the purposes of this project, suitable habitat structure has been taken to be represented by three variables combined: the percentage of bare ground, the vegetation height, and the availability of suitable seed. These have been judged according to the method provided in Chapter 2.6 Assessing plot suitability. To complete the suitability diagrams of a plot's progressive suitability throughout each growing season, management moments have been marked by a solid black line.

To illustrate how the diagrams work, the following 2 suitability diagrams are for Field G spring plot, which often presented suitable foraging habitat, and Field B spring plot, which was predominantly unsuitable (Figures 10 and 11). Both diagrams have been annotated to explain why or how the plot's suitability changed throughout each growing season. A complete overview of test plot suitability diagrams can be found on the following page. Figure 12 provides an overview of field suitability in all test plots each year of the project.

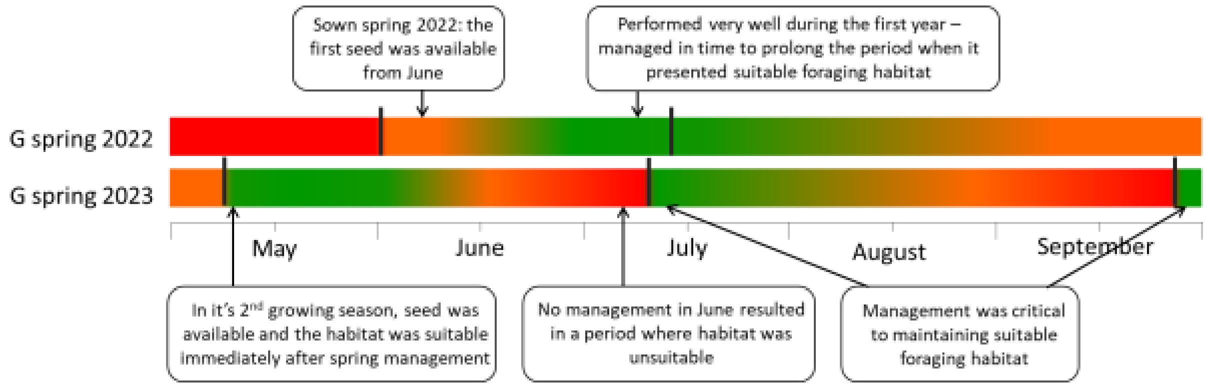


Fig. 10. Suitability of field G spring plot in 2022 and 2023.
Fig. 10. Geschiktheid van veld G voorjaarsveldje in 2022 en 2023.

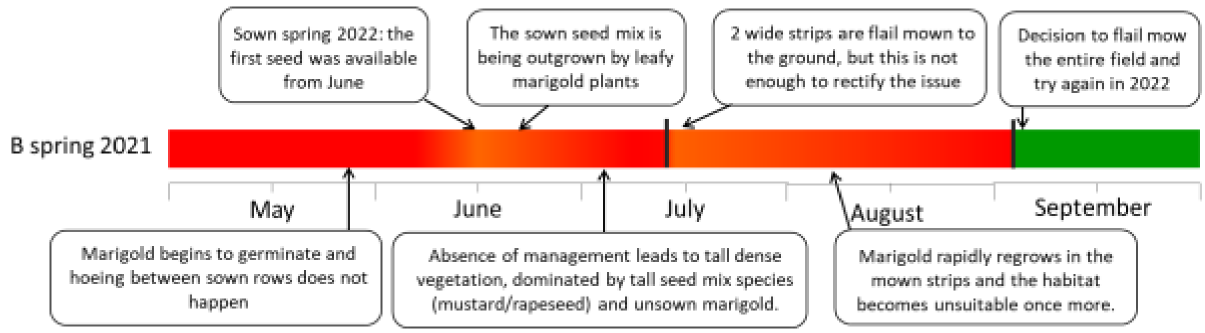


Fig. 11. Suitability of field B spring plot in 2021.
Fig. 11. Geschiktheid van veld B voorjaarsveldje in 2021.

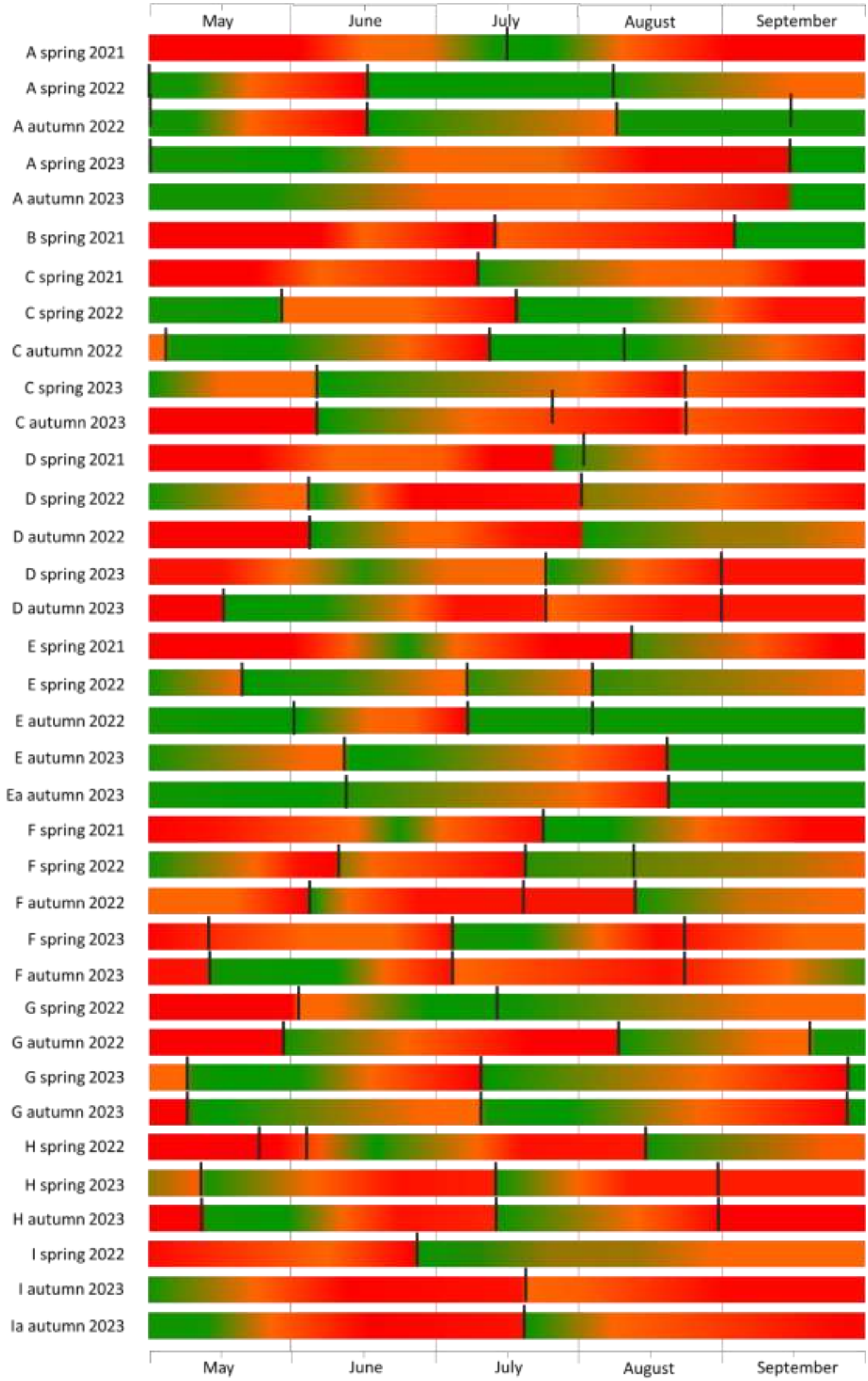


Fig. 12. Suitability diagrams for all test plots, 2021 to 2023.
Fig. 12. Geschiktheid van alle testveldjes, 2021-2023.

3.2 Turtle dove use of test plots

Camera traps

There were 13 instances of turtle doves recorded by the camera traps: 4 in 2021, 1 in 2022 and 8 in 2023 (Table 7). These were recorded across 5 test plots in just 3 fields.

Table 7. Summary of turtle dove camera trap records on/next to test plots. *2 individuals on a single photo.
*Tabel 7. Samenvatting van cameravalregistraties van zomertortels op/bij testpercelen. *2 individuen op één foto.*

Test plot	Year	Type observation	Number of records	Month (and days) of records
C – spring	2021	Camera	3	May (20, 21, 23)
C - autumn	2023	Camera	1	July (1)
E - spring	2021	Camera	1	June (15)
G - spring	2022	Camera	1	July (14)
G - spring	2023	Camera	5	July (12, 21, 23, 24*)
G - autumn	2023	Camera	2	July (9, 14)

While recording turtle doves was the primary aim of camera traps, the presence of other species whose primary reason for visiting the fields would be to forage on seed, can be used as an indicator of seed availability. These results deal with recordings of the following species: collared dove, stock dove, wood pigeon, turtle dove, pheasant, partridge, mallard duck, Egyptian goose, house sparrow, linnet, goldfinch, chaffinch, dunnock, plus other undetermined dove, pigeon, duck and finch species. A complete inventory of all recorded species can be found in Appendix 11.

Camera trap results were recorded as the 'daily maximum' of each bird species i.e. the maximum total of unique individuals seen in a single camera trap photo. This results in a likely underestimation of visitor numbers but avoids the risk of counting a single individual multiple times throughout the day. The figures below illustrate the sums of the recorded daily maximums.

Pheasant and *Columba* species (stock dove and wood pigeon) were the most numerous each year, with pheasants being the most common visitor in 2022 and 2023. Pigeons were more numerous than any other group of birds in 2021, while *Streptopelia* species (collared and turtle doves) and finches (primarily goldfinch and linnet) had more visits recorded in 2023 (Figure 13).

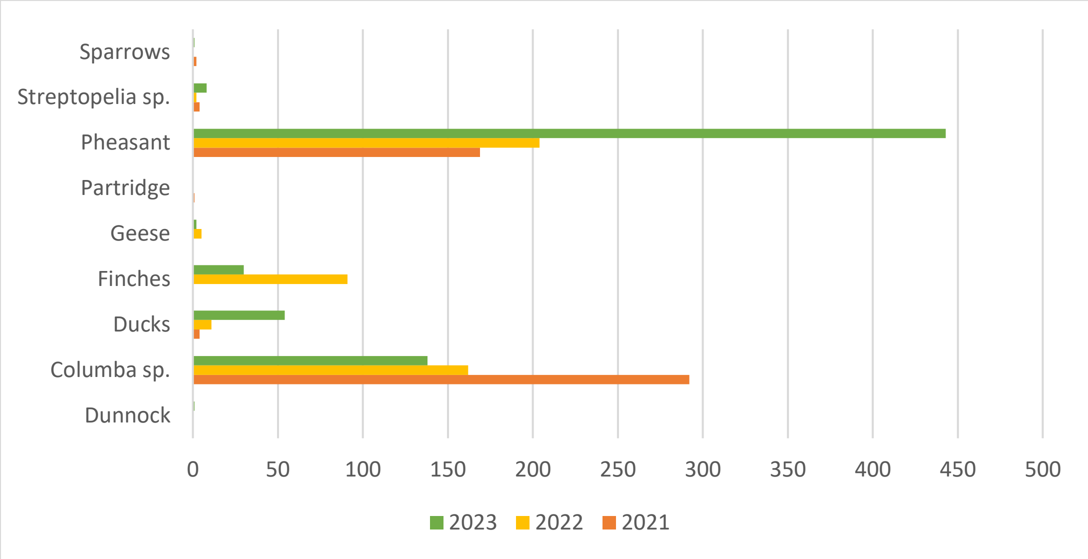


Fig. 13. Sum of daily maximums of seed eating species, grouped according to family, for the period of 18 May to 7 August in 2021, 2022 and 2023.

Fig. 13. Som van de dagelijkse maxima van zaad-etende soorten, op basis van soortgroep, voor de periode van 18 mei tot 7 augustus in 2021, 2022 en 2023.

Comparing individual plots in 2022 and 2023 revealed huge variations in the total daily maximum of seed eating species. The graphs below show the 2022 and 2023 totals for spring and autumn sown test plots.

Of the spring sown test plots (Figure 14), Field G in 2023 stood out as having the most visitors coming to forage (>110), with more wood pigeon and pheasant recorded than in other plots. The next most frequently visited fields were Field A in 2023, I in 2023 and F in 2022 (with totals between 55 and 65).

Of the autumn plots (Figure 15), three plots stood out from the rest with more than 80 visitors recorded on camera. Field D had a large number of goldfinch and pheasant in 2022, while in 2023 Fields G and I had the most visitors (Field G for visiting pheasants, doves and pigeons, and Field I for pheasants, pigeons and mallard ducks).

If the total number of visitors is taken to representative of seed availability, then these graphs are a clear indicator that seed was indeed available in the test plots.

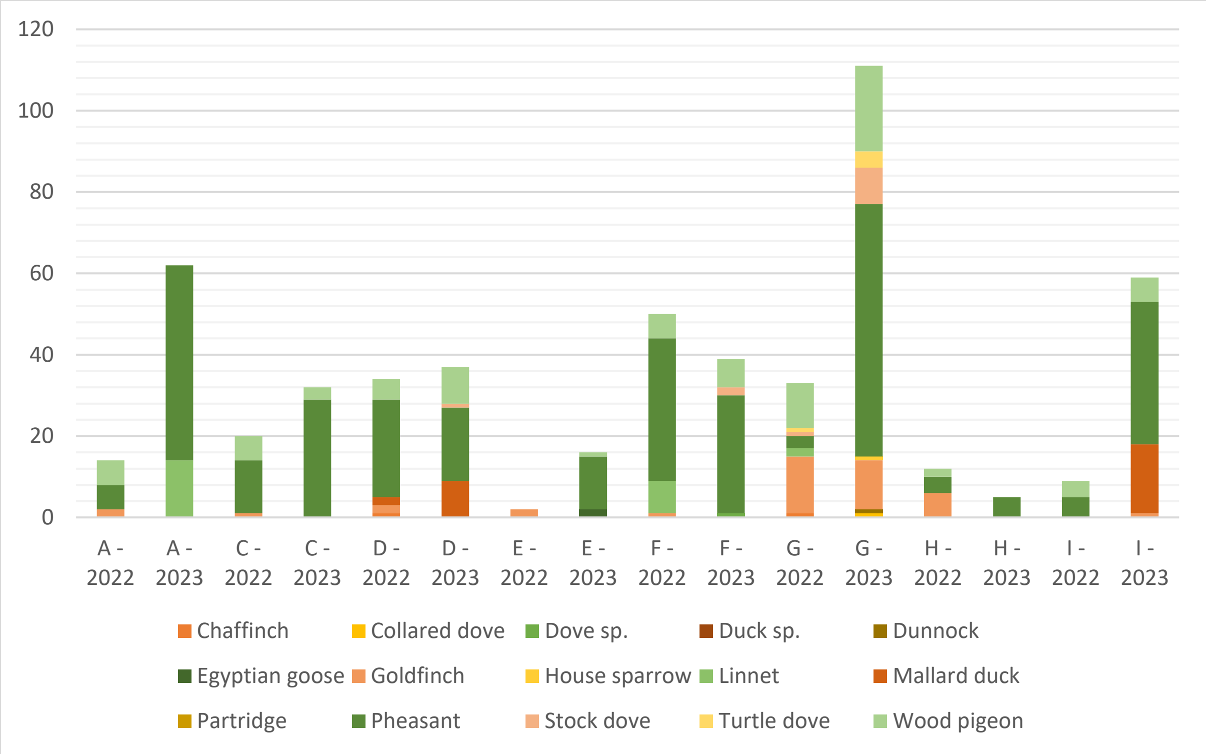


Fig. 14. Sum of daily maximum number of birds for spring plots in 2022 and 2023 (Period: 18 May – 7 August).
Fig. 14. Som van de dagelijkse maximumaantallen vogels op voorjaarsvelden in 2022 en 2023 (periode: 18 mei – 7 augustus).

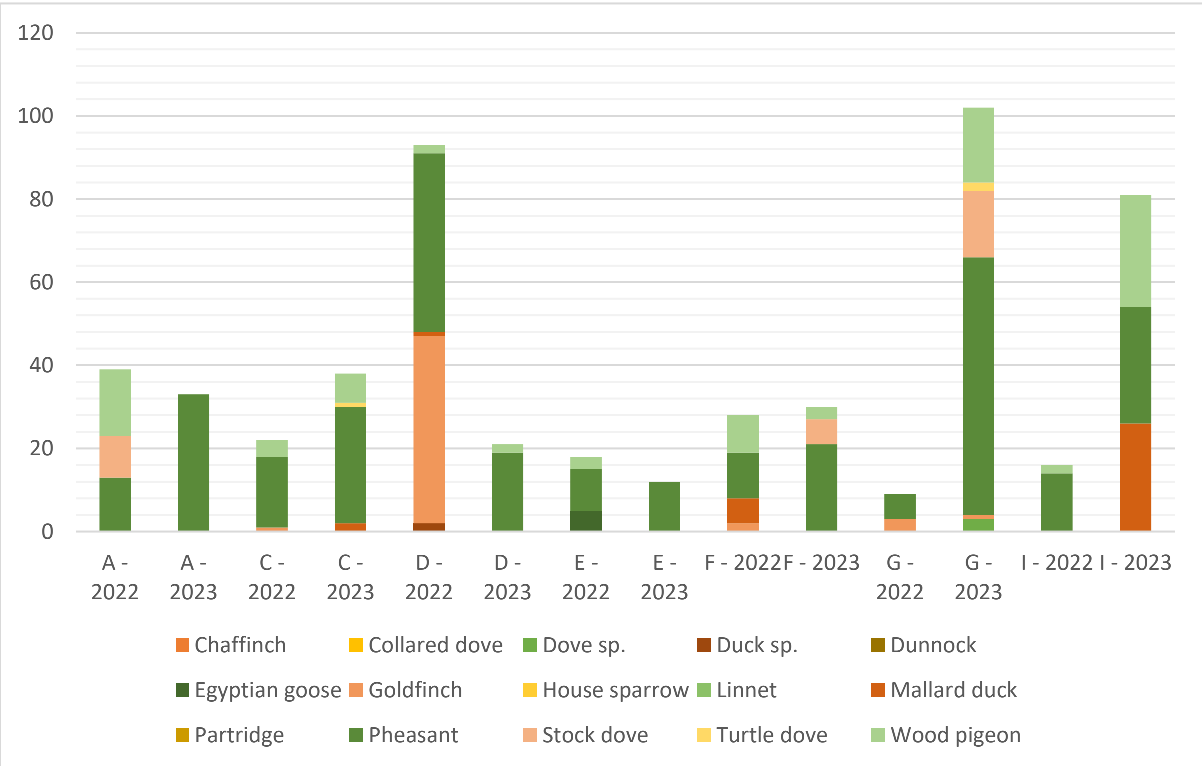


Fig. 15. Sum of daily maximum number of birds for autumn plots in 2022 and 2023 (Period: 18 May – 7 August).
Fig. 15. Som van de dagelijkse maximumaantallen vogels op najaarsvelden in 2022 en 2023 (periode: 18 mei – 7 augustus)

Field observations

The primary aim of carrying out field observations was to confirm turtle dove presence on test plots and to identify whether visits coincide with periods of 'optimal' foraging habitat on the plot. Due to the low sighting rate of all bird species via field observations, these surveys were only carried out in 2021 and 2022.

Just one turtle dove was seen on a test field during field observations: a single dove was foraging on the edge of Field C's spring sown test plot on the 18th May 2021. This was the first year of the project, and around the time when seed mix 1 was sown. Therefore, this observation is more likely a dove foraging among the agricultural weeds growing on the edge of the plot, or else on seed from the sowing process.

GPS-tagged turtle doves

A total of eight doves* were tagged and followed during 2022 and 2023 – 3 females and 5 males. Each was followed from its date of capture, up until the tag ceased to give data. Table 8 below provides a truncated summary of the data collected by each dove (complete tables of dove information and data collection can both be found in Appendices 12 and 13).

*An additional dove was captured, tagged and ringed during 2022, though a tag malfunction led to its recapture and removal of the tag for repairs.

Table 8. A summary of the data collected by each dove.
Tabel 8. *Samenvatting van verzamelde gegevensper gezenderde zomertortel.*

Name	Tracking period	No. days	Total fixes (diurnal)	Av. fixes/day (min - max)	Nest
Sebastiaan	8/6/22-11/9/22	96	1182 (788)	12 (1 - 22)	Yes
Marein	8/6/22-1/9/22	86	957 (673)	11 (2 - 20)	Yes
Paulina	11/6/22-17/9/22	99	526 (526)	5 (0 - 16)	Yes
Victor	17/6/22-10/9/22	86	1122 (758)	13 (3 - 21)	Yes
Ina	9/6/23-9/9/23	93	861 (702)	9 (0 - 27)	Yes
Marion	9/6/23-5/7/23	27	468 (409)	17 (0 - 31)	No
Cornelis	5/7/23-10/9/23	68	812 (714)	12 (0 - 31)	unknown
Patrick	5/7/23-14/8/23	41	413 (364)	10 (0 - 23)	unknown

The period of time where each dove's tag was collecting data is visually represented in Figure 16. There are several rather clear gaps in data collection (for example, Paulina), and other instances where data collection ceased earlier than expected of a turtle dove breeding in the Netherlands (Marion and Patrick).

The exact cause of tags ceasing to provide data can often be deduced by considering the preceding data fixes and the date at which data collection stopped. Six of the doves only stopped transmitting data in September – when you would expect turtle doves to migrate south for the winter. Once out of permanent range of the base station, no more data is transferred from the tag.

In some cases, such as Marion in 2023 who was only followed for 27 days, predation can be deduced. Marions tag recorded only the coordinates of a raptor's nest (almost certainly buzzard) for several days before the tag stopped transmitting data. In other cases, such as Paulina in 2022, the tag malfunctioned causing a period without data collection (in this case, suspected water damage causing a temporary short circuit within the tag), after which the tag resumed functioning again.

The circumstances regarding what happened to Patrick in 2023 are more ambiguous. In the absence of a clear territory or nest, it is possible that he was a non-breeding male (perhaps due to the small population size he was unable to pair). As such, he could have simply moved to an area outside of the base station range. However, having disappeared from the radar early August it is also possible that he migrated south earlier than the other tagged doves.

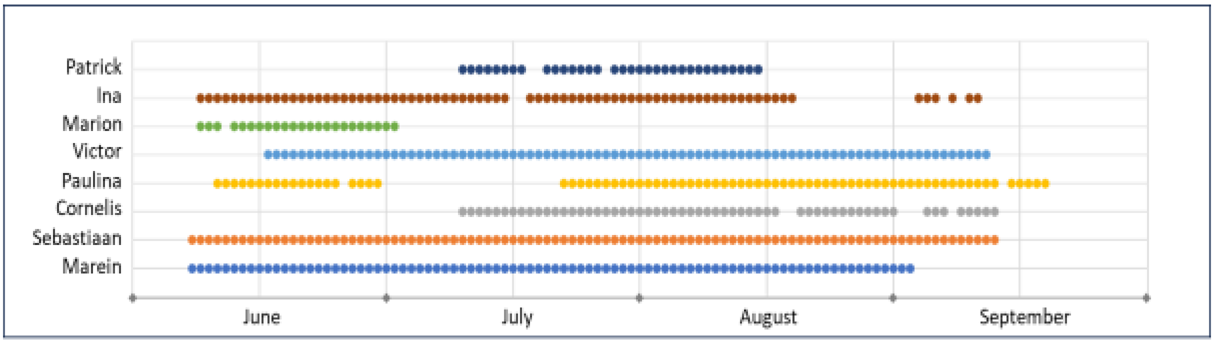


Fig. 16. Visual overview of days where each tagged dove collected data (2022 and 2023).
Fig. 16. Visueel overzicht van de dagen waarop elke gezenderde zomertortel gegevens verzamelde (2022 en 2023).

The maps below show an overview of all data fixes collected in 2022 and in 2023 (Figures 17 and 18). Four doves were captured in the Westkapelle study area, and four in the Oostkapelle study area. It is clear from the maps below that the doves caught in a particular area have a tendency to stay in the area. Doves caught in the Westkapelle study area ventured largely south, concentrating in the trees, scrub and dune habitat along the coast near Dishoek. Doves caught in the Oostkapelle study area had additional clusters of points in Vrouwenpolder and Veerse Dam, in areas of trees, scrub and dune habitat.

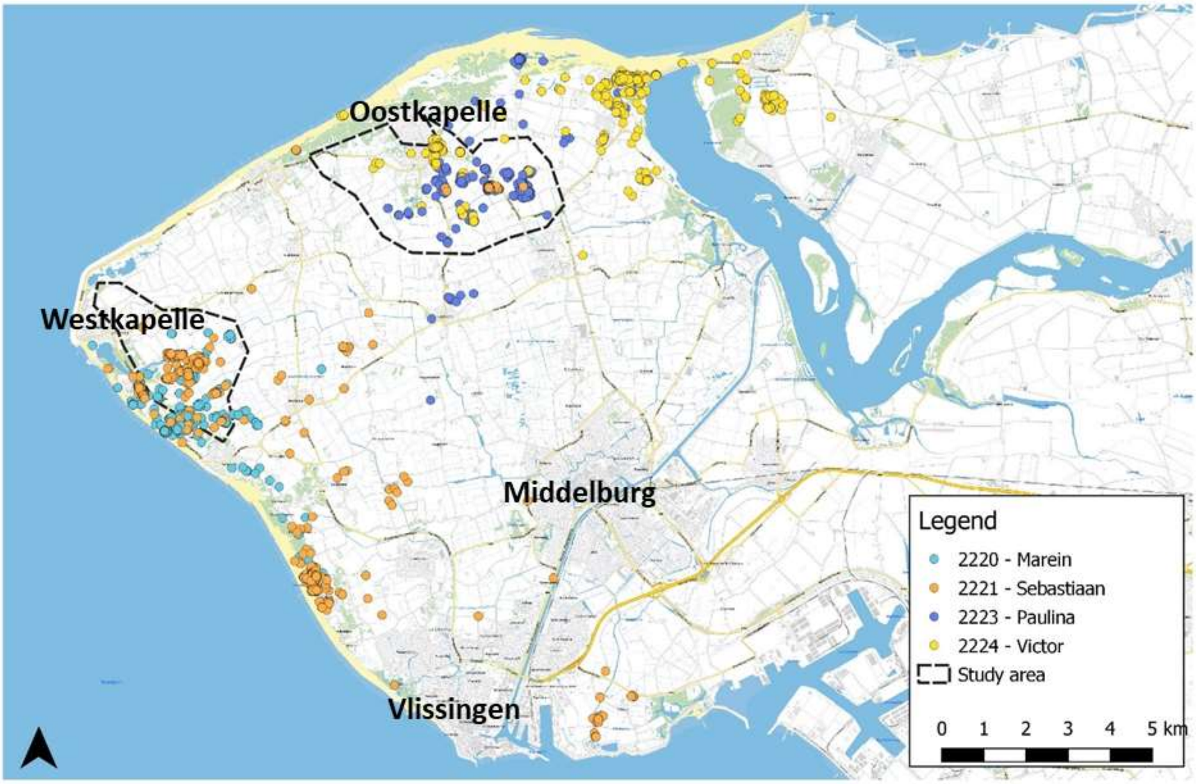


Fig. 17. An overview of data fixes taken by tagged turtle doves in 2022.
Fig. 17. Overzicht van de datapunten verzameld door gezenderde zomertortels in 2022.

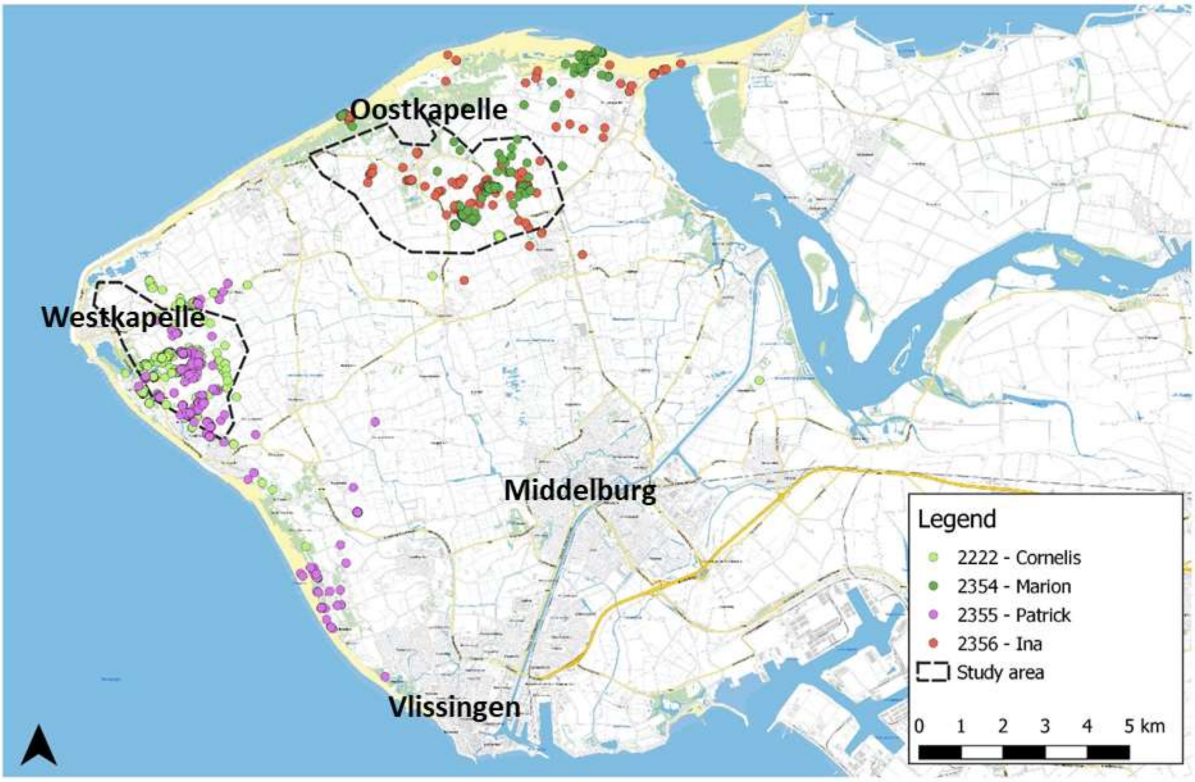


Fig. 18. Overview of data fixes taken by tagged turtle doves in 2023.
Fig. 18. Overzicht van de datapunten verzameld door gezenderde zomertortels in 2023.

There were 11 data fixes made by tagged turtle doves on test plots, of which 3 in 2022 and 8 in 2023 (Table 9). All fixes were in just one field: Field G. Multiple fixes from the same dove, at the same plot, during a single day were counted as independent visits: the minimum time interval for data fixes was 30 minutes, and the dove was recorded at a different location in between data fixes. This indicated that the dove had flown elsewhere and returned later to the test plot for a subsequent foraging visit.

Table 9. Summary of turtle dove data fixes taken on or next to test plot. ** Non-consecutive data fixes and therefore 'separate' visits.
*Tabel 9. Samenvatting van de zomertortel datapunten die op of bij testpercelen verzameld waren. ** Niet-opeenvolgende datapunten, en daarom 'gescheiden' bezoeken.*

Test plot	Year	Type observation (dove name)	Number of records	Month (and days) of records
G - spring	2022	Tag 2223 (Paulina)	2	Aug (18, 21)
G - spring	2023	Tag 2356 (Ina)	5	July (9, 9, 10, 10, 11)**
G - autumn	2023	Tag 2356 (Ina)	3	July (9, 9, 12)**
G - autumn	2022	Tag 2223 (Paulina)	1	June (21)

When were turtle doves recorded?

The timing of turtle dove visits to test plots in each year is summarized in Table 10 (Appendix 14 for the full dataset). In 2021, the seed mix was sown in the first week of May and the first plants (spurrey and camelina) did not produce seed until mid-June. Consequently, it is most likely that at least 4 of the 5 turtle dove records from that year are 'coincidental', and not due to the state of the sown plot. While it is possible that the doves could have been interested in the sown seed, this is fairly unlikely as no peak in dove activity was recorded immediately following sowing. Another possible explanation for their presence would be that the doves were interested in weed species growing around the field edges, or in finding suitable grit for digestion on the bare ground of the spring plot.

Interestingly, more than half of the records were made in the third year of the test plots, and only in one month (July). All of these records except one were from Field G, suggesting that these data fixes relate to the specific moment, state and location of that feed plot.

Table 10. Total number of turtle dove observations per half month, 2021-2023.
Tabel 10. Aantal waarnemingen van zomertortels per halve maand, 2021-2023.

	May II	June I	June II	July I	July II	August II	**Total**
2021	4	1					**5**
2022				1		2	3
2023				13	4		**17**
Total	**4**	**1**	**0**	**14**	**4**	**2**	**25**

Where were turtle doves recorded?

Only 5 plots were visited, belonging to just 3 fields (Fields C, E, G), with 19 out of 25 records coming from Field G in July 2023 (Table 11). The only turtle dove visits documented in 2021 were made in spring, to Fields C and E. As previously stated, turtle dove records from May 2021 are most likely not due to the field's suitability as a foraging site. In addition to the absence of ripening seed in Fields C and E in May, Field C is situated next to a chicken farm with an open manure silo and a vegetable garden where birdseed is regularly spread. Both the silo and garden are known to be regularly visited by turtle doves for feeding, with 1 or 2 pairs nesting in the surrounding scrub most years. The combination of these factors supports the suggestion that turtle doves recorded here, at this moment, were not related to the quality of Field C as a foraging site.

On plots where a single visit was made, it is difficult to determine whether this was a 'coincidental' visit or a foraging visit. The three plots indicating a single turtle dove recording show that the habitat structure (bare ground: vegetation height) was likely suitable at the time of the visit. However, the absence of subsequent visits by turtle doves suggests that these plots were not worth returning to. This could be related to the plot itself (habitat structure or seed availability), but could equally be related to other factors such as landscape features or distance from territories.

Multiple visits were recorded to Field G in 2022 and 2023, indicating that this combination of field location and suitable habitat was particularly good. Of the 19 visits to Field G, 11 were taken by GPS tag and 8 by camera trap. In 2022, 3 of the records on the spring (2) and autumn (1) test plots were from the tagged dove Paulina (Tag 2223). She is known to have finished a nest around mid-August, just 150 m away. In 2023, 8 of the records to spring (5) and autumn (3) test plots are from Ina (Tag 2356), from 9/7/2023 until 12/7/2023. At this time, Ina was just beginning her second nest after the failure of her first, ca. 850 m away. While the camera trap records do not allow for individual identification of turtle doves, there's a good chance that other visits to Field G during these periods were made by either these 2 females or their partners.

Of particular note is that the vast majority (15 out of 19) of Field G's visits were made in the first 10 days immediately following plot management (Figure 19). It clearly illustrates how critical the management of plots is in maintaining a suitable habitat structure and in making seed available to doves foraging on the ground.

It is interesting that Field G appears most visited in July and apparently less visited in May, June and August, despite the field being deemed suitable for turtle doves. This can only partly be explained by the discrepancies in the effectiveness of different data collection methods: of Field G's records, 9 out of the 20 records were collected by tagged doves. So, despite the fact that doves were only tagged from the 8th of June onwards in both 2022 and 2023, this doesn't account for the virtual absence of turtle dove records on Field G in other months.

Table 11. Number of turtle dove observations on field plots, 2021-2023.
Tabel 11. Aantal zomertortels geobserveerd op voedselveldjes, 2021-2023.

	Field C		Field E	Field G		**Total**
	Autumn	Spring	Spring	Autumn	Spring	
2021		4	1			**5**
2022				1	3	**4**
2023	1			5	10	**16**
Total	**1**	**4**	**1**	**6**	**13**	**25**

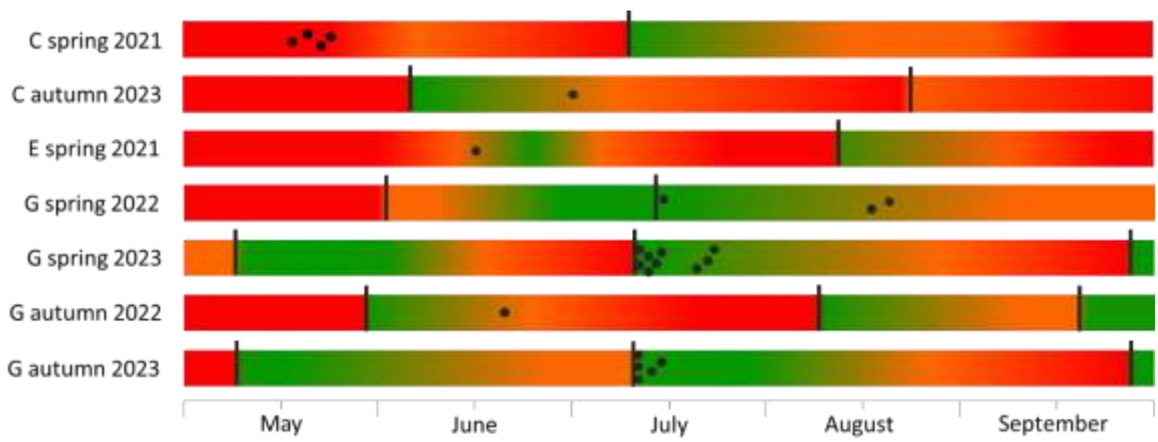


Fig. 19. Illustrative diagram showing turtle dove observations on field plots, 2021-2023, in relation to field suitability and management moments.
Fig. 19. Illustratief diagram met zomertortelwaarnemingen op voedselveldjes, 2021-2023, in relatie tot veldgeschiktheid en beheermomenten.

Turtle dove visits vs vegetation survey data

As previously established, turtle doves prefer foraging locations with plenty of bare ground (30 – 60%), plenty of seed, and a low and open vegetation (<20cm average). Comparing the dates of turtle dove visits to the vegetation survey data taken from that time reveals the following information regarding bare ground, vegetation height and seed availability (Figure 20*):

- Average percentage of bare ground was 44% (range 41% - 47%).
- Average percentage cover of vegetation measuring less than 20 cm is 18% (range 16% - 19%).
- All test plots presented plants producing seed at the time of the visits. These seed-producing plants comprised between 10 and 65% of the total vegetation cover in survey quadrats.

*Turtle dove visits in 2021 were discounted, since no seed mix was growing on the fields at this time.

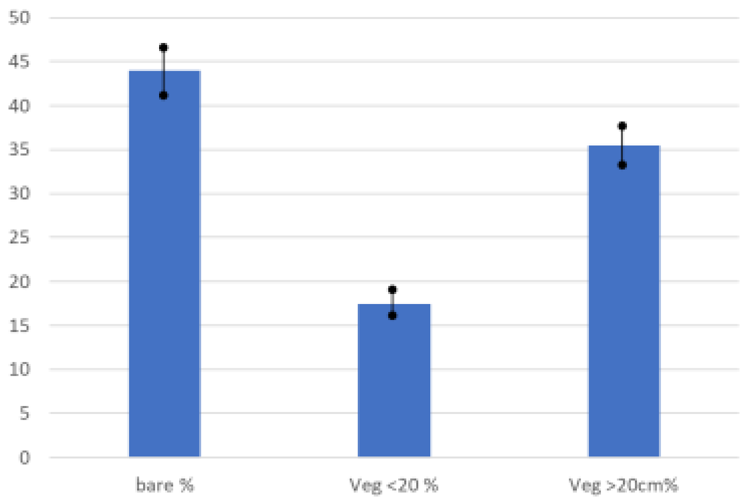


Fig. 20. Bar chart showing mean percentage cover (and range) at each test plot during moments when turtle doves were also recorded.
Fig. 20. Het gemiddelde percentage bedekking (en spreiding) op elk voedselveldje tijdens momenten waarop zomertortels aanwezig waren.

Proximity of test plots to home ranges

One of the aims while setting up test plots was to ensure they had the best chance of falling within range of multiple turtle doves looking for food. For this reason, the home range, territories and nest locations of the tagged doves were analysed in relation to each test field. Details of each doves' home range, territories and nesting attempts are summarised in Table 12. Maps for each dove can be found in Appendix 15.

Each dove's home range has been calculated based on the entire dataset after the removal of unrealistic outliers*. The concave Hull (alpha shapes) algorithm in QGIS was used, with a 'threshold' of 0.4, to calculate home range. The resulting area has an additional buffer of 15m added to it, to account for the 15m accuracy of the tags used.

*Outliers were classed as such when a single data fix occurred out at sea or more than 20 km away from the (visual) rest of the data.

Without the ability to determine a dove's activity at each data point, territories have been identified using the following criteria:

- The overall spread of data points: territories are characterized by a high concentration of points.
- The assumption that turtle doves must be present in their territory daily to claim and possibly defend it.
- The knowledge that turtle doves sing to announce their presence and claim a territory.
- The fact that turtle doves are diurnal and likely roost within their territory at night.

For each dove, clusters of data fixes were analysed for roosting locations (coordinates recorded between 00:00 and 05:00) and daily activity. During field visits, doves were occasionally heard singing within a suspected territory. Observations of territorial behaviour, such as singing and courtship displays, were recorded on www.waarneming.nl. These records helped confirm the presence of a territorial turtle dove. On a few occasions, the singing dove was identified as one of the tagged individuals.

Since it is difficult to define a precise territory boundary, this analysis defines it as the cluster of points which fulfil the above criteria, and where points are within 100 m of each other. A line of 'best fit' has then been drawn based on the daily convex hull of these points and concentrations of activity. Some territories are very clear within the dataset; they fulfil the above criteria for a prolonged period of time and, in some cases, reveal a nest. These have been taken to be 'confirmed' territories. However, in some cases, this was less clear cut. For example, the above criteria were met but there were odd days when no data fixes were recorded in the territory. This could be due to the dove's absence from the area, but could also be a restriction of the tags' abilities. In the case of Paulina, the territory criteria were fulfilled, but only for a short period of time (9 days), followed by radio silence due to tag malfunction (22 days), after which she appeared to have moved and set up a territory elsewhere.

Instances where a territory was not confirmed (either for lacking a nest or else for being occupied for an unusually short period of time), these were recorded as 'possible' territories.

In the case of identifying nests, close study of the dataset revealed a concentration of data fixes in a specific tree or hedge. When these were accessible and visited by a field researcher, a nest could be confirmed. This was the case with Ina, whose two nests were both visited and confirmed – the first with 2 chicks, the second with just 1. Where a nest could not be visited, due to accessibility issues, but the data revealed the turtle dove taking clear 'shifts' to sit on the nest (incubating eggs), followed by a period of activity but consistently returning to the suspected nest site (young), these were also taken to be confirmed nests.

As with the identification of territories, sometimes the data was not as black and white. Victor, for example, had 2 confirmed territories – each with a suspected nest. While one nest could be confirmed given the intensity of data fixes and the time period involved, the other nest could not be confirmed as such because the time period seemed questionable. Not knowing the exact laying and hatching dates, meant that the best status this nest could achieve was 'probable'.

In the case of Cornelis and Patrick, both tagged in 2023, both doves had a possible territory where data fix concentration was elevated over a certain area within their home range. Cornelis even had indications of a possible nest (a high concentration of fixes over 2 small areas of scrub in close proximity to each other). However, his data fix intensity here quickly began to decrease (rather than increase, as expected with an active nest) and he appeared to resume the sporadic daily activity typical of a pre-breeding turtle dove. It is possible that Cornelis tried to nest but for some reason failed. The data collected by Patrick's tag showed no areas of peak activity which might hint at a nesting attempt. There is a good chance that the nests of Paulina, Cornelis, and perhaps one of Victor's nests, were predated, though no evidence of this was found.

Table 12. Overview of each dove's breeding activity (2022/2023).
Tabel 12. Overzicht van broedactiviteit van alle gezenderde zomertortels (2022/2023)

Name	Confirmed territory	Possible territory	Territory habitat(s)	Confirmed nest	Other nest	Nest habitat(s)
Cornelis	0	1	Unimproved grassland	0	1 possible	Hawthorn
Patrick	0	1	Unimproved grassland	0	0	
Ina	1	0	Campsite	2	0	Hawthorn
Marion	0	2	Dunes	0	0	
Sebastiaan	1	0	Dunes	0	0	
Marein	1	1	Holiday park	1	0	Hawthorn
Paulina	1	1	Campsite	1	1 possible	Hawthorn
Victor	2	0	Park, Dunes	1	1 probable	Hawthorn

Previous research in Zeeland (Vreugdenhil-Rowlands, 2021) found that non-nesting turtle doves flew more than 5 km from their territories to forage, while birds that had an active nest stayed closer to their nest site, predominantly foraging within 1 km. Research in the UK (Dunn *et al*, 2016) found that newly fledged chicks stayed within a radius of up to 329 m of the nest site for the first two weeks after fledging.

All test fields were within a 5 km range of multiple tagged turtle dove territories during the breeding season (Table 13). Fields A, C, F and G were less than 1 km from one or more territories, with field G actually falling inside the territory of tagged dove Paulina.

Table 13. Proximity of test fields to tagged turtle dove territories.
Tabel 13. Nabijheid van voedselvelden ten opzichte van territoria van gezenderde zomertortels.

Test Field	No. territories <1km	No. territories <5km
Field A	1	2
Field B		2
Field C	2	5
Field D		5
Field E		5
Field F	3	6
Field G	3	6
Field H		5
Field I		2

3.3 Alternative foraging sites

Since turtle doves have clearly been finding alternative food sources to the test plots, it is important to identify what their alternatives are and if the circumstances surrounding their food supply are stable. This process will help conservationists, at least in the Netherlands, to support turtle doves in their search for foraging habitat and could ultimately lead to the improvement of foraging fields or alternative foraging options that provide a stable source of food during the breeding season.

- Where are they going for food?
- When during the breeding season are turtle doves visiting these land uses?
- Why are they choosing these locations?

Where are turtle doves going for food, if not to foraging fields?

For the purposes of this report, foraging sites were identified based on our current knowledge of foraging behaviour. We know that doves are diurnal, meaning they are active during the day. They typically find food on the ground and are opportunistic feeders, taking advantage of available resources.

In order to identify foraging sites, the dataset was first refined to isolate foraging data fixes. This was accomplished by removing datapoints located in trees, scrub, hedges, buildings, when doves will be either nesting, singing or loafing, and those recorded at night (22:00 to 05:59) when doves are inactive. Following this, foraging sites were identified as clusters of points which had the same land use (based on a cadastral map and field visits), and where doves were recorded on multiple occasions ($\geq$5 datapoints) and across multiple days ($\geq$2 days). These criteria require that a site is valuable enough for a dove to return to multiple times, thereby reducing the chance of locations being falsely classified as suitable 'foraging sites', when a dove may have incidentally visited the site.

Table 14. Number of foraging sites identified per dove.
Tabel 14. *Aantal foerageerlocates geïdentificeerd per zomertortel.*

Dove	# foraging sites
Cornelis	13
Ina	11
Marein	10
Marion	3
Patrick	7
Paulina	12
Sebastiaan	12
Victor	15
Total	**83**

In order to reduce considerable time identifying the land uses within the map, a single GIS layer was created to reflect an edited version of the English National Land Use Database v4.4 (NLUD). The NLUD recognizes 51 land use classes, aggregated into 13 land use divisions (Appendix 16). Land use classes were adjusted, to reflect the land used by the tagged doves and provide additional detail regarding their land use preferences. For example, details on woodland and water were not necessary, while additional detail was useful for certain divisions such as residential and recreation; turtle doves were frequent visitors at campsites and holiday parks, and occasional visitors to rural gardens, but no urban areas. An additional division was also added for this project:

supplementary feeding station. While bird feeding inevitably occurs in various gardens around Walcheren, it was useful to identify turtle dove specific supplementary feeding areas. The resulting categories used for identifying land use at foraging sites can be found in Appendix 17.
A total of 83 foraging sites were identified (Appendix 18). Table 14 shows the breakdown of foraging sites identified per dove, while Figure 21 illustrates the breakdown of foraging sites per land use.

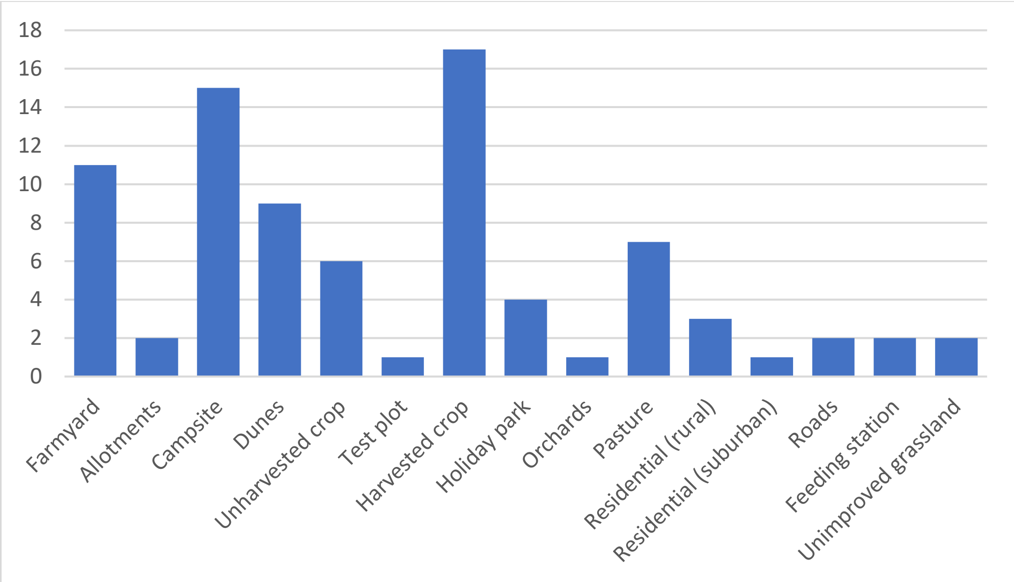


Fig. 21. Number of foraging sites identified within each land use category.
Fig. 21. Aantal foerageerlocaties geïdentificeerd binnen elke categorie van landgebruik.

The largest number of foraging sites occurred on fields containing crops (28%). On the back of previous research (Browne & Aebischer, 2003) and anecdotal evidence, this was expected. However, the next most frequently occurring land uses came as bit more of a surprise: campsites (18%), dune habitat (11%) and holiday parks (5%). While doves have been observed at such locations throughout this project, it was interesting to find their presence at tourist 'hotspots' so clearly reflected in the telemetry data. For a dove with a reputation to be flighty and shy, this result was not expected.

With crops being such a popular land use for foraging turtle doves, a distinction was made between harvested and unharvested fields. The ratio of visited crop fields, harvested to unharvested, was 17:6 – 74 % of all visited crop fields were harvested around the time of the turtle dove's visits.

Crop type	Total sites (harvested)
beans (abandoned)	1
flower seed	3 (3)
onion	1
sugar beet	2
sweetcorn	1
wheat	15 (14)
Total	23

Table 15. Crop land use foraging sites classified by crop type (of which were harvested when turtle doves visited in brackets).
Tabel 15: Gebruik van akkers als foerageerlocaties geclassificeerd op gewastype (aantal locaties dat geoogst was op het moment van zomertortel aanwezigheid tussen haakjes).

The type of crop grown was also investigated (Table 15). The main crop visited by turtle doves was wheat (15 sites out of 23), followed by flower seed. Compared to the percentage of all crops grown on Walcheren, the doves appear to actively be seeking out these fields.

Another popular land use which was investigated further was agricultural buildings: 13% of foraging sites were located on areas of farm related buildings and yards. Of these 11 sites, chicken and dairy farms comprised the bulk of sites (Table 16).

Some land uses were poorly represented (orchard, feeding station), while others were simply absent. Land uses falling within heavily built-up areas, for example, are well represented on Walcheren but were not visited by turtle doves.

Though woodland and scrub were not well represented in Zeeland, it's absence as a foraging site land use was caused by the foraging data fix criteria, which excluded these data fixes in order to differentiate foraging from singing and loafing behaviour. Other land uses, such as heathland and mining uses, are (virtually) absent in Zeeland.

Table 16. 'Farm' foraging site land uses classified by farm type.
Tabel 16. Type boerderijen gebruikt als foerageerlocaties.

Land Use	# sites
Small holding	1
Crop or unknown	2
Dairy	4
Chicken	4
Total	11

A number of locations stood out as being particularly interesting for turtle doves: 29 different locations containing ≥1 identified foraging site were *also* visited at least once by one or more other tagged doves. Almost a quarter of these locations were on campsites (Figure 22).

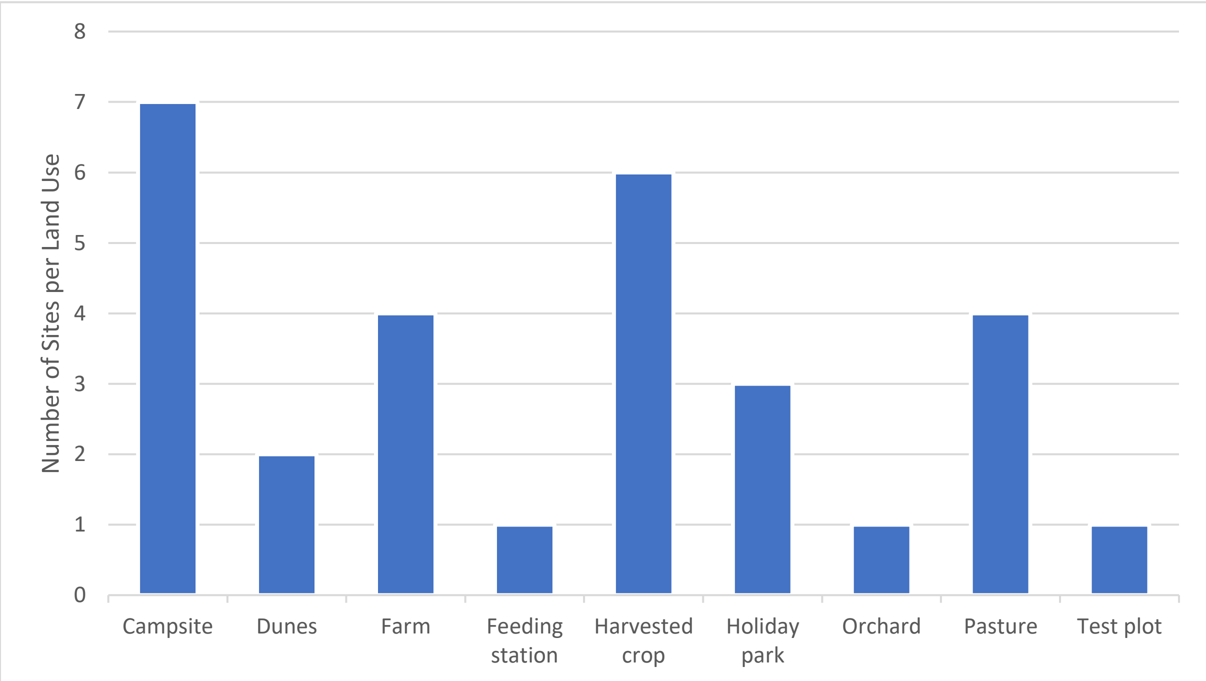


Fig. 22. Land uses of 29 foraging sites visited by multiple tagged doves.
Fig. 22. Landgebruik van de 29 foerageerlocaties bezocht door meerdere gezenderde zomertortels

When was each land use visited by tagged turtle doves?

Before examining individual foraging locations in detail, it's important to know the timing of the dove's visits. This might give insight into food availability or human activity, thereby helping explain why they chose a particular site. The following graph (Figure) illustrates which dates each land was used by a tagged turtle dove. It indicates which land uses were more heavily relied on and when during the breeding season.

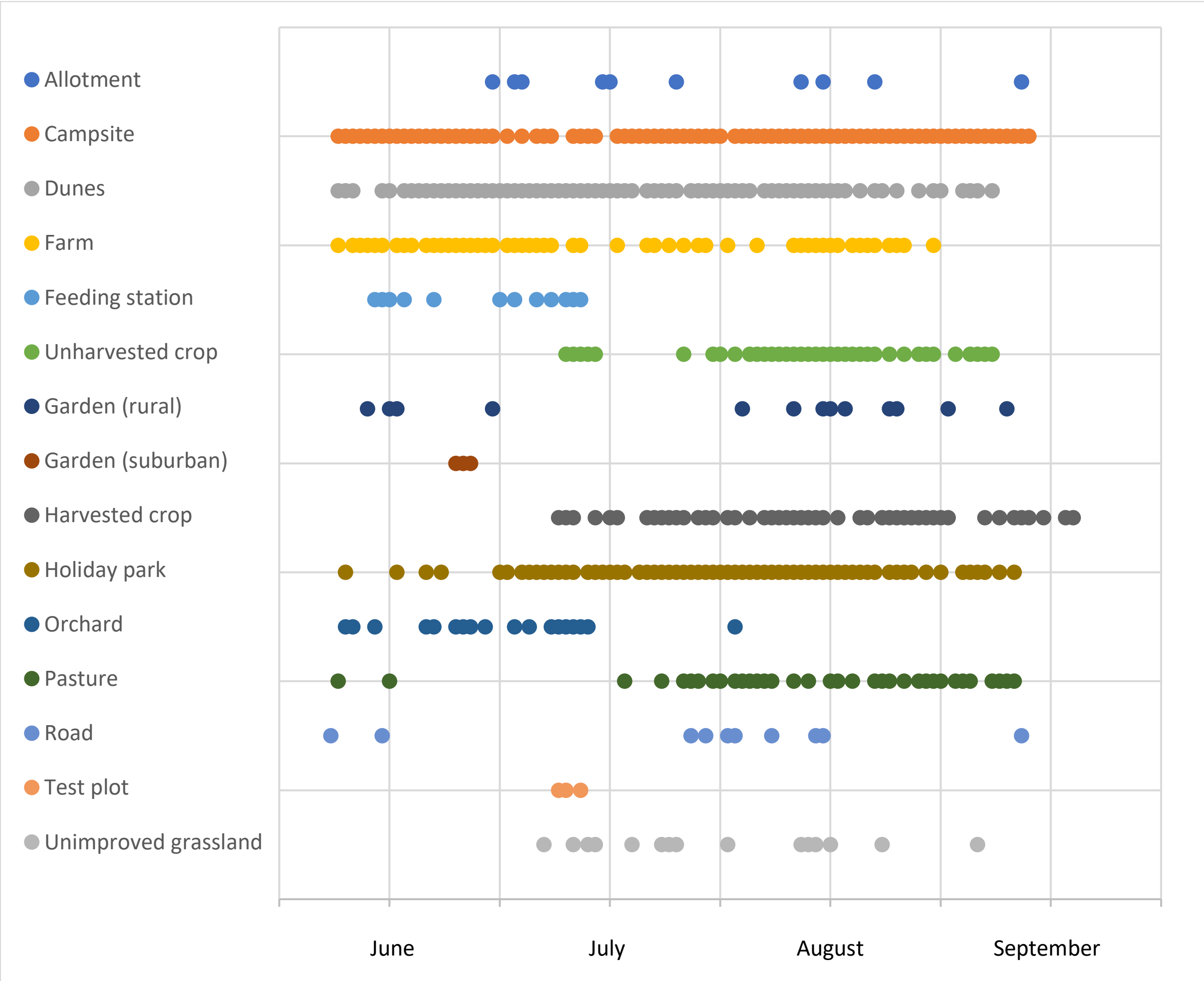


Fig. 23. Days when a turtle dove data fix was recorded at a particular land use (foraging data fixes only).
Fig. 23. Dagen waarop van een gezenderde zomertortel coördinaten werden geregistreerd op een type landgebruik (alleen foerageercoördinaten).

Campsite, dune habitat, rural gardens and allotments were all visited regularly throughout the breeding season, but campsites and dune habitat were visited much more frequently. Subsequently, their average visiting date is around 23rd July – right in the middle of the breeding season.

Some land uses had peaks of activity: crop and holiday park land uses were visited infrequently at the beginning and end of the breeding season (June and September), but almost daily in August and July/August respectively. In the case of crop land use, the average visiting date is 12th August, indicating it is used more heavily in the second half of the breeding season. Interestingly, the average visiting date for both harvested and unharvested crops was the same, and both were visited between mid-July and mid-September. There are some notable differences though: virtually all grain/seed crops (wheat and flower) were only visited after the harvest, while other crops were visited before harvest.

Three land uses, chicken farms, dairy farms and orchard, show a different visitation pattern entirely: intense visits for a rather short period of time, early in the breeding season. The average visiting date for these land uses is relatively early – in June and up until the 10th of July.

CHAPTER 4: Discussion

4.1 Were the foraging fields used?

Research aim: Investigate the effectiveness of foraging fields in supporting European turtle doves.

Objectives:

- Investigate the extent of test field measure use by local turtle doves.
- Compare the use of test plots compared to alternative sources of food.

Camera traps

Data collected over 4458 days was reviewed in connection with this project, covering all test plots for the greater part of the turtle dove breeding season each year (2021-2023). There were 14 camera trap records of turtle doves on the test fields spread over the 3 years, with the majority of instances falling into the third and final year of the research.

The first year was a pilot year, testing different mixes, sowing and management methods in spring sown plots. Consequently, the test plots as a whole performed better in the second and third years of this project. It is likely these results would have been different if the combination of mixes and management, as well as both spring and autumn plots, had been available in the first year.

There are obvious limitations to using camera traps, including its potential overlap with tagged dove visits, counting the same individuals more than once, and the chance of birds being too small or too distant to trigger the movement or warmth sensors. These limitations can only be partially compensated for by the data collection and the analysis methodology. The fact still remains that there will be many instances of birds that have not been captured on the camera - the recorded daily maximum of each species is likely lower than the actual figures.

One factor, which cannot easily be compensated for, is that cameras have only a limited view of the field (ca. 20% under good conditions). Even under the best conditions and methods, the data recorded by each camera is taken to be representative of each test plot. There's no way to determine whether the vegetation variation within each test plot has impacted camera trap recordings of turtle doves.

Regardless of its limitations, the presence of seed eating species on all test plots is encouraging – it indicated that seed was indeed available on all plots, in quantities (and in a location) which made the field attractive to seed eating birds. Pigeons, doves and pheasants were the most frequent visitors to fields, both known to forage from the ground and from low growing plants. However, the presence of goldfinch foraging on the seed heads of tall plants does not indicate a sparse, open habitat. If seed is present, then it comes down to finding the right management balance and techniques required to maintain the habitat in such a way that it remains appealing to doves.

Field observations

Field observations were employed as a monitoring method during the first and second years of this project. However, the results were limited, with bird sightings per visit remaining incredibly low. Only one turtle dove was observed on a test plot.

One advantage of using field observations is that bird watchers can survey the entire field, allowing them to view both test plots simultaneously. Additionally, bird identification can be accomplished through both sight and sound, which enhances the overall monitoring process.

On the downside, certain bird species, such as pheasants, tend to hide in longer vegetation, making them difficult to detect during observation rounds. This challenge persists even when these rounds are followed by walks through the test plots. Furthermore, field observations can be quite time-consuming, especially given the low volume of data collected.

Despite the considerable time and effort invested by field researchers and volunteers, the number of bird sightings recorded per house was too low to justify the continuation of this method in 2023.

Tagged doves

This method recorded 11 GPS fixes within or near designated test plots. Notably, the majority of these fixes were attributed to a single dove in 2023. The use of telemetry offered several advantages. It allowed researchers to follow individual birds at an intensity level that is otherwise not possible. The method does not rely on the dove's vocalizations to indicate its presence, and monitoring of the dove does not stop when the dove flies to another location. Additionally, the turtle doves' coordinates can be recorded at any location, regardless of whether a dove was hidden in vegetation or perched in a tree.

There were, however, a few major limitations to using telemetry. Only eight doves were tagged—four in each study area—which restricted the data pool. Furthermore, it was impossible to predict where the doves would establish their territories or nests – a choice which significantly influences where the doves fly to find food. Additionally, the tags used did not follow a regular data collection pattern due to differences in pre-determined data collection times, and in the battery status and ability to recharge. A dataset with irregular intervals means there are periods of high intensity data collection and periods of low intensity. This inconsistency increased the likelihood of turtle doves going undetected on test plots, particularly if their visit was for only a short period of time. Interestingly, there were only 2 instances where a camera trap record may have overlapped with a tagged dove record ($9^{th}$and 12^{th} July 2023) – the image quality was not sufficient to identify whether the dove recorded was tagged or not.

Despite its limitations, telemetry proved to be a valuable addition to the project: half of the turtle dove records on test plots were collected by tagged doves.

Test plot use

There were relatively few incidences where turtle doves were documented on test plots. For the purposes of this analysis, only records made on or within 5 meters of test plots were included. During the project, a total of 25 turtle dove recordings were made on the test plots (Appendix 14). At least 13 separate visits by turtle doves were recorded by camera trap, including one photograph showing two foraging individuals. Additionally, there were 11 GPS fixes from the tagged doves, most of which were from a single individual in 2023, plus 1 field observation (in 2021).

It has therefore been possible to establish that turtle doves do use foraging fields. However, the test plots were not heavily visited: there were fewer records of turtle doves visiting the test plots than initially expected at the start of this project. To some extent this can be attributed to the fact that the foraging habitat was unsuitable on the test plots, particularly during the first year of the project. There are also some limitations to the methods monitoring turtle dove presence on test plots, which could lead to fewer records than the actual number. However, there are undoubtedly other factors influencing the foraging site selection of turtle doves. Regardless of the cause, the limited observations of turtle doves on test plots have made it difficult to draw many firm conclusions about the effectiveness of foraging fields as a field measure.

The presence of turtle doves on the test plots only partially reflected field suitability. On the one hand, turtle dove visits did indeed coincide with either 'suitable' and, on occasion, 'partially suitable' habitat on fields. In terms of which fields presented optimal foraging habitat for the longest time during the breeding season, Field G autumn and spring 2023, and Field G spring 2022 were among the most successful. These three plots were also the most frequented by turtle doves. It is also noticeable that turtle dove visits to Field G plots were clustered in the period immediately following management, when bare ground and seed availability were at the highest. Both of these observations clearly reiterate the importance of suitable habitat structure and seed availability on attracting foraging doves.

On the other hand, however, there were numerous occasions where the habitat on test plots was considered suitable, but where turtle doves were not recorded. These were Field A autumn and spring in both 2022 and 2023, Field E autumn and spring in 2022 and 2023, and Field C spring and autumn 2022. Field E in 2022 and 2023 was in fact the 'best' field, presenting (visually) suitable foraging habitat for most of the breeding season – a longer time period even than Field G. There are likely other factors playing a role, such as the presence of predators, proximity of landscape features which are not considered in this study. It is also possible that more attractive food source alternatives were available, which is partly reflected in the (tagged) dove's choice to visit farmyards and campsites, where weeds are also plentiful.

Regarding seed availability, it is also interesting that, even in Field G following a management round, the dove/s did not continue to visit the site after the first weeks, despite the plots still having bare ground, an open vegetation structure, and plants of all heights developing seed. The turtle doves seemed to make the most of fallen seed, true to their opportunistic nature, but quickly moved on to the next site where seed is (presumably) more readily accessible. It could be that, after the initial increase in freed up seed lying on the ground, there is a decrease in seed availability which makes the field less attractive, but in the absence of a more rigorous monitoring of seed production and availability it is not possible to determine whether this was in fact the case. Other possible explanations for their behaviour could include, for example, disturbance or the presence of predators.

Factors affecting test plot use

Despite our rather limited knowledge of the drivers behind turtle dove foraging site selection, there are many factors which might explain why some plots were visited and others not, or why individual doves visited a test plot for just a short time period when, to the human eye, a plot appeared 'suitable'. The following are just a few.

1) Turtle dove visits vs vegetation survey data

Comparing the dates of turtle dove visits to the vegetation survey data taken from these moments revealed that plots were visited at moments when bare ground was around 44% and when seed was available. While the average vegetation height could not be investigated in this analysis, more than half the test plot (average 62%) was comprised of either bare ground, or else low vegetation. It is important to note that the limited records of turtle dove visits, combined with the short time periods and limited range of test plots visited, will have influenced these results, making them less reliable. Nevertheless, comparing the vegetation height, seed availability and the percentage of bare ground at these plots broadly reflects the findings of Browne and Aebischer (2003) and Dunn (*et al*, 2015).

2) Field Proximity to turtle doves

Data collected by the eight tagged doves during this project, confirmed that all test fields were well situated for providing foraging habitat. All fields were within 5 km of two or more turtle dove territories, with four fields being within just 1 km of a turtle dove territory. Given the fact that this information represents just a small sample of the turtle dove population in Zeeland, we can assume that each test field fell inside multiple turtle dove home ranges.

Vreugdenhil-Rowlands (2021) suggested that turtle doves with an active nest might be purposely foraging closer to their nest location. Some fields were indeed much closer to turtle dove territory than others: Field G actually fell within the territory of tagged doves Paulina, in 2022, and Ina, in 2023. Paulina nested less than 200 m away from the test plot, and Ina nested twice at a campsite 700 m away (where both she and Paulina regularly foraged in their respective years). Further investigation of the influence of active nests on foraging site location would be useful.

3) Proximity to suitable alternatives

Another possible explanation for the lack of turtle doves recorded on test plots is their proximity to preferred alternative food sources. In the case of Field G and Field C, both are situated literally next door to where birds are fed throughout the breeding season. Field A is next door to a very quiet small holding with livestock. While doves were clearly in the area, perhaps the presence of 'fast food' reduced the need for turtle doves to use test plots for foraging in these areas.

It is worth noting that the Field G test plots were still visited despite the presence of supplementary feeding next door, however the frequency varied per dove. In 2022, Paulina was actually recorded foraging 18 times, throughout the breeding season, in the garden where supplementary feeding was provided, compared to just 3 records of her on the test plots next door. Ina in 2023, however, was never recorded in the garden, yet was recorded 8 times on the test plots. The exact reasons for these discrepancies are unclear, though it does indicate that foraging fields could still play a role in providing food for turtle doves, despite the presence of supplementary feeding at a neighbouring site.

Aside from supplementary feeding locations, alternative foraging sites also include harvested crop fields, which are popular from the end July. As opposed to a constant supply of seed, such as that of many test plots, in wheat and flower seed crops, harvesting brings about a sudden surge in suitable habitat (stubble) filled with spilt seed. Other foraging site alternatives could include sites rich in weeds – rural gardens, unsprayed farmyards, marginal and fallow ground all have the potential to offer foraging habitat.

4) Behavioural Adaptation to the 'hunger gap'?

It is interesting that, despite many plots having optimal foraging habitat in early spring (May 2022 and 2023), no turtle doves were recorded on test plots at this time aside from the (likely) coincidental visits made to C and E 2021. With Browne & Aebischer (2004) postulating that a hunger gap is an issue for turtle doves, the expectation was that turtle dove visits would most likely be recorded in May when 'natural' seed abundance in the wider landscape is still rather low. This could partly be attributed to the fact that turtle doves were only tagged in June: no dove was followed for more than a single breeding season. The absence of this monitoring method in spring This project, along with the study carried out in the Zak van Zuid Beveland (Vreugdenhil-Rowlands, 2021) revealed that turtle doves were visiting farms and smallholdings earlier in the breeding season (late May to early June), followed by marginal areas from June until mid-July, and predominantly harvested fields from mid-July onwards. Turtle doves are highly opportunistic with respect to foraging location and appear to be going wherever there is the most seed.

It is not impossible that their shift in behaviour (and therefore diet) from agricultural weeds to harvested grains (Browne & Aebischer (2003) also extends to a behavioural shift associated with food shortages in early spring. Perhaps they no longer consider fields to be a suitable food source in April and May, and purposely target farms and small holdings due to their abundance of seed. It raises the question of whether they still experience the 'hunger gap', if they have adapted to find sufficient food elsewhere. Unfortunately, such alternative food rich locations will not always be available. If turtle doves have become dependent on humans, who intentionally or unintentionally provide them with food, this would make them very vulnerable to food availability changes. It would be preferable if the 'natural environment' in which they live is able to provide them with a stable food source.

Birds of Prey

In the cases of Fields C and D, these locations had the greatest incidences of buzzards caught on camera traps, and Field E had an active buzzard nest in the adjoining copse. Raptor presence could be putting turtle doves off foraging in the openness of the field next door.

Other Possible Factors

Besides the above-mentioned factors, there are numerous other factors which may also weigh in to the decision of a turtle dove to select a certain site for foraging.
These include the following:

- The location of foraging fields within the wider landscape (i.e. their proximity to small- or large-scale agriculture, urban areas or dikes)
- Proximity to turtle dove friendly landscape features (such as trees, scrub, pools etc.)
- Proximity to suitable nesting habitat (such as overgrown Zeeuwse hedges or hawthorn scrub for example)
- Site disturbance (either from humans or from predators)

4.2 Creating and managing foraging fields

Research aim: Identify agri-environmental measures that will provide suitable foraging habitat for European turtle doves.

Objectives:

- Test bespoke seed mixes to identify the most suitable combination of species to provide ripe seed throughout the breeding season.
- Investigate the impact of different sowing moments (spring sowing vs autumn sowing) in providing suitable foraging habitat.
- Test management methods to create a vegetation structure suitable for turtle doves.

Seed mix

The seed mix composition used during each sowing round was constantly improved upon. The third and fourth mixes (sown in 2022), sown at a density of 5 kg/ha and using the final sowing method (Figure 24) appeared to provide the best vegetation density of those tested in this project. The decision to remove grass species from seed mix 4 was a logical one, given that species such as cocks-foot and wild rye are neither low growing nor quick to go to seed. This mix was only tested for a single growing season on three particularly challenging fields, so further trials would be beneficial before drawing firm conclusions regarding seed mix composition.

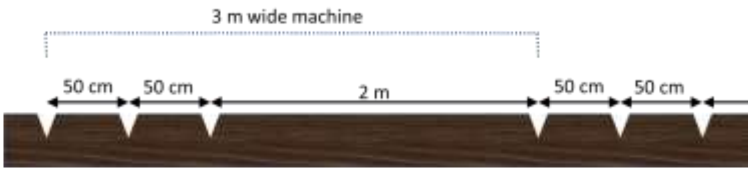


Fig. 24. Illustration of the final sowing method used.
Fig. 24. Ter illustratie – uiteindelijke definitieve inzaaimethode.

It is possible that an even simpler seed mix of the lowest growing and quickest seeding five species (field pansy, miner's lettuce, corn spurrey, black medick and lesser trefoil), in combination with spontaneous plants in the seed bed, could produce an even better mix in terms of vegetation height and the speed at which the mix matures and produces seed following sowing/management. NB) Regardless of the mixture composition or whether spontaneous weeds are expected to provide seed for turtle doves, extra management between the sown rows is still necessary to ensure minimal competition against the sown species.

Sowing moment

Regarding differences in sowing moments (spring sowing vs autumn sowing), if the aim is to immediately bridge the turtle dove 'hunger gap' (the time period between turtle doves arriving from Africa in April and the setting of seed by native plants in spring), then autumn sowing of foraging fields is more suitable. These plots produced seed much earlier than their spring sown counterparts during the first growing season. However, this is not to say that spring sown plots are completely unsuitable: during their first growing season, suitable foraging habitat was present on several spring plots from June onwards, with Field G receiving repeated turtle dove visits during this time. During their second growing season, there appeared to be little visual difference between autumn and spring sown fields. The timing of sowing did influence the presence of certain spontaneous weeds however. Sowing in spring led to the germination of large amounts of goosefoot species on certain test plots, while autumn sown plots had more common groundsel. Some spontaneous weeds such as camomile and orache germinated regardless of sowing moment.

The spring plots where seed mix 1 was followed through a third growing season indicated a decline in the lower growing, quick seeding plants that were more desirable, and an increase in grasses and spontaneous weeds. This suggests that bespoke turtle dove seed mixes can only go a maximum of 2 growing seasons before needing to be cleared and resown.

Seed mixes 2 and 3 were tested for 2 consecutive seasons, and seed mix 4 for just a single growing season. Further testing and/or analysis is needed to determine whether seed mixes 2, 3 and 4 would (likely) experience the same issues in their third growing season.

Field management

All fields, regardless of sowing time or growing season, needed management in mid-April (and then again in mid-May) to ensure the test plots presented suitable foraging habitat for returning doves. For test plots entering their first growing season, hoeing was an effective technique, while for subsequent growing seasons shallow harrowing was a more suitable technique to use with the taller and greater quantities of vegetation present.

Hoeing between the sown rows of seed mix was very effective in reducing spontaneous weeds, and therefore the competition. It was particularly useful in spring sown plots where seeds in the existing seed bed have the advantage of a head start. Hoeing was only during the first growing season, when sown rows were visible, and only as long as the germinating vegetation was sufficiently low, after which another management method was needed.

The biggest difference between the techniques was on how quickly the vegetation regenerated and made the habitat less suitable for foraging turtle doves. By disturbing the soil (and therefore root system) of growing plants, power harrows and cultivators created very bare ground which took a few weeks to regenerate and grow. (Flail)mowers on the other hand left the root system intact, meaning the vegetation could immediately start regrowing following management.
The quicker the vegetation regrew, the quicker the plot became less suitable for turtle doves and the sooner landowners needed to manage the ground again. In this sense, shallow power harrowing or cultivating were the more effective of the management techniques.

The other factor affecting management frequency was the percentage of bare ground created in a single round. The best strategy was to create wider bare strips (2-3 m), with remaining vegetation strips of 1 m wide, which creates 60 – 70% bare ground. This took 3-4 weeks before the vegetation started to grow too dense or tall for turtle doves. Narrower bare strips (1 m wide), with remaining vegetation strips of 1.5 m wide, also worked to some extent, but created just 40% bare ground. Once vegetation started to regrow, the percentage quickly fell below 30%. Furthermore, the narrower bare strips had a tendency to 'feel' more closed in than wider strips – particularly as the vegetated strips either side grew taller and vegetation started to collapse into the cleared strips. Consequently, subsequent management was needed sooner than when wider bare strips were created.

Further details regarding management strategy, some of the challenges faced and lessons learned are detailed in Appendix 19.

Test plot performance: trends

While each field performed differently, and despite variations each year in weather and management timing, these suitability diagrams can be interpreted with the help of field photos, expert knowledge and the information gathered from field visits. Some important trends emerge when the diagrams are compared.

Trend #1) Sowing moment effect on a plot's first growing season

The first notable difference is how soon or late spring and autumn sown plots presented suitable foraging habitat for doves in the subsequent first growing season. Plots sown in the spring only developed their seed from June onwards, meaning fields were not suitable for foraging until mid-June at the earliest. To the contrary, autumn sown test plots were already producing their first seed in May, which meant that fields were suitable as soon as they were managed. In subsequent growing seasons, there was little difference between spring and autumn sown plots: if managed in early May, both could provide suitable foraging habitat for turtle doves.

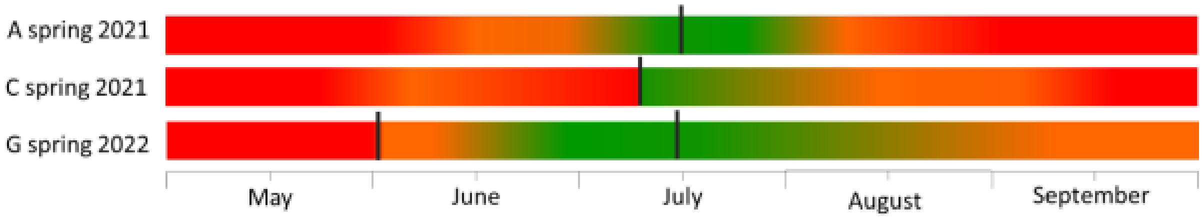


Fig. 25. Field suitability of spring sown test plots during their first growing season.
Fig. 25. Geschiktheid voorjaarsveldjes in hun eerste groeiseizoen.

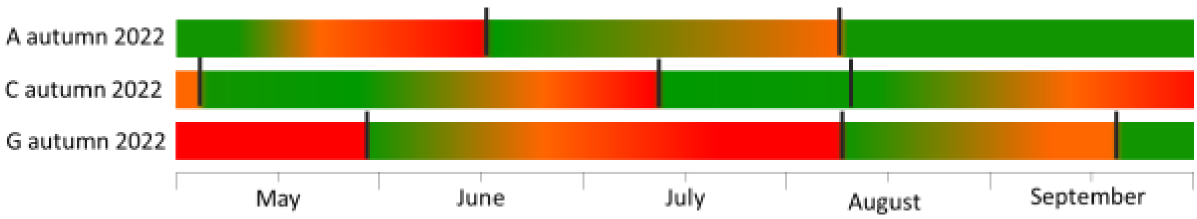


Fig 26. Field suitability of autumn sown test plots during their first growing season.
Fig. 26. Geschiktheid najaarsveldjes in hun eerste groeiseizoen.

Trend #2) The importance of field management before turtle doves arrive back in the Netherlands
For any established plot, seed availability is not the limiting factor affecting the plot's suitability: the presence of sufficient bare ground is. In all cases, as soon as strips were harrowed through the vegetation, the plots were offering suitable habitat for foraging turtle doves.

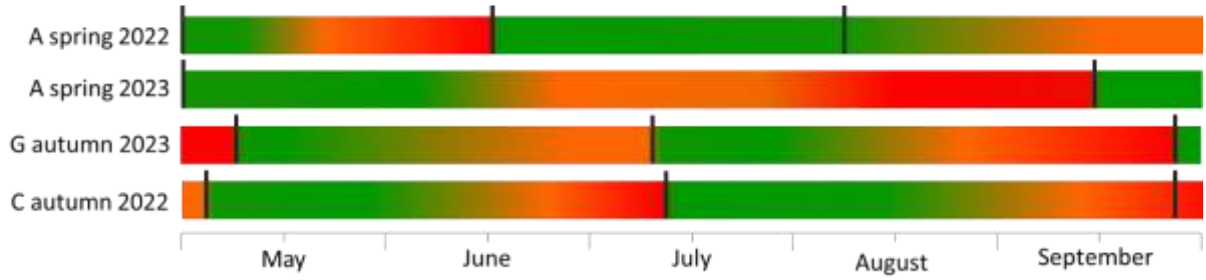


Fig 26. Field suitability of established plots (both spring and autumn sown), illustrating the importance of managing each plot before/when turtle doves return to the Netherlands.
Fig. 27. Veldgeschiktheid van gevestigde percelen (zowel voor- als najaarsvelden), waarbij het belang wordt geïllustreerd van het beheren van elk perceel voordat zomertortels terugkeren naar Nederland.

Trend #3) The importance of management to maintain suitable foraging habitat
As evidenced by these suitability diagrams, management plays an essential role in maintaining the suitability of plots for turtle doves. Timely management, as seen in both autumn and spring plots in Field A, can result in maintaining suitable foraging habitat for turtle doves for weeks at a time. Equally, waiting too long between management moments resulted in a plot quickly becoming overgrown and therefore unsuitable for turtle doves. In all plots where management created sufficient bare ground, suitable foraging habitat was achieved. In the case of fields A, C and G (shown in the diagram below), power harrowing bare strips was the primary management technique. This technique, applied to 60-70% of the plot, resulted in no further management being needed for 4 – 6 weeks.

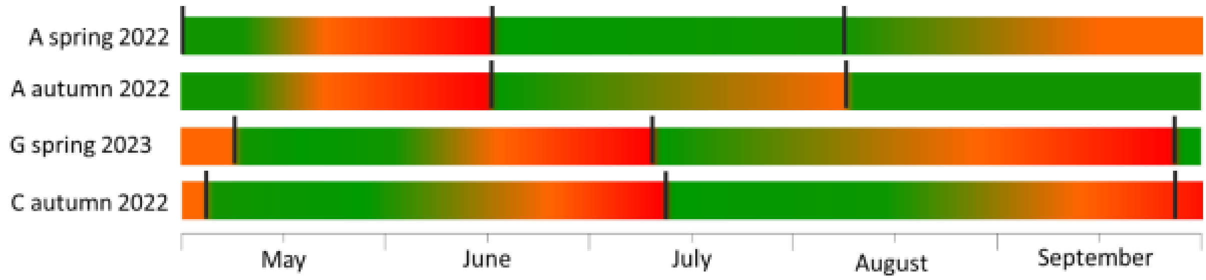


Fig. 278. Field suitability of established plots (both spring and autumn sown), illustrating the importance of management throughout the growing season.
Fig. 28. Veldgeschiktheid van gevestigde percelen (zowel voor- als najaarsvelden), waarbij het belang van beheer gedurende het groeiseizoen wordt geïllustreerd.

There were ultimately a small number of instances where a following management round occurred before the plot became less suitable, namely in Field E and Field G (diagram below). On the spring plot of Field G in 2022, management occurred in early June on the newly sown plot (hoeing between rows and clearing unsown strips). As more seed began to ripen, the habitat went from being 'partially suitable' to 'suitable'. The next management moment occurred approx. 5 weeks later, in mid-July, while the habitat was still suitable for turtle doves. By creating new bare ground, before the old bare strips had completely revegetated, a prolonged period of suitable habitat was created – 2 ½ months of suitable foraging habitat, with an additional 1 ½ months of partially suitable habitat before and after in June and September.

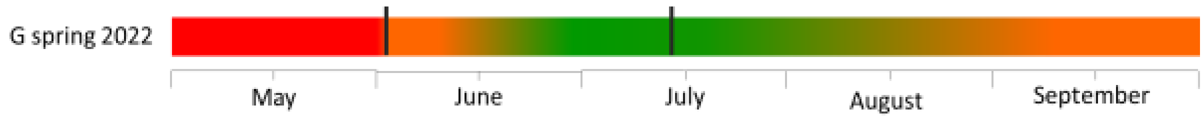


Fig 28. Suitability of field G spring plot during its first growing season - timely management led to prolonged habitat suitability.

Fig. 29. Geschiktheid van veld G voorjaarsveld tijdens het eerste groeiseizoen – tijdig beheer leidde tot langdurige geschiktheid van de habitat.

Trend #4) Harrowing, cultivating and hoeing worked better than mowing

The following suitability diagrams compare 2 spring plots during their first and second growing seasons, on 2 different fields. Field D used flail mowing to create bare ground and reduce vegetation height, while Field G used harrowing instead.

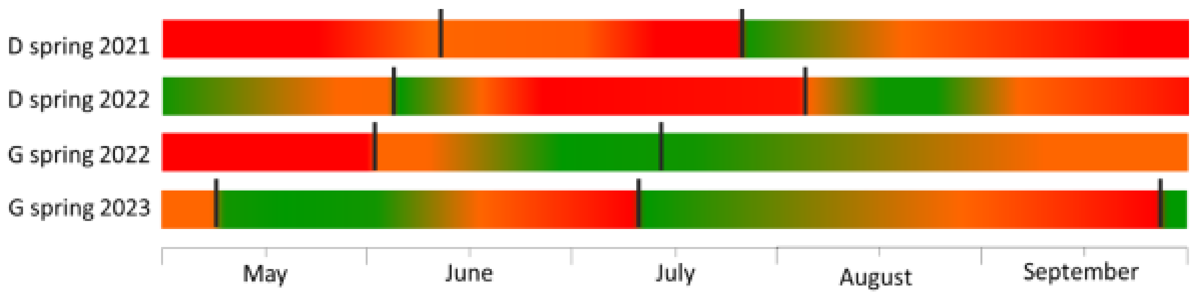


Fig. 29. Field suitability of spring plots from Field D and Field G, during their first and second growing seasons. Field D was managed by flail mowing, Field G by harrowing.

Fig. 30. Geschiktheid van voorjaarsvelden D en G, tijdens hun eerste en tweede groeiseizoen. Veld D werd beheerd door klepelmaaien, veld G door frezen.

The diagrams of Field D indicate that the spring plot only stayed suitable for 2-3 weeks following a management moment. The Field G diagrams on the other hand, indicate that the plots remained suitable for 4-5 weeks following management.

While fewer fields used flail mowing as opposed to harrowing, the general trend was that mown plots required their next management round within 3 weeks, while harrowed plots could go 4 or 5 weeks before needing further management. This difference makes the latter management technique (harrowing) preferable.

4.3 Foraging site selection

While differences between test plots might influence their use by turtle doves, the examination of alternative foraging locations sheds some light onto other factors which may play a role in foraging site choice. There are a few important considerations when interpreting the telemetry data to identify foraging sites.

Firstly, as previously mentioned, the tags did not follow a regular data collection pattern. With periods of high and low data collection, there are therefore many opportunities for doves to visit an area (such as a foraging site) and go unrecorded. This is especially the case for sites which are visited intensely by doves for a short period of time.

The second major influencing factor is that the number of foraging sites identified is entirely dependent on the criteria used to define them. By excluding datapoints directly above trees, scrub, water and buildings, it was possible to exclude locations where the turtle doves were likely nesting, loafing and singing, and include foraging locations found within their territory. However, with the variation in tag accuracy there are undoubtedly points incorrectly included and excluded from the foraging dataset used to identify the foraging sites. This has been partially compensated by the sheer volume of data fixes combined with the criteria that a dove must regularly return to a suspected foraging location on multiple days: even with infrequent, inaccurate points, foraging 'hotspots' visited by multiple doves on multiple days are certainly identifiable.

By choosing to include territories (areas of high data fix frequency and density) when identifying foraging sites, the risk of wrongly labelling a site as a foraging site is higher. It was considered worth the risk in this project on the premise that young turtle doves forage within 300 m of their nest for the first weeks after fledging (paper). This means that turtle dove territories undoubtedly contain suitable foraging habitat.

For land uses well represented, such as crop and campsites, the danger of some sites being incorrectly labelled as foraging sites is offset. In the case of irregularly or infrequently visited land uses, such as orchard and allotment, the influence of a singly misidentified foraging site is substantial. For this reason, conclusions have been drawn based on expert knowledge and interpretation of multiple facets of the data.

The largest number of foraging sites occurred on fields containing crops (28%). On the back of previous research and anecdotal evidence, this was expected: in the Netherlands, as in the UK, turtle doves are seen as a farmland bird. The analysis of faecal samples has shown a dietary shift in dominant plant species, from non-cultivated arable plants in the 1960s, to cultivated plants, such as wheat and oilseed rape in the 1990s (Browne & Aebischer, 2003; Murton *et al*, 1964).

The next most frequently occurring land uses came as bit more of a surprise: campsites (18%) and dune habitat (11%). Additionally, there were several foraging sites whose land use necessitated further investigation (holiday park, dairy farms and chicken farms).

Certain land uses were naturally excluded (woodland) due to the foraging data fix criteria that excluded all fixes taken in woodland and scrub. This was done to separate occasions when doves were foraging on the ground from when they were likely singing or loafing in a tree. It is worth noting that turtle doves breeding further south (France, Spain) are also known to forage on the bare ground level of mediterranean forests. In the Netherlands there is evidence that turtle doves use clearings to forage but, due to the lack of densely forested areas in Zeeland there is a paucity of data regarding this aspect of their behaviour.

Crops

The popularity of wheat and of harvested fields often appear together – the stubble or, in some cases, lightly worked ground following harvest leads to a sudden change in habitat structure and seed availability. The densely growing wheat, typically too tall and dense to provide suitable foraging habitat for turtle doves, is replaced by bare ground and short stubble. The inefficiencies of farming machinery create a field full of spilled grain suitable for turtle doves and other seed eating birds.

Interestingly, the average visiting date for both harvested and unharvested crops was the same, and both were visited between mid-July and mid-September. There are some notable differences though: virtually all grain/seed crops (wheat and flower) were only visited after the harvest, while other crops were visited before harvest.

Campsites

One of the most notable developments in lieu of the growing tourism and hospitality sector has been that many farmers have broadened their income base by setting up small campsites on their land. These small campsites were very popular with the tagged doves throughout the whole of the breeding season, not only for foraging, but also for nesting.

In general, these 'minicampings' on Walcheren, and some holiday parks, reflect the (weed) rich, 'small scale landscape' referred to in literature as being preferred by turtle doves (Murton *et al*, 1964): bare parking areas, weed rich verges and playgrounds, areas of grassland and bare ground, overgrown hedges, trees and scrub, clover rich lawns, are all present in close proximity. This might explain why the doves are targeting these sites, despite the presence of holiday makers.

Regarding the dove's absence from towns, yet undisputable use of these campsites suggests they are not entirely put off by people. It is possible that turtle dove behaviour reflects moments of peak human activity – perhaps a closer look at the timing of dove visits to tourist hotspots would reveal that doves are most active in moments when human activity would be reduced, such as early morning, late evening, or around lunchtime. In some cases, it could be that doves are selecting these areas as suitable nesting/foraging locations before tourism reaches its peak. By the time the dove realises how busy the site is, they may have already committed to a territory or nest here and be more reluctant to relocate.

Small campsites were visited throughout the breeding season, illustrating their apparent suitability as a stable food source. The fact that they were visited almost daily speaks to their suitability as foraging habitat: they seem to be at least as suitable as the seed stores/spills at dairy and chicken farms, and the newly harvested crop fields the doves are visiting.

Chicken farms

Two chicken farms were visited by four different tagged doves, but only one of these farms could be investigated in real detail. Most notably, the biggest attractions at the chicken farm were the open manure silo, which undoubtedly collected left over grains as well as manure, and a private allotment which contained a lot of bare ground and weeds, and where birdseed was often scattered.

Dairy farms

Four dairy farms were visited by tagged doves in 2022 – Sebastiaan (2), Victor (1) and Marein (1). At these locations, as with chicken farms, foraging data fixes were clustered around specific areas of the farm including weed rich corners of the farmyard, areas of spilt silage and grain, and open concrete trench silos containing ensiled maize.

Supplementary feeding stations

The lack of supplementary feeding station use by tagged turtle doves was an interesting finding, though not entirely unexpected. Anecdotal evidence suggests that turtle doves use the feeding stations in Zeeland more heavily and regularly earlier in the season (May/June), but their use of this food source peters off in July and is limited by August. This pattern was also observed during the project. In June it was not uncommon for field researchers to observe multiple doves foraging together on a daily basis, while in July turtle dove activity decreased and visits of (untagged) turtle doves to feeding stations became more sporadic. In the absence of colour rings, individual identification of birds was not possible, but 4 individuals were caught and ringed during their feeding station.

Land Use Preference over time

On Walcheren, as seen with turtle doves breeding in the Zak van Zuid Beveland (Vreugdenhil-Rowlands, 2021), the turtle doves appeared to experience a shift in their foraging site choice: in May and June, when agricultural weeds are limited or else have not yet gone to seed, their foraging behaviour is focussed on areas where seed is stored or spilt. Later in the season, when fields are being harvested and seed/grain is being ‘released’, crop fields suddenly become a more attractive foraging alternative.

The timing of turtle dove visits to chicken and dairy farms, in the first half of the breeding season, could indicate either a lack of food availability elsewhere, and/or that the opportunistic nature of turtle doves draws them to these food sources following migration and prior to egg laying. As observed in the research by Vreugdenhil-Rowlands (2021), the turtle doves apparent lack of interest in these food sources during the rest of the breeding season, despite their constant availability, suggests that the latter may be a more plausible explanation.

Foraging sites identified in this study indicate a high number of ‘crop’ land use sites in the second half of the breeding season, once again aligning with what was observed by Vreugdenhil-Rowlands (2021). The tagged doves on Walcheren, appear to be actively visiting seed/grain crops around and immediately following their harvest. While harvesting dates were not accurately recorded during this project, the timing of turtle doves visiting certain crops, combined with anecdotal evidence certainly agrees.

This shift in land use preference over time is almost certainly a reflection of the turtle doves’ opportunistic nature; they are selecting locations where seed is most readily available.

Multiple foraging sites

Turtle doves used several foraging sites at once both in this study as well as in the Zak van Zuid-Beveland (Vreugdenhil-Rowlands, 2021). It appears to be in their nature to move from field to field according to the food supply. With this being the case, it can also be expected that turtle doves will naturally be using alternative food sources alongside foraging fields.

CHAPTER 5: Conclusions

Foraging Fields as a Field Measure

This project has made significant progress in identifying suitable seed mix species and effective methods for sowing and maintaining test plots. While the resulting plots have attracted various birds, animals, and insects, their use by turtle doves has been limited. In part this can be explained by unfavourable vegetation characteristics in test plots, probably rendering them unsuitable as turtle dove foraging habitat some of the time.

Despite this, this research highlights several key insights with regard to the creation and maintenance of foraging fields for turtle doves:

- Foraging fields can be successfully created and contribute to the turtle dove diet.
- Foraging fields, in their current form, are not the primary choice for turtle doves.
- There is potential for improvement in the establishment and maintenance of foraging fields.
- Foraging fields have the potential to offer a stable food source during the breeding season, complementing existing food options.
- Creating and maintaining foraging fields within standard agricultural settings is challenging; they require flexibility beyond a standardized approach.
- Further research into alternative methods for establishing these fields and other stable, alternative food sources is needed.
- The possible effect of foraging field proximity to territories, nests and landscape features on foraging habitats needs further exploration. This could help guide further improvements to the area surrounding foraging fields, or the selection of new foraging field locations.

A primary challenge has been achieving the right balance in management techniques and timing to create adequate foraging habitats. More than half of the participating fields qualified for exceptions to the management methodology, indicating a need for adaptive field management. These adaptations—ranging from using hand tools to specific weed control measures—reflect the variability among agricultural practices and the influence of historical farming methods. Thus, a tailored approach is essential for maximizing the success of foraging fields, as a "one size fits all" strategy is not applicable.

As a result, foraging fields for turtle doves are not yet ready for formal policy adoption. The challenges surrounding the consolidation of different management needs and uncertainties regarding their effectiveness necessitate further research if this is to be the aim.

Insights into turtle dove foraging site selection

This research also highlights several interesting insights into the behaviour of turtle doves:

- Doves utilize a variety of food sources. Even in the event that specially created foraging fields become their primary food source, it should still be expected that doves will utilise several foraging sites simultaneously.
- The foraging sites preferences of turtle doves throughout the breeding season seem to reflect food availability, as in previous research (Vreugdenhil-Rowlands, 2021): livestock farms and farmyards in early spring, and harvested fields in the mid to late summer.
- Small areas with human activity and concrete are not necessarily off-putting for turtle doves, though if these sites are used, they are indeed particularly rural and invariably include hedges, low-intensity grass and trees.
- Small scale landscapes, such as the mini campsites found on Walcheren, appear particularly attractive to turtle doves and likely provide a reliable food source throughout the breeding season.

Moving Forward

The findings of this study can serve as guidelines for creating best practice foraging fields, or as a starting point for future efforts to create foraging opportunities for turtle doves.

Each field should be evaluated individually, considering its historical uses when developing a management plan. To increase the chances of success, landowners should be well acquainted with the needs of the turtle dove and the characteristics of suitable foraging habitats. This will help them make independent decisions regarding the timing of management. Regular (external) assessments, approximately every six weeks from April to July, would help ensure that management efforts are aligned with turtle dove needs.

A complete list of practical recommendations for the creation of a foraging field, based on our findings from this project, can be found in Chapter 7 (Recommendations for foraging fields).

Efforts to investigate alternative turtle dove foraging opportunities and locations, outside of the agricultural setting, can be guided by the land use preferences that tagged doves have shown. For example, their constant presence at small campsites makes it worthwhile to investigate foraging strips, or similar, at these locations.

CHAPTER 6: Further Research Needs

This project highlights the need for follow-up research in specific areas. particularly regarding European turtle dove behaviour.

One important area to explore is the potential for creating foraging opportunities for turtle doves beyond agricultural contexts. The challenges faced in managing test plots raise questions about the feasibility of implementing prescribed measures like foraging fields within current agricultural systems.

It would be worth investigating whether alternative land users—such as small campsites, holiday parks, recreational grounds, or other private landowners—might be more successful in creating suitable foraging opportunities for doves.

Additional data is needed on where turtle doves forage in April and May. Although at least one tagged dove returned, no tagged individuals were contacted by the base station in subsequent years, resulting in a lack of data immediately after their arrival in April and May.

Further investigation of how different factors influence foraging site selection would be useful in guiding further efforts to support the species. Factors such as nest and territory locations appear to influence how far turtle doves are willing to travel, though the extent of this influence is not yet clear. Additionally, obtaining concrete information regarding the impact of supplementary feeding stations and various landscape features on the turtle doves foraging site selection process would be valuable. Specifically, it would be useful to determine what drives turtle doves to prefer one dairy farm or harvested wheat field over another.

CHAPTER 7: Recommendations for foraging fields

Recommendations for creating and maintaining foraging fields for the European turtle dove, based on research carried out in Zeeland (2021-2023)

Foraging fields as a field measure

The foraging fields tried and tested during this project all performed differently due to a range of factors including, but not limited to, past land use, crops grown in previous years, soil type, weather following sowing, and appropriate and timely field management. The findings of this study can serve as guidelines for creating best practice foraging fields, or as a starting point for future efforts to create foraging opportunities for turtle doves.

Each field should be evaluated individually when developing a management plan. To increase the chances of success, landowners should be well acquainted with the needs of the turtle dove and the characteristics of suitable foraging habitats. This will help them make independent decisions regarding the timing of management. Regular (external) assessments, approximately every four to six weeks, from April to July, would help ensure that management efforts are aligned with turtle dove needs.

Efforts to investigate alternative turtle dove foraging opportunities and locations, outside of the agricultural setting, can be guided by the land use preferences tagged doves have shown during this research. For example, their constant presence at campsites, make it worth investigating the feasibility of foraging strips, or similar, at these locations

Disclaimer

The advice provided here regarding the creation and management of bespoke 'foraging fields' for the European turtle dove is based on our current knowledge and expertise regarding the species, and on research that has been carried out in Zeeland the past years. However, it is important to note that our understanding of European turtle dove ecology is constantly evolving. Furthermore, the effectiveness of 'foraging fields' in turtle dove conservation has not yet been established.

Additionally, it is important to consider that the research this advice is based on has been carried out on Walcheren, Zeeland, an area dominated by heavy clay soils. Therefore, the applicability of these recommendations will likely vary, depending on the specific environmental conditions and soil types in other regions.

Site selection

Foraging fields should be located 300 m from existing turtle dove territories (Operation Turtle Dove, UK) or else within 300 m from suitable nesting habitat and a source of water.

Seed mix and sowing

Recommended species: corn spurrey, black medick, lesser trefoil, miner's lettuce, field pansy

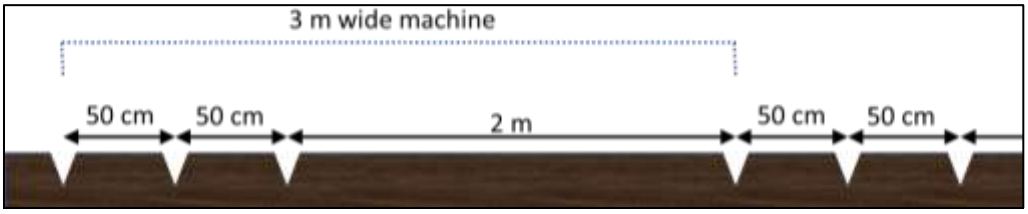
The final seed mix tested on this project was as follows (percentage weight). A simpler mix of just 4 or 5 species could be just as suitable and needs further testing.

Red Clover Pastor	2%	Common Vetch	5%	Long-headed Poppy	10%
White Clover	3%	Narbonne Vetch	5%	Miner's Lettuce	15%
Common Bird's-foot	5%	Spurrey	10%	Cornflower	5%
Black Medick	15%	Camelina	5%	Field Pansy	5%
Lesser Trefoil	5%	Buckwheat	10%		

Sowing density: 5 kg/ha

Sowing moment: Autumn

Sowing method: Before sowing, create a false seedbed to reduce problematic weeds.
Sow 3 rows (50 cm apart), followed by a 2 m wide unsown (see figure)
Resowing is required every 2 years



Management

Regular, timely management is needed to maintain an open and sparse foraging habitat through the growing season. When harrowing and hoeing are used, management will be needed every 4 – 6 weeks (see figure for suggested timing).

Each management round is carried out in a different direction. This ensures that vegetation does not become too dense or tall, sufficient bare ground is available, and seed from either the sown mix or from spontaneous weeds has time to develop and ripen.

	April		May				June				July				Aug	
Week	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Management round	Round 1				Round 2					Round 3					Round 4/ End	

Round 1

When: Late April/early May

Aim: Create 60% bare ground in strips

How: EITHER Hoeing between sown rows (applicable only during first growing season when rows are visible) .

OR Hoeing or shallow power harrowing unsown strips (5 cm depth) of 2 m wide, and leaving a vegetated strip of 1 m wide.

Rounds 2 - 4

When: Every 4 – 6 weeks

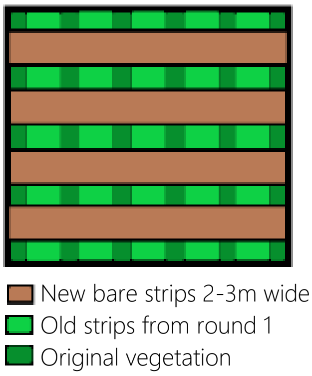
Aim: Create 60% bare ground in strips

How: Each round harrows a different direction.

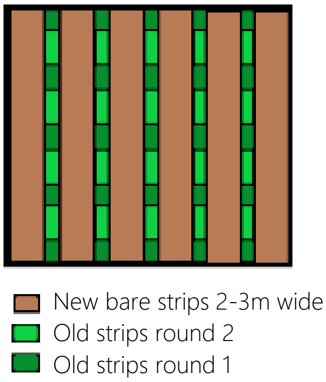
Hoeing or shallow power harrowing 2 – 3 m wide strips, leaving a vegetated strip of 1 m wide.

Round 1

Round 2



Round 3



Photos: How vegetation should look after 3 or 4 management rounds. There should be squares of vegetation at different heights and flowering stages, alongside the newly harrowed bare strips.

Management Round (final)

When: From early August

Aim: Create 60 – 90 % bare ground

How: EITHER create more bare strips when needed until the end of September, then leave the field vegetated through the winter,
OR mow the entire field so it appears 'harvested'. Leave it as stubble through the winter*.

*This was done on test plots during the project, however there is no evidence to determine whether this was beneficial or not. At this time of year, once harvested cropped fields such as flower seed and wheat became available, these land uses provided popular foraging sites for the tagged doves.

Notes)

To ensure landowners are knowledgeable of the needs of turtle doves, it would also be beneficial to meet with landowners, prior to setting up a foraging field. This would provide a chance to explain the instructions, educate them on how to recognise and judge suitable habitat and answer any questions.
Some form of standardised reminders and regular plot assessment from a knowledgeable field ecologist would need to be incorporated into the plan.

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Images: Fieldwork related

Jennifer Vreugdenhil-Rowlands, Lead Researcher

Elsa July – Intern 2023

Sebastiaan Roest - Intern 2022

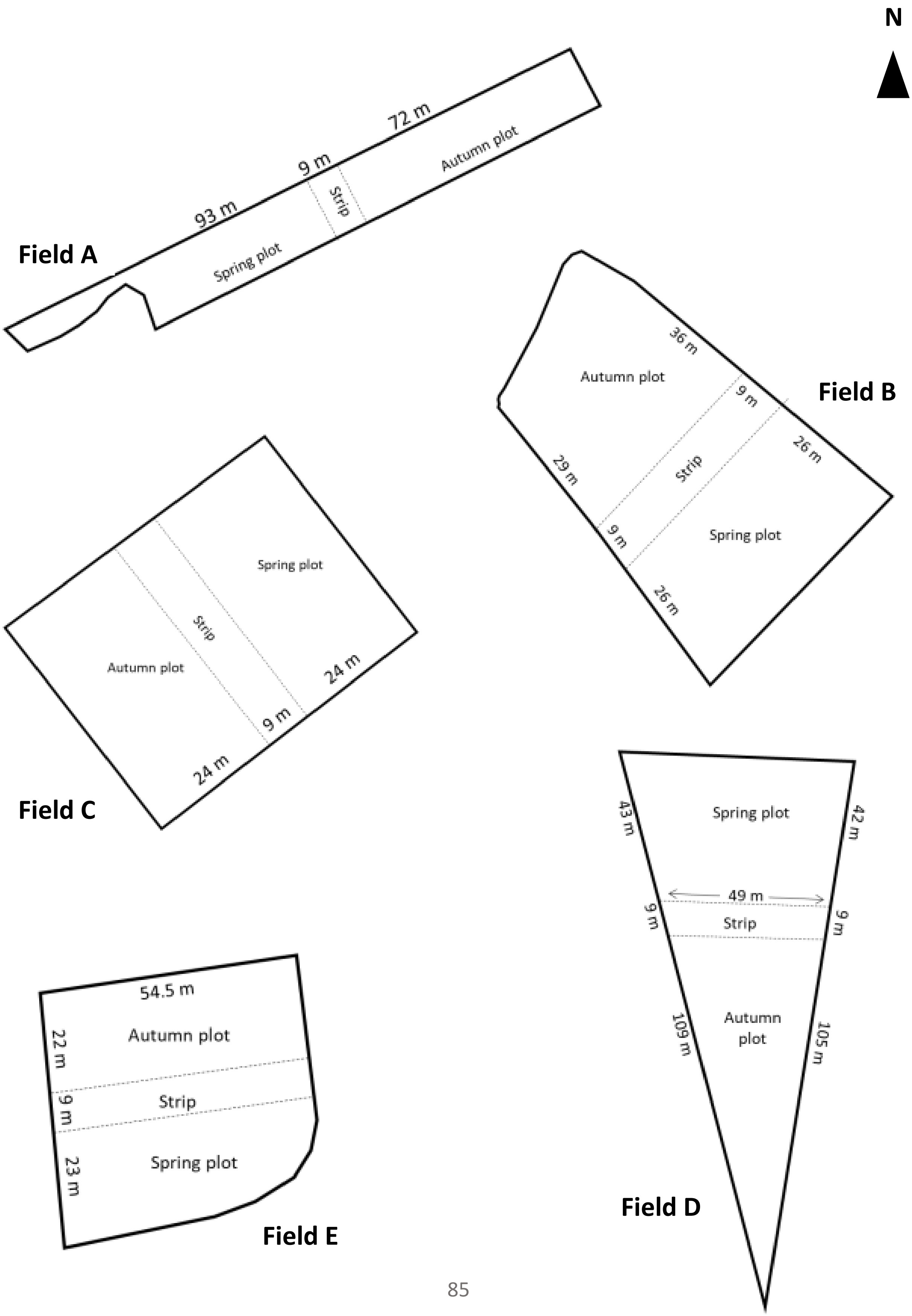
Bastiaan van de Wetering – Intern 2021

Images: farming machinery

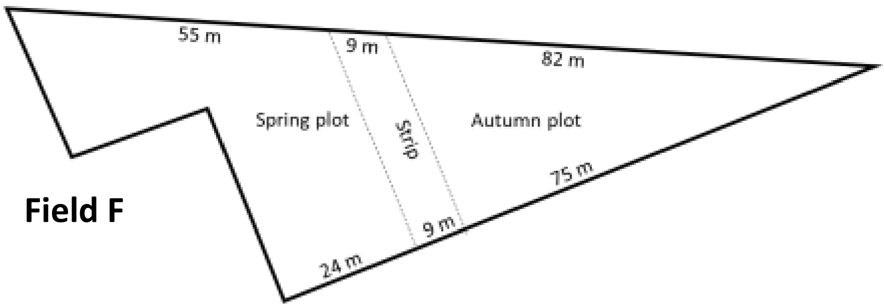
Pommeq –	Online: pommeq.nl/schoffel-techniek/
Schoffelonderdelen -	Online: schoffelonderdelen.nl/en/collections/machines/products
De Schutter BV -	Online: www.mdsbv.be/vierwielige-trekker/ortolan-sirio-rotorkopeg-driepunt-2/
Eemsned Grondfrees -	Online: markt.trekkerweb.nl/nl/advertenties/tw80487-grondfrees-boxer-type-gf-diverse-breedtes/

Appendices

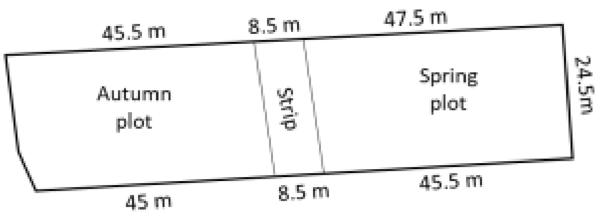
Appendix 1: Details of participating fields

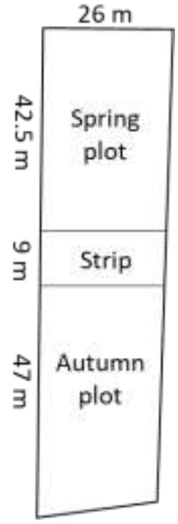


Field F



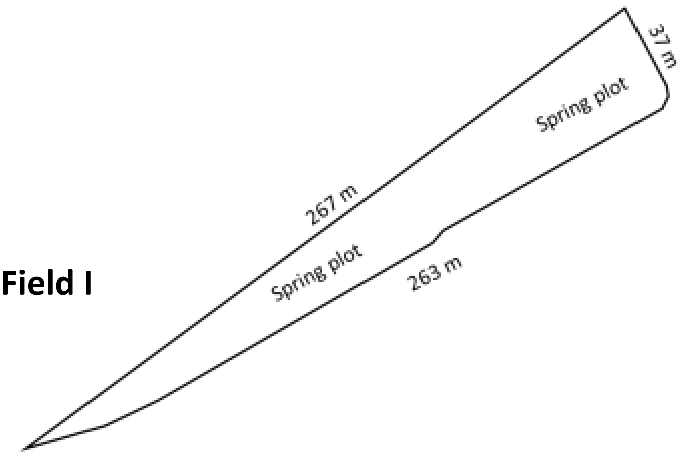
Field G





Field H

Field I



Appendix 2: Seed mix composition

Seed mix 1 Spring 2021	Seed mix 2 Autumn 2021	Seed mix 3 Spring 2022	Seed mix 4 Autumn 2022
20% Grain/Grass:	25% Grain/Grass:	25% Grain/Grass:	100% Herbs:
5% Crested Dog's-tail	7% Crested Dog's-tail	7% Crested Dog's-tail	2% Red Clover Pastor
5% Cock's-foot	6% Cock's-foot	3% Cock's-foot	5% Common Vetch
5% Common Bent	6% Common Bent	6% Common Bent	5% Narbonne Vetch
5% Creeping Bent	6% Rye		5% Common Bird's-foot
80% Herbs:	75% Herbs:	75% Herbs:	15% Black Medick
15% Black Medick	15% Black Medick	5% Red Clover	3% White Clover
10% Red Clover	10% Red Clover	2% Fale Mayweed	10% Spurrey
10% Fale Mayweed	5% Fale Mayweed	10% Common Vetch	5% Camelina
10% Common Vetch	10% Common Vetch	5% Narbonne Vetch	10% Buckwheat
10% Rapeseed	5% Narbonne Vetch	10% Common Bird's-foot	10% Long-headed Poppy
5% Field mustard	5% Common Bird's-foot	5% White Clover	5% Cornflower
5% White mustard	5% White Clover	4% Spurrey	5% Field Pansy
5% Spurrey	4% Spurrey	5% Camelina	15% Miner's Lettuce
5% Buckwheat	5% Camelina	10% Buckwheat	5% Lesser Trefoil
1% Long-headed Poppy	3% Buckwheat	4% Long-headed Poppy	
1% Cornflower	2% Long-headed Poppy	4% Cornflower	
1% Camelina	2% Cornflower	4% Common Fumitory	
1% Common Fumitory	2% Common Fumitory	3% Field Pansy	
1% Field Pansy	2% Field Pansy	3% Miner's Lettuce	
		10% Lesser Trefoil	

Appendix 3: Overview of test plot participation

		2021			2022			2023		
	Test plot	Spring	Summer	Autumn	Spring	Summer	Autumn	Spring	Summer	Autumn
Field A	spring	Seed mix 1 sown	Growing season 1	Management	Management	Growing season 2	Management	Management	Growing season 3	Cleared
	autumn			Seed mix 2 sown	Management	Growing season 1	Management	Management	Growing season 2	Cleared
Field B	spring	Seed mix 1 sown	Too much marigold	Cleared	Seed mix 3 sown	Too much marigold				
	autumn			Seed mix 2 sown	Management	Too much marigold				
Field C	spring	Seed mix 1 sown	Successful	Management	Management	Growing season 2	Management	Management	Growing season 3	Cleared
	autumn			Seed mix 2 sown	Management	Growing season 1	Management	Management	Growing season 2	Cleared
Field D	spring	Seed mix 1 sown	Growing season 1	Management	Management	Growing season 2	Management	Management	Growing season 3	Cleared
	autumn			Seed mix 2 sown	Management	Growing season 1	Management	Management	Growing season 2	Cleared
Field E	spring	Seed mix 1 sown	Growing season 1	Management	Management	Growing season 2	Seed mix 4 sown	Management	Growing season 1	Cleared
	autumn			Seed mix 2 sown	Management	Growing season 1	Management	Management	Growing season 2	Cleared
Field F	spring	Seed mix 1 sown	Growing season 1	Management	Management	Growing season 2	Management	Management	Growing season 3	Cleared
	autumn			Seed mix 2 sown	Management	Growing season 1	Management	Management	Growing season 2	Cleared
Field G	spring				Seed mix 3 sown	Growing season 1	Management	Management	Growing season 2	Cleared
	autumn			Seed mix 2 sown	Management	Growing season 1	Management	Management	Growing season 2	Cleared
Fiel d :	spring				Seed mix 3 sown	Growing season 1	Management	Management	Growing season 2	Cleared

	autumn			Seed mix 2 sown	Management	Too much black grass	Seed mix 4 sown	Management	Growing season 1	Cleared
Field I	spring				Seed mix 3 sown	Too many unwanted sp.	Seed mix 4 sown	Management	Growing season 1	Cleared
	autumn			Seed mix 2 (hand)sown	Management	Too many unwanted sp.	Seed mix 4 sown	Management	Growing season 1	Cleared

Appendix 4: Sowing method 2021 - 2023

	Spring 2021 Seed mix 1	Autumn 2021 Seed mix 2	Spring 2022 Seed mix 3	Autumn 2022 Seed mix 4
Sowing Date	Week of 4th May	Week of 4th Oct	Week of 28th March	Week of 10th Oct
Density	10 kg/ha	7.5 kg/ha I think	5 kg/ha	5 kg/ha
Method Requested	Rows 50 cm apart	Requested: 2 rows spaced 50 cm apart, followed by a bare/unsown strip of 1.5 – 2 m.	3 rows spaced 50 cm apart, followed by a bare/unsown strip of 2 m	3 rows spaced 50 cm apart, followed by a bare/unsown strip of 2 m
Method Used	Rows 50 cm apart	Communication error – in practice every field was sown slightly differently. Some were sown with 4 rows (spaced 50 cm apart), followed by a bare strip, other fields were sown completely with a spacing of 1 m.	3 rows spaced 50 cm apart, followed by a bare/unsown strip of 2 m	3 rows spaced 50 cm apart, followed by a bare/unsown strip of 2 m
Fields sown	A to F – spring test plots	A to H autumn test plots	B, G, H, I spring test plots	E (*spring test plot)* H (autumn test plot) I (whole field)
Fields participating	A to F	A to H	A to I	A and C to I (Field B cancelled)

Appendix 5: Management plan used in 2023 (Dutch)

Beheer ('Voedsel voor zomertortels', 2021-2023)

Elke beheers rond gebeurt op een andere richting (zie plaatjes beneden) om te zorgen dat niet 1 stuk van de vegetatie te hoog wordt, dat kale grond verspreid was, en dat rijp zaad van hogere planten kwamen op de grond tevoorschijn.

2023	April		Mei					Juni				Juli				Aug*
Week nr	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31+
Beheer Rond	Rond 1				Rond 2							Rond 3				Eind

Rond 1 is voordat zomertortels terugtrekken (eind april/begin mei).

- Velden die hun eerste groeiseizoen ingaan krijgen een schoffel beurt om de niet ingezaaide stroken opnieuw kaal te maken en ongewenste onkruid langer weg te houden.
- Velden die minst één jaar oud zijn kunnen beheerd worden met een rotorkopeg in stroken: stroken ondiep eggen (2 a 3 m breed) over het hele velddeel, en tussen de kale stroken 1 a 2 m vegetatie laten staan.

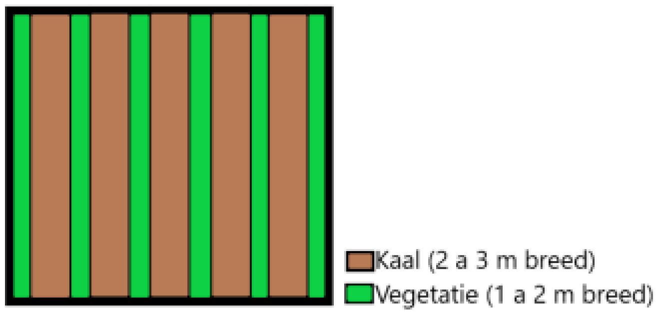


Fig. Hoe velden eruitzien na rond 1

Rond 2 gebeurt rondom 4 weken later, afhankelijk van hoe het veld eruit ziet, tussen begin mei en midden juni.

- Bij nieuwe velden moet er beslist worden of eggen gaat weer in hetzelfde richting/banen als in de eerste rond, of er wordt dwarse stroken gemaakt. Dit is afhankelijk van de structuur en zaad aanbod tegen die tijd.
- Velden in hun tweede groeiseizoen krijgen allemaal dwarse stroken eggen (2 a 3 m breed) over het hele

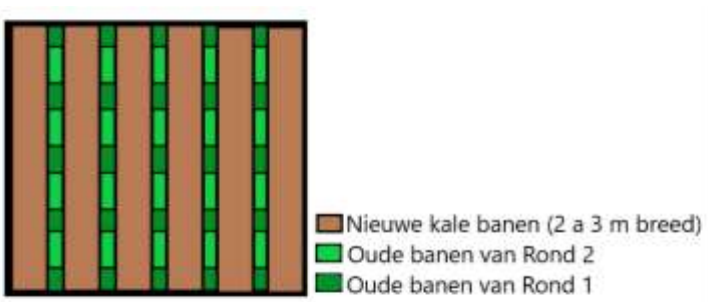


Fig. Hoe velden eruitzien na rond 2

velddeel, *op een andere richting dan bij Rond 1*. Tussen de kale stroken, 1 a 2 m vegetatie laten staan.

Rond 3 valt tussen midden juni en eind juli, rond om 4 a 6 weken later, afhankelijk van hoe het veld eruitziet.

Alle velden krijgen nu hetzelfde behandeling: dwarse stroken eggen (2 a 3 m breed) over het hele velddeel, *op een andere richting dan bij eerdere ronden*. Tussen de kale stroken, 1 a 2 m vegetatie laten staan.

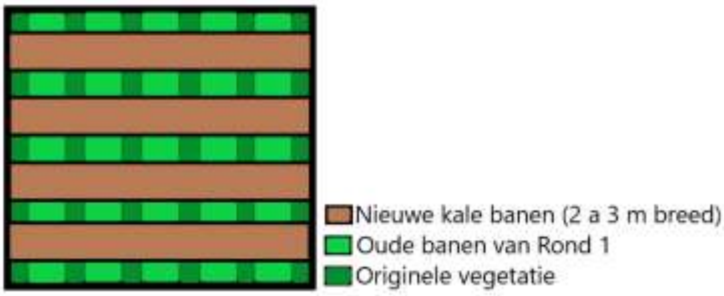


Fig. Hoe velden eruitzien na rond 3

Fotos. Velden zien er zo uit na beheer: met vierkanten van verschillende fases en hoogtes vegetatie, en veel kale grond.

Rond 4 gebeurt vanaf augustus

Het is niet helemaal duidelijk voor ons wat het beste is in deze periode: zomertortels lijken veel geoogste velden te bezoeken, dus het kan zijn dat het beste is om alles te maaien dat de veld stoppel-achtig eruitziet. *Wij hebben geen bewijs van zomertortel gebruik tijdens dit periode.*

Appendix 6: Management strategy summary

Summary of the advantages and disadvantages of the two management strategies used.

	2021/2022	2023
Approach	Chain-of-command	Management plan
Advantages	- Landowners enthusiastic and proactive at start of the project, hoping to help turtle doves. - The decision of field suitability is made based on a turtle dove expert. - Flexibility to cater for exceptions and limitations presented by each field.	- After 2 years of few (or no) turtle dove sightings on their fields, enthusiasm has diminished for some. - No 'chain' of people means less chance of instructions being lost in translation - No concerns about ecologists contacting farmers 'too frequently'. - Landowners have more flexibility to plan in management moments when it suits them and best fits alongside their existing agricultural work.
Disadvantages	- The longer the communication chain, the greater the chance of concise instructions getting lost in translation. - The need for management needs to be signalled in time for farmers to get around to doing the work. - Less flexibility: management is only requested when it becomes necessary. However, management requests are unplanned and rarely conveniently timed for a farmer to carry out immediately. - Reminders are often needed: It's difficult to balance the frequency of reminders with the increasing urgency for management of a plot.	- Clear instructions need to be given beforehand regarding management methods and timing. - Decision of habitat suitability relies on landowners and not somebody with turtle dove expertise. - More rigid and less bespoke means there's less flexibility for challenging fields.

Appendix 7: Suitability criteria

Suitability assessment and score classifications used in 2022 and 2023.

Percentage Bare Ground	Percentage vegetation ≤20cm	Percentage cover of seed baring species	Suitability	Score
30 – 70%	30 – 70%	>10%	Optimal	1
16 – 29% **OR** 71 – 89%	11 – 29% **OR** 71 – 89%	6 – 10%	Not optimal	0.5
0 – 15% **OR** 90 – 100%	0 – 10% **OR** 90 – 100%	0 – 5%	Unsuitable	0

Suitability assessment and score classifications used in the pilot year (2021).

<table>
<tr><th>Percentage Bare Ground</th><th>Vegetation height</th><th>Seed availability</th><th>Suitability</th><th>Score</th></tr>
<tr><td>30 – 70%</td><td rowspan="3">Not included in suitability assessments: vegetation height was taken as an average in cm, rather than a percentage.</td><td>Seed present</td><td>Optimal</td><td>1</td></tr>
<tr><td>16 – 29%
OR 71 – 89%</td><td>Very limited presence</td><td>Not optimal</td><td>0.5</td></tr>
<tr><td>0 – 15%
OR 90 – 100%</td><td>No seed</td><td>Unsuitable</td><td>0</td></tr>
</table>

Appendix 8: GPS tag and harness information

Company: Microsensory

Tag Model: Datalogger Transmitter Mod. GPSLR-M4.5

Tag weight: 4.76 g

Base Station Model: Base station DTL1170

Harness type: Full body harness with crimp ring

Harness material: Teflon tape 2 mm

Harness weight (average): 0.73 g

Weight standard metal ring: 1.18 g

Average accuracy in an 'open' location *(n=754)*: 4.8 m

Average accuracy in a vegetated location *(n=914)*: 6.3 m



Appendix 9: Seed mix species height and seeding date

Common name	Latin name	Flowers from	Height in literature (cm)	Est. min height in field (cm)	Est. max height in field (cm)	Family
Common Bent.	*Agrostis capillaris*	June	10-70	20	30	*Poaceae*
Creeping Bent	*Agrostis stolonifera*	June	40-100	40	40	*Poaceae*
Rapeseed	*Brassica napus*	May	60-120	40	120	*Brassicaceae*
Field mustard	*Brassica rapa*	May	30-100	40	120	*Brassicaceae*
Camelina	*Camelina sativa*	May	30-120	20	60	*Brassicaceae*
Cornflower	*Centaurea cyanus*	May	40-90	25	50	*Asteraceae*
Miner's lettuce	*Claytonia perfoliata*	April	10-20	5	15	*Montiaceae*
Crested Dog's-tail	*Cynosurus cristatus*	May	15-45	30	30	*Poaceae*
Cock's-foot	*Dactylis glomerata*	June	20-140	30	100	*Poaceae*
Buckwheat	*Fagopyrum esculentum*	June	15-60	10	50	*Polygonaceae*
Common Fumitory	*Fumaria officinalis*	May	10-50	15	15	*Papaveraceae*
Common birds-foot trefoil	*Lotus corniculatus*	May	10-25	10	25	*Fabaceae*
Black Medick	*Medicago lupulina*	April	5-75	5	30	*Fabaceae*
Long-headed poppy	*Papaver dubium*	May	30-60	20	20	*Papaveraceae*
Wild rye	*Secale multicaule*	June seed	60-200	100	200	*Poaceae*
White mustard	*Sinapis alba*	May	60-120	40	120	*Brassicaceae*
Corn Spurrey	*Spergula arvensis*	April	to 60	5	15	*Caryophyllaceae*
Lesser Trefoil	*Trifolium dubium*	May	5-20	5.00	30.00	*Fabaceae*
Wild Red Clover	*Trifolium pratense*	May	20-80	15	80	*Fabaceae*
White Clover	*Trifolium repens*	May	to 15	15	15	*Fabaceae*
False Mayweed	*Tripleurospermum maritimum*	June	10-30	15	75	*Asteraceae*
Narbonne vetch	*Vicia narbonensis*	May	30-60	30	60	*Fabaceae*
Common Vetch	*Vicia sativa*	May	200 length	100	150	*Fabaceae*
Field Pansy	*Viola arvensis*	April	to 20	3	15	*Violaceae*

Appendix 10: Test plot photo pages

Field A – spring sown test plot, 2021

6th April 2021

12th May 2021

18th May 2021

1st July 2021

13th July 2021

23rd Sept 2021

5th Nov 2021

Field A – spring sown test plot, 2022

15th Mar 2022

19th April 2022

9th June 2022

21st June 2022

20th July 2022

9th Aug 2022

Field A – spring sown test plot, 2023

14th April 2023

9th May 2023

5th June 2023

7th July 2023

19th Sept 2023

Field A – autumn sown test plot, Nov 2021 – 2022

19th Nov 2021

15th Mar 2022

15th Mar 2022

19th April 2022

10th May 2022

17th May 2022

9th June 2022

21st June 2022

20th July 2022

Field A – autumn sown test plot, 2021 – 2022 (continued)

28th July 2022

9th Aug 2022

7th Sept 2022

Field A – autumn sown test plot, 2023

14th April 2023

5th June 2023

7th July 2023

4th Sept 2023

19th Sept 2023

Field B spring sown test plot, 2021

12th May 2021

18th May 2021

End June 2021

Early July 2021

End July 2021

Following germination, marigold coming from the seedbank took over the field. The field became a sea of marigold and musteard – too tall and dense for turtle doves, and attempts to carry out partial management and control growth were unsuccessful.
In August the field was flail mown completely with a view to starting afresh

23rd Sept 2023

Field B spring sown test plot, 2022

9th Mar 2022

19th April 2022

10th May 2022

10th May 2022

9th June 2022

As the marigold once again went into flower and then seed in this field before management could be carried out, the mutual decision was made with the landowner to stop the trial on Field B.

Field B autumn sown test plot, Nov 2021 – 2022

19th Nov 2021

There was no sign of the autumn sown seed mix germinating, while the marigold continued to thrive.

The decision was made to keep the field under control – through flail mowing or working the soil, to create a false seed bed and knock back the marigold issue.

9th March 2022

9th June 2022

This partially worked, though management on this field remained a challenge: marigold continued to flower and seed.

7th Sept 2022

Field C – spring sown test plot, 2021

12th May 2021

18th May 2021

8th Sept 2021

23rd Sept 2021

18th Nov 2021

Field C – spring sown test plot, 2022

15th March 2022

14th April 2022

14th April 2022

10th May 2022

9th June 2022

5th July 2022

28th July 2022

7 Sept 2022

Field C – autumn sown test plot, Nov 2021 – 2022

23rd Sept 2021

5th Nov 2021

15th March 2022

14th April 2022

10th May 2022

9th June 2022

21st June 2022

5th July 2022

Field C – autumn sown test plot, 2021 - 2022 (continued)

28th July 2022

10th Aug 2022

7th Sept 2022

Field I – spring sown test plot, 2022

19th March 2022

10th May 2022

7th June 2022

8th July 2022

28th July 2022

1st Sept 2022

7th Sept 2022

Field C – spring sown test plot, 2023

14th April 2023

9th May 2023

2nd June 2023

26th June 2023

26th Aug 2023

19th Sept 2023

Field C – autumn sown test plot, 2023

14th April 2023

9th May 2023

2nd June 2023

7th June 2023

26th June 2023

27th Aug 2023

19th Sept 2022

Field Ea – autumn sown test plot, 2023 (seed mix 4)

14th April 2023

14th April 2023

9th May 2023

9th June 2023

9th June 2023

4th July 2023

19th Sept 2023

Field G autumn sown plot Nov 2021 – 2022

18th Nov 2021

18th Nov 2021

15th March 2022

14th April 2022

14th April 2022

14th April 2022

26th April 2022

10th May 2022

10th June 2022

21st June 2022

5th July 2022

26th July 2022

5th July 2022

10th Aug 2022

30th Aug 2022

Field G spring sown plot, 2022

14th April 2022

10th May 2022

10th May 2022

10th June 2022

21st June 2022

5th July 2022

5th July 2022

5th July 2022

26th July 2022

26th July 2022

10th Aug 2022

30th Aug 2022

7th Sept 2022

Field H spring sown plot, 2022

14th April 2022

10th May 2022

21st June 2022

21st June 2022

5th July 2022

5th July 2022

10th Aug 2022

7th Sept 2022

Field H spring sown plot, 2023

14th April 2023

9th May 2023

5th June 2023

4th July 2023

4th July 2023

19th Sept 2023

Field I – autumn sown test plot, 2023

14th April 2023

9th May 2023

5th June 2023

5th June 2023

7th July 2023

4th Sept 2023

19th Sept 2023

Appendix 11: Camera trap total of daily maximum

Total of the daily maximum per species recorded each year on camera trap (NB. Seed eating species in **bold**)

Species (English)	Soort (Nederlands)	2021	2022	2023	Total
Barn swallow	Boerenzwaluw		12		12
Blackbird	Steenmarter	66	23	227	316
Buzzard	Buizerd	4	10	9	23
Carrion crow	Zwarte kraai	86		24	110
Chaffinch	**Vink**		**2**		**2**
Collared dove	**Turksetortel**			**1**	**1**
Dove sp.	**Duif sp.**	**3**	**1**	**5**	**9**
Duck sp.	**Eend sp.**	**2**			**2**
Dunnock	**Heggenmus**			**1**	**1**
Egyptian goose	**Nijlgans**		**7**	**3**	**10**
Finch sp.	**Vink sp.**	**1**			**1**
Goldfinch	**Putter**		**79**	**19**	**98**
Green woodpecker	Groenespecht			2	2
Grey heron	Blauwe reiger	2	1	18	21
Herring gull	Zilvermeeuw	7		1	8
House sparrow	**Huismus**	**2**		**23**	**25**
Jackdaw	Kauw		81	6	87
Jay	Vlaamse gaai			14	14
Kestrel	Torenvalk			1	1
Lesser black-backed gull	Kleine mantelmeeuw	1			1
Linnet	**Kneu**		**10**	**18**	**28**
Magpie	Ekster	41	12	55	108
Mallard duck	**Wilde eend**	**4**	**20**	**98**	**122**
Marsh harrier	Bruine kiekendief			1	1
Oystercatcher	Scholekster	4		3	7
Partridge	**Patrijs**	**1**			**1**
Pheasant	**Fazant**	**200**	**371**	**718**	**1289**
Robin	Roodborst			2	2
Song thrush	Zanglijster	8	10	31	49
Starling	Spreeuw	3		32	35
Stock dove	**Holenduif**	**11**	**11**	**58**	**80**
Turtle dove	**Zomertortel**	**4**	**2**	**8**	**14**
Wagtail sp.	Kwikstaart sp.	1			1
Wheatear	Tapuit		1	1	2

Whinchat	Paapje			8	8
White wagtail	Witte kwikstaart	16	3	8	27
Wood pigeon	**Houtduif**	**290**	**348**	**141**	**779**
Yellow wagtail	Gele kwikstaart			1	1

Total of the daily maximum per mammal species recorded in 2023 by camera traps.

Species	Soort	2023
Cat	Kat	202
Chicken	Kip	3
Deer sp.	Hert sp.	30
Fallow deer	Damhert	27
Fox	Vos	17
Hare	Haas	564
Hedgehog	Egel	81
Marten sp.	Marter sp.	24
Mouse	Muis	5
Rat	Rat	1
Roe deer	Ree	98

Appendix 12: Dove information

Name	Ring Number	Tag ID	Sex	Wing length (mm)	Weight upon catching (g)	Weight upon releasing (g)	Weight of equipment* (g)	Percentage bird's body weight (%)
Cornelis	NLA2518166	2222	Male	177	147.1	152.3	5.2	3.5
Patrick	NLA2518167	2355	Male	182	148.7	154.0	5.3	3.6
Ina	NLA2518165	2356	Female	185	152.6	158.1	5.5	3.6
Marion	NLA2518164	2354	Female	185	160.0	165.3	5.3	3.3
Sebastiaan	NLA2518159	2221	Male	179.5	147.5	153.5	6.0	4.1
Marein	NLA2518160	2220	Male	184	154.1	159.7	5.6	3.6
Paulina	NLA2518161	2223	Female	184	141.1	146.2	5.1	3.6
Victor	NLA2518162	2224	Male	183	149.7	155.7	6.0	4.0

*Collective weight of metal leg ring, harness and tracker

Appendix 13: Dove (raw) data collection summary

Name	Tag ID	Sex	Tracking period	No. days	Total fixes	Fixes/day (min)	Fixes/day (max)	Nest
Cornelis	2222	Male	11:15; 10/7/23-12/9/23	62	926	0	31	unknown
Patrick	2355	Male	10:45; 13/7/23-14/8/23	30	375	0	24	unknown
Ina	2356	Female	19:45; 7/6/23-9/9/23	76	965	0	30	Yes
Marion	2354	Female	19:13; 7/6/23-2/7/23	26	535	0	32	No
Sebastiaan	2221	Male	10:15; 8/6/22-11/9/22	96	1241	1	21	Yes
Marein	2220	Male	10:15; 8/6/22-2/9/22	87	1018	2	20	Yes
Paulina	2223	Female	09:10; 11/6/22-17/9/22	77	553	0	16	Yes
Victor	2224	Male	08:55; 17/6/22-10/9/22	86	1192	2	22	Yes

Appendix 14: Turtle dove visits to test plots

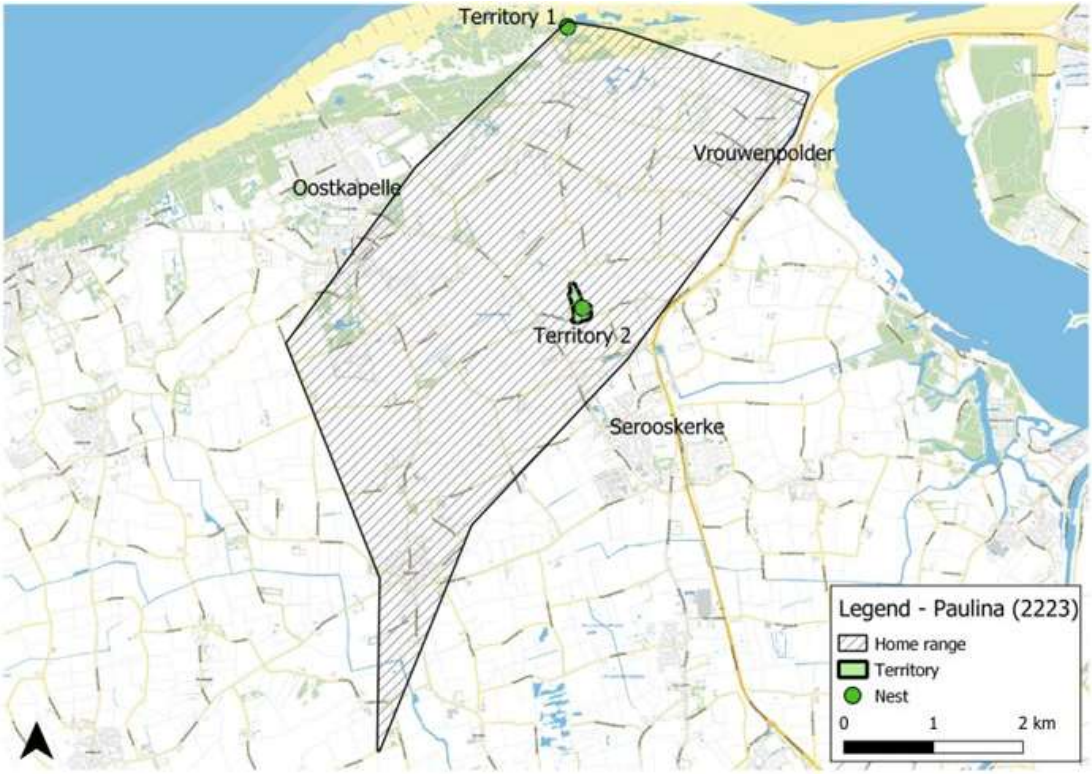
Summary of turtle dove camera trap records, GPS fixes and field observations on or next to test plots.

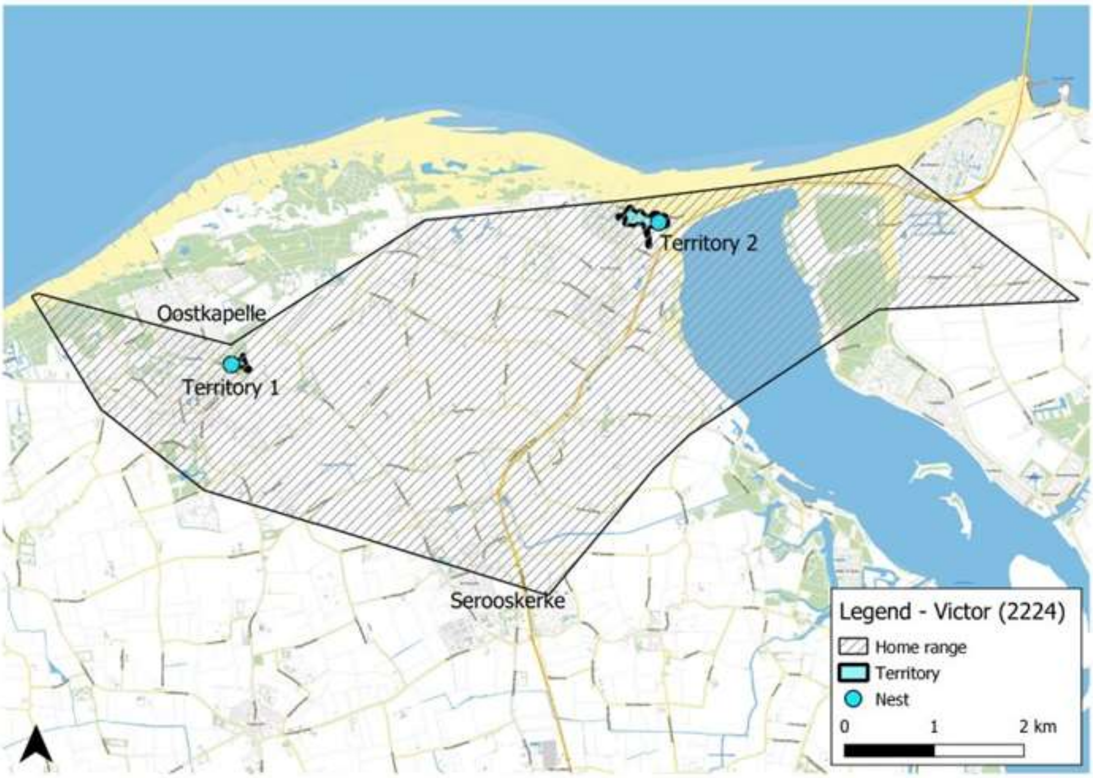
Test plot	Year	Type observation (dove name)	Number of records	Month (and days) of records
C – spring	2021	Field Obs	1	May (18)
C – spring	2021	Camera	3	May (20, 21, 23)
C - autumn	2023	Camera	1	July (1)
E - spring	2021	Camera	1	June (15)
G - spring	2022	Camera	1	July (14)
G - spring	2022	Tag 2223 (Paulina)	2	Aug (18, 21)
G - spring	2023	Camera	5	July (12, 21, 23, 24*)
G - spring	2023	Tag 2356 (Ina)	5	July (9, 9, 10, 10, 11)**
G - autumn	2023	Tag 2356 (Ina)	3	July (9, 9, 12)**
G - autumn	2022	Tag 2223 (Paulina)	1	June (21)
G - autumn	2023	Camera	2	July (9, 14)

* 2 individuals on a single camera trap photo.

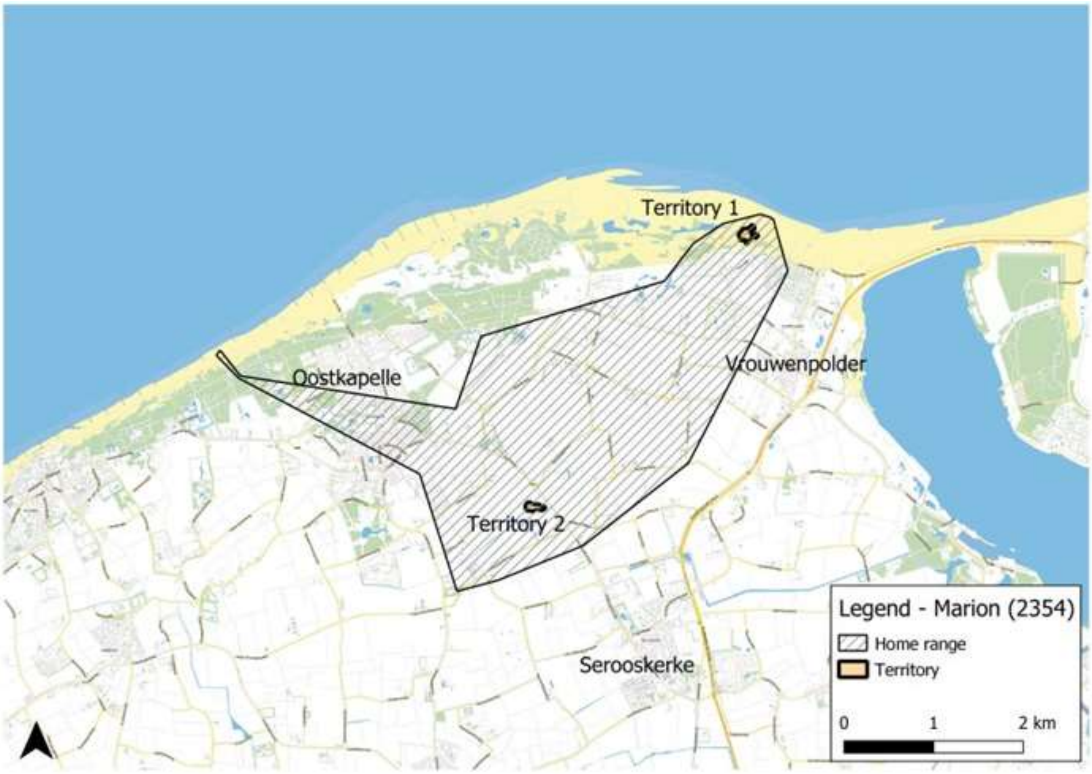
** Non-consecutive data fixes and therefore 'separate' visits.

Appendix 15: Home ranges, territories and nests

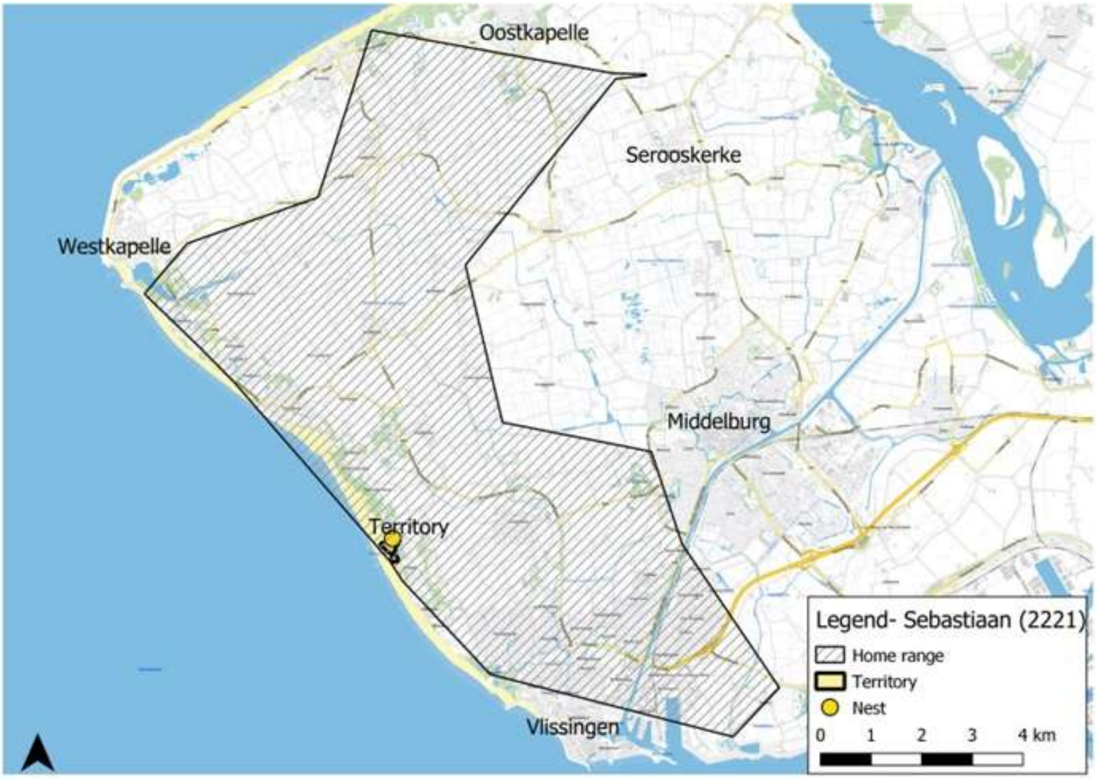


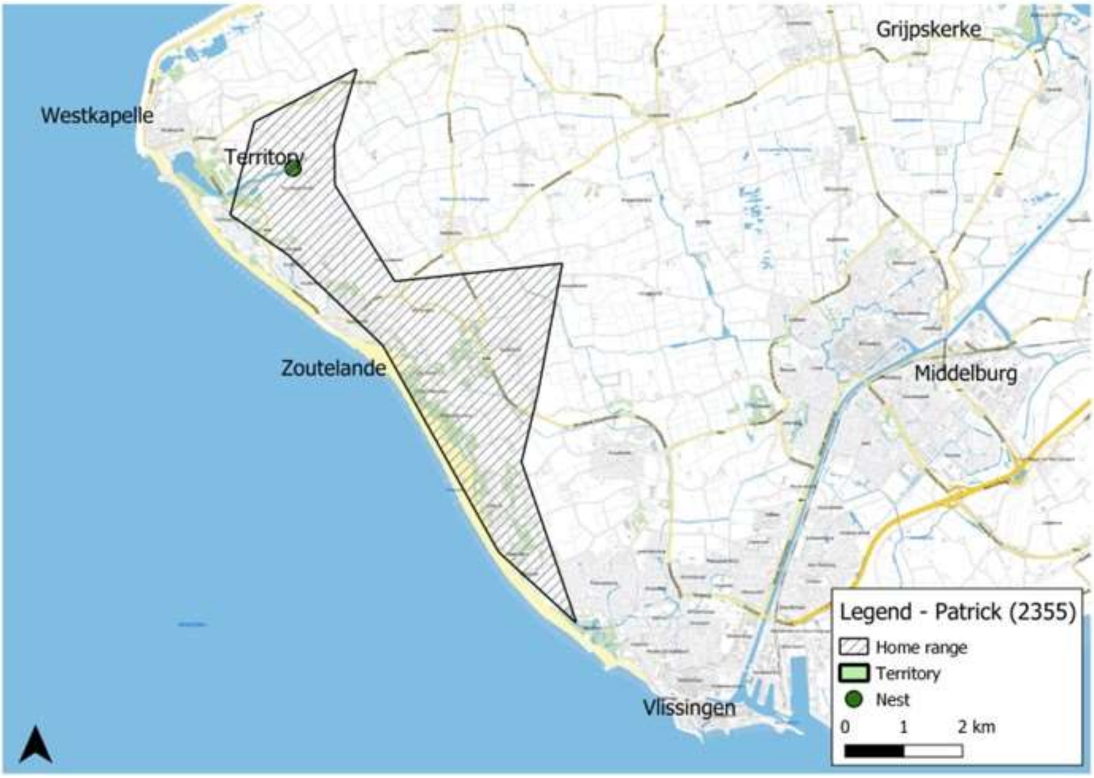


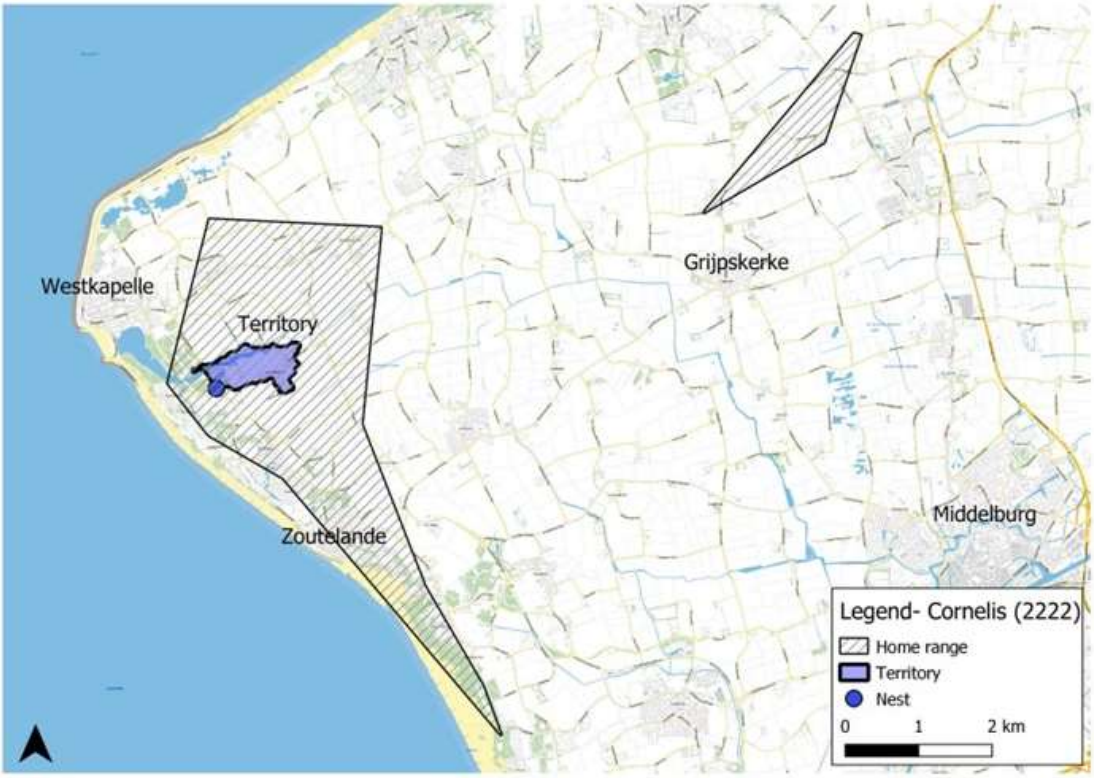

Oostkapelle
Vrouwenpolder
Serooskerke
Legend - Ina (2356)
Home range
Territory
Nest
0
1
2 km


Territory 1
Oostkapelle
Vrouwenpolder
Territory 2
Serooskerke
Legend - Marion (2354)
Home range
Territory
0
1
2 km


Westkapelle
Grijpskerke
Territory 2
Zoutelande
Territory 1
Legend - Marein (2220)
Home range
Territory
Nest
0
1
2 km


Oostkapelle
Serooskerke
Westkapelle
Middelburg
Territory
Vlissingen
Legend- Sebastiaan (2221)
Home range
Territory
Nest
0
1
2
3
4 km


Grijpskerke
Westkapelle
Territory
Zoutelande
Middelburg
Vlissingen
Legend - Patrick (2355)
Home range
Territory
Nest
0 1 2 km


Westkapelle
Territory
Grijpskerke
Zoutelande
Middelburg
Legend- Cornelis (2222)
Home range
Territory
Nest
0 1 2 km

Appendix 16: National Land Use Classification 3.2 (NLUD)

1 Agriculture
- 1.1 Field crops
- 1.2 Ploughed fields
- 1.3 Fallow land
- 1.4 Horticulture and orchards
- 1.5 Improved pasture
- 1.6 Field margin

2 Woodland
- 2.1 Conifer Woodland
- 2.2 Mixed woodland
- 2.3 Broadleaved woodland
- 2.4 Undifferentiated young woodland
- 2.5 Scrub
- 2.6 Felled woodland
- 2.7 Land cultivated for afforestation

3 Unimproved Grassland and Heathland
- 3.1 Unimproved grassland
- 3.2 Heathland
- 3.3 Bracken
- 3.4 Upland mosaic

4 Water and Wetland
- 4.1 Sea/Estuary
- 4.2 Standing water
- 4.3 Running water
- 4.4 Freshwater marsh
- 4.5 Saltmarsh
- 4.6 Bog

5 Rock and Coastal Land
- 5.1 Inland Rock
- 5.2 Coastal rocks and cliffs
- 5.3 Intertidal sand and mud
- 5.4 Dunes

6 Minerals and Landfill
- 6.1 Mineral workings and quarries
- 6.2 Landfill waste and disposal

7 Recreation
- 7.1 Indoor recreation
- 7.2 Outdoor recreation
- 7.3 Allotments

8 Transport
- 8.1 Roads
- 8.2 Car parks
- 8.3 Railways
- 8.4 Airports
- 8.5 Docks

9 Residential
- 9.1 Residential
- 9.2 Institutional and communal accommodation

10 Community Buildings
- 10.1 Institutional buildings
- 10.2 Educational buildings
- 10.3 Religious buildings

11 Industrial and Commercial
- 11.1 Industry
- 11.2 Offices
- 11.3 Retailing
- 11.4 Storage and warehousing
- 11.5 Utilities
- 11.6 Agricultural buildings

12 Vacant Land and Buildings
- 12.1 Previously developed land now vacant
- 12.2 Vacant buildings
- 12.3 Derelict land and buildings

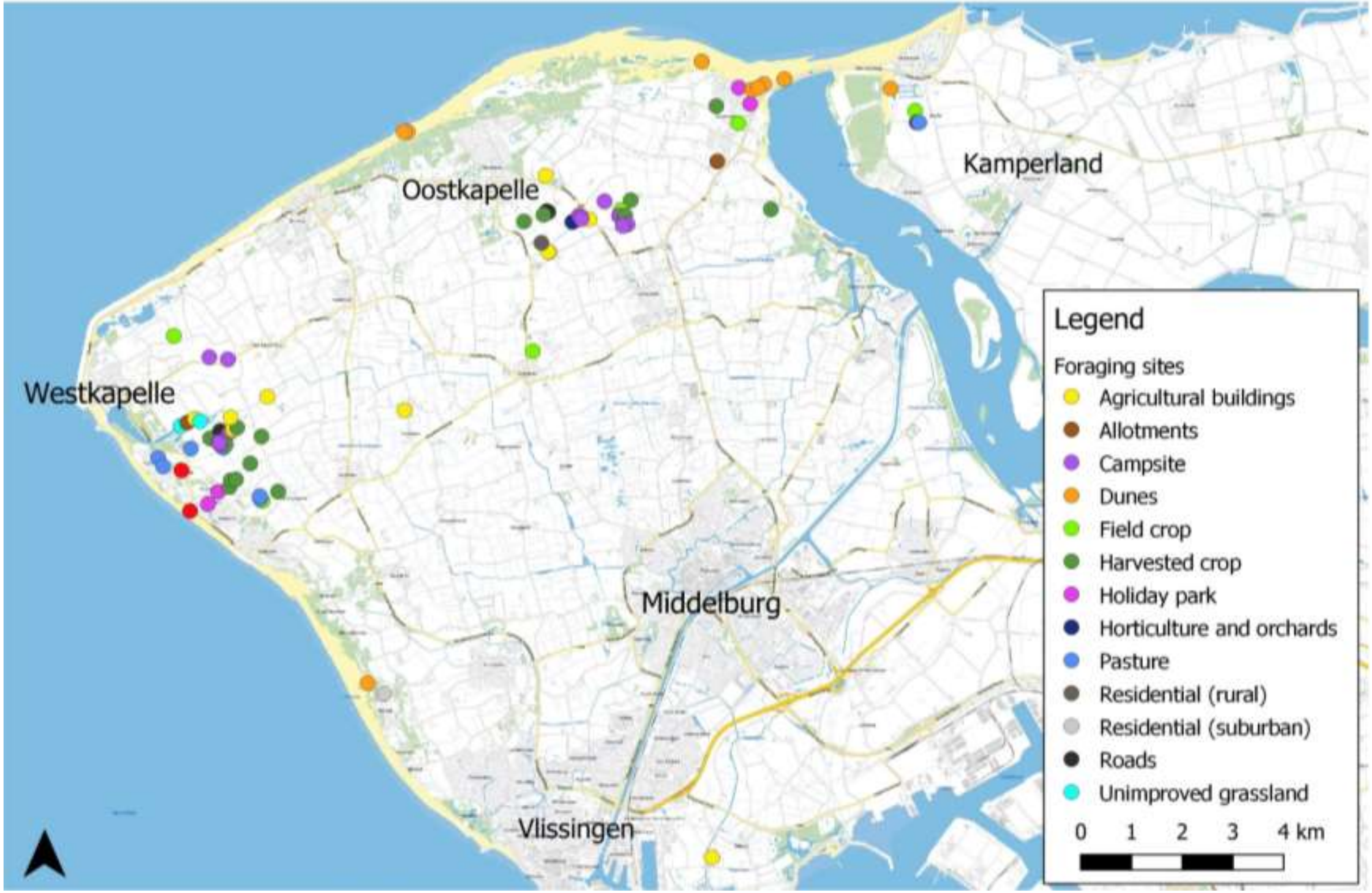
13 Defence Land and Buildings

Appendix 17: Land use classification for turtle doves

- 1 Agriculture
  - 1.1 Unharvested crops
  - 1.2 Harvested crops
  - 1.3 Fallow land
  - 1.4 Horticulture and orchards
  - 1.5 Pasture
  - 1.6 Field margin
  - 1.7 Foraging field
- 2 Woodland
- 3 Unimproved Grassland and Heathland
- 4 Water and Wetland
- 5 Rock and Coastal Land
  - 5.1 Dunes
  - 5.2 Other
- 6 Minerals and Landfill
- 7 Recreation
  - 7.1 Indoor recreation
  - 7.2 Outdoor recreation
  - 7.3 Allotments
  - 7.4 Holiday park
  - 7.5 Campsite
- 8 Transport
  - 8.1 Roads (including verges)
  - 8.2 Other
- 9 Residential
  - 9.1 Residential (rural)
  - 9.2 Residential (urban and suburban)
  - 9.3 Other
- 10 Community Buildings
- 11 Industrial and Commercial
  - 11.1 Agricultural*
  - 11.2 Industry
  - 11.3 Other
- 12 Vacant Land and Buildings
- 13 Defence Land and Buildings
- 14 Feeding Station

*Agricultural include farmyards and silos.

Appendix 18: Map of identified foraging sites



Appendix 19: Management

Management strategy

In 2021 and 2022 management was requested and carried out via a chain of command, while in 2023 landowners were given a management plan to work to (Appendix 5). There were some notable challenges met with implementing both management strategies.

Chain-of-command strategy: challenges

Ideally, plot management would be combined with a moment when the farmer is already in the neighbourhood, managing a commercial field. However, our requests for management were not always suitably timed for landowners. This combined with the small size of the turtle dove plots, created something of a hurdle in contacting landowners when it was needed: we were painfully aware that landowners would need to make a special trip, with a specific piece of machinery, to manage a small plot.

Another unavoidable issue was that, having been asked to carry out management, some landowners immediately acted while others put it on a 'to do' list and risked forgetting about it altogether. The latter needed to be reminded, but the ecologist can never be certain how long to wait before sending a reminder: there was no plan in place for how quickly landowners should take action having been asked, nor for how long an ecologist should wait before re-contacting a landowner.

The chain of command was sometimes made even longer in cases where the landowner does not personally carry out the management but asks one of their farmhands to do this. This increases the risk of management instructions being misinterpreted. Weather conditions often impacted when management could be carried out: too dry or too wet, and harrowing the ground is not possible.

Management plan strategy: challenges

This strategy, while perhaps preferable, was not without its struggles. Landowners forgot to take the management plan into their planning: all but one failed to carry out the second management round in time and everyone had to be contacted and reminded when most of the fields were already too overgrown to provide suitable foraging habitat. The management plan was interpreted differently by each landowner: apparently more or clearer explanation and detail was required with regard to carrying out the management.

A chain of command was still sometimes created when landowners didn't personally carry out the management but asked a farmhand to do it. The risk of management instructions being misinterpreted is not completely eliminated.

As with the chain of command strategy, weather played an independent role in when management could be carried out: too dry or too wet, and harrowing the ground is not possible.

Improving the Management Strategy

With the limitations presented in analysing field suitability, the apparent lack of differences on field suitability between the two management strategies could have been caused by numerous variables. Which method worked the most effectively during this project is therefore inconclusive. Given the advantages of using a management plan over a chain of command strategy, it is worth pursuing the use of a management plan further. At the very least, some form of standardised reminders and regular plot assessment from a knowledgeable field ecologist would need to be incorporated into the plan. It would also be beneficial to hold a meeting for landowners, prior to their participation, to explain the instructions, educate them on how to recognise and judge suitable habitat and answer any questions.

It's possible that a management plan for creating suitable foraging fields for turtle doves on farmland needs to be more 'bespoke' and requires too much monitoring to be implemented as a one-size-fits-all ANLb (or similar) measure.

Adaptive Field Management

More than half the fields participating in this project qualified for 'exceptions' to the management methodology. For some this was the use of hand tools/machines instead of farming machinery, for others the use of chemical control to tackle specific weeds. The multiple instances where management methods were adapted to suit each field reflect the variation between individuals in the agricultural community and the influence of past farming methods on the present. It becomes nearly impossible to pinpoint what the 'correct' combination of sowing timing, density and method is together with the management method, timing and technique. "One size fits all" does not apply here – tailoring is required to ensure maximum success of a foraging field.

Management: Lessons learned

Hand tools vs Machinery

There were 2 test fields (E and H) which were managed by hand or small-scale machines rather than by larger scale farming machinery. The same techniques were employed as in the other fields, but using garden cultivators, hoeing by hand, a sit-on mower etc. Differences in most instances were negligible: all had the desired effect of increasing bare ground, removing spontaneous plants, and reducing vegetation height. As expected, hoeing between sown rows by hand was very labour intensive for the landowner and was a last resort, but it was extremely effective and gave the newly germinating mixture a much better chance to compete against the competitive black grass.

Chemical 'weed' management

In a few instances, the use of chemicals was unavoidable due to the field's historical use. Fields F and C were both grassland previously and Field H was previously wheat for several years but had a serious issue with black grass.

Field C was full of couch grass, having been mown for hay in previous years. Couch grass spreads via its root system and was not sufficiently knocked back by the false seed bed prior to sowing, and quickly germinated and began out competing the sown mixture. This led to the decision to chemically treat both plots before and immediately following sowing and, in subsequent years, spot treatment of the worst affected areas as it returned. The chemical used acted against all grass species and, while this included grass species within the mixture, it was considered worth.

Field F, having been pasture for several years prior to the project, had a similar issue with grasses growing too quickly and outcompeting the sown mixture. Chemical treatment was only used once on this field, on both plots, in 2021.

Photos. Couch grass (Dutch: "kweekgras") in Field C, 2021.

Field H was plagued by black grass *(Dutch: "duist")*, which is notoriously problematic. This field joined the project during the summer of 2021: the first seed mix sown here was on the autumn plot in 2021. It did not take well at all and the extent of the black grass issue became quickly apparent. The decision was made to scratch the plot, chemically treat the whole field in spring, and start again with the spring plot, leaving the autumn plot bare in 2022.

Seed mix 3 took well on the spring test plot, but was quickly being outcompeted by returning black grass and needed management. Due to the absence of farming machinery, a small rotary power harrow was borrowed to keep the wide bare strips as free from black grass as possible. Hoeing between the rows was done by hand following germination of the seed mix – a last resort and highly labour intensive. The combination was highly effective and played a large role in the success of the seed mix on this spring plot.

Seed mix 4 was sown onto the autumn plot in 2022. Once again, the mix did not take as well as hoped and, combined with no hoeing or harrowing, the mix was more or less suffocated. The autumn plot in 2023, despite efforts to regularly mow wide strips to the ground, was dominated by tall camomile and black grass and was for the large part unsuitable for foraging turtle doves.

The spring plot in 2023 did surprisingly well, despite the returning black grass. In contrary to the changing the direction of bare strips, as done in other fields, mowing was consistently done in the old 2m wide unsown strips. While the original sown rows from 2022 had disappeared, the presence of desirable plant species from the seed mix was still greatest here. By leaving these old rows intact and managing the black grass dominated vegetation, this field still had periods where it presented a habitat that appeared visually suitable for foraging turtle doves.

Photos. Black grass (Dutch: "duist") in Field H autumn test plot, Nov 2021, Apr 2023 and May 2023 (left to right).

Difficult Ground to Manage

Field B had in recent years been used as a 'flower picking' field for the public. 'Flower Picking' fields on Walcheren are part of a local initiative: land is sown with a flowering seed mix and during the summer the public can pay to come when they want and pick a bouquet. The seed mix contains a variety of species including marigold, sunflowers, cornflowers and other species used by birds and insects. Flower picking fields offer a good use for fields where the ground is particularly difficult to manage regularly and are less suitable for growing crops.

Photo. Field B, 2021 - a sea of marigold and brassicas whose density and height, even before flowering, overshadowed the seed mix.

The effect of years of flower picking mixes on this field was marked: marigold dominated the field and proved to be a strong and early germinator which quickly outcompeted the sown seed mix. Timely management here was therefore of the utmost importance to ensure the marigold did not get the upper hand. The only sown species to outcompete the marigold were the field mustard and rapeseed, which germinated and grew at a similar rate and, eventually, higher.

Field B was situated on particularly heavy clay soil, making it one of the project fields most susceptible to the effects of weather. A hot and dry period led to solid, cracked clay ground which was almost impossible to cultivate. A wet period led to ground so wet it rendered it unsuitable for heavy machinery. Timely management for this plot proved a constant struggle for the landowner.

Photo. Field B, 2021 - spurrey (sown) and marigold (spontaneous) growing together on hard, dry clay ground.

After several failed attempts to address the marigold problem on the spring plot in 2021, the decision was made to scratch the plot. A false seed bed was created, the autumn plot was sown in October, and the spring plot in 2022. When both these sowing attempts were once again met with the issue of marigold management, the mutual decision was made to cancel this field altogether.