Cyfoeth Naturiol Cymru
Natural Resources Wales

Sand lizard surveys at Newborough Warren NNR and sand dune habitat management guidance

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Amphibian and Reptile Conservation Trust

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Madfall y tywod, *Lacerta agilis* yw'r fadfall brinnaf ym Mhrydain ac mae wedi cael ei hailgyflwyno'n llwyddiannus i Gymru, a hynny wedi iddi diflannu o'r wlad. Mae i'w chanfod ar safleoedd twyni tywod yng Nghymru, ac mae mwy a mwy o enghreifftiau o gynefinoedd o'r fath yn gorsefydlogi. Yn aml, argymhellir bod gwaith adfer yn cael ei gyflawni er mwyn datrys y sefyllfa hon, ac mae manteision gwaith o'r fath, o ran dynameg y systemau twyni a rhywogaethau arbenigol y twyni, wedi'i gofnodi.

Mae Cwningar Niwbwrch a Gwarchodfa Natur Genedlaethol Ynys Llanddwyn ar Ynys Môn yn safle gwarchodedig sy'n cynnal system fawr o dwyni tywod. O ganlyniad i orsefydlogi, mae maint y tywod agored yng Nghwningar Niwbwrch wedi gostwng 94% ers y 1940au, ac oherwydd ei statws safle gwarchodedig gwnaed gwaith sylweddol i'w adfer yn ystod gaeaf 2014-15. Golygodd hyn ddefnyddio peiriannau trymion i dorri rhiciau yn y blaendwyni, ynghyd â dileu glaswelltir o'r twyni ôl.

Mae poblogaeth o fadfallod y tywod i'w chael yng Nghwningar Niwbwrch, y credir iddi fod yno o ganlyniad i fod wedi cael eu rhyddhau yno heb ganiatâd (yn wahanol i'r rhan fwyaf o boblogaethau Cymru sy'n tarddu o raglen ailgyflwyno wedi'i chynllunio). Er gwaethaf ei tharddiad anawdurdodedig tebygol a'r posibilrwydd i hynny ddileu gwarchodaeth y Gyfarwyddeb Cynefinoedd, mae'n debyg bod Cyfoeth Naturiol Cymru yn ystyried bod y boblogaeth yn cyfateb yn gyfreithiol i boblogaeth frodorol neu boblogaeth wedi'i hailgyflwyno'n ffurfiol. Fe ymddengys fod hwn yn benderfyniad pragmataidd yn sgil yr opsiynau i ailgyflwyno'r rhywogaeth.

Lleisiwyd pryderon ynghylch y ffaith fod y gwaith o adfer y twyni'n effeithio'n uniongyrchol ar boblogaeth madfall y tywod. Y prif bryderon oedd y perygl o farwolaethau yn sgil y gwaith ar y tir, a'r lleihad ym maint y cynefinoedd a'r cysylltedd rhyngddynt o ganlyniad i greu ardaloedd mawr o dywod agored.

Casglwyd gwybodaeth gennym o ystod o ffynonellau gwybodus er mwyn asesu effeithiau tebygol y gwaith o adfer y twyni ar boblogaeth madfall y tywod yng Nghwningar Niwbwrch. Cynhaliwyd asesiadau cynefinoedd ac arolygon ym mis Medi 2015. Casglwyd gwybodaeth a'i dadansoddi gan ddefnyddio'r system gwybodaeth ddaearyddol (GIS).

Canfuwyd fod y gwaith o adfer y twyni'n debygol o fod wedi effeithio ar boblogaeth madfall y tywod mewn sawl gwahanol ffordd, a hynny'n gyda chanlyniadau cadarnhaol a negyddol. Yn gyntaf, mae bron yn sicr bod rhai anifeiliaid wedi'u lladd gan y broses. Yn ail, mae canlyniad uniongyrchol y gwaith wedi golygu colled net fechan o gynefin o ansawdd uchel a lleihad mewn cysylltedd ar y safle. Aseswyd bod tua 17% o'r cynefinoedd wedi'u colli, a llawer o'r rhain y cynefinoedd o'r ansawdd uchaf oedd ar y safle. Mae cynefin o ansawdd uchel i'w chael mewn tair ardal fechan ac un ardal fwy erbyn hyn, yn hytrach nag mewn un llain fawr fel ag yr oedd cyn cyflawni'r gwaith. Yn drydydd, bu gwelliant yn y rhagolygon tymor hir ar gyfer cynnal cynefinoedd y blaendwyni drwy ddynameg aeolaidd, a ddylai fod o fudd i boblogaeth madfall y tywod yn yr hirdymor, yn dilyn unrhyw effeithiau tymor byr.

Dangosodd arolygiadau yn 2015 fod poblogaeth madfall y tywod yn dal i fodoli, ac awgrymwyd bod ganddi broffil demograffig gweddol. Canfuwyd madfallod y tywod yn agos iawn i ardaloedd a oedd wedi'u hadfer, yn ogystal â mewn ardaloedd nad effeithiwyd arnynt yn uniongyrchol. Fodd bynnag, oherwydd amgylchiadau y tu hwnt i'n rheolaeth, cyfyngedig oedd yr arolygiadau ac nid oedd eu hamseriad yn ddelfrydol ychwaith ac o'r herwydd roeddent yn annigonol o ran gallu asesu statws presennol y boblogaeth yn drylwyr ac asesu'r rhagolygon ar gyfer dyfodol y boblogaeth.

Ar sail yr wybodaeth gyfredol, daethom i'r casgliad y bydd poblogaeth madfall y tywod Niwbwrch yn parhau yn yr hirdymor er gwaethaf effeithiau negyddol tymor byr y gwaith o adfer. Serch hynny, rydym yn argymell yn gryf y dylid cynnal arolygiadau pellach er mwyn asesu'r sefyllfa'n fwy trylwyr. Fel rhagofal, rydym yn argymell opsiynau ar gyfer gwella cynefin fel ffordd o wrthbwyso'r colledion tymor byr yng nghysylltedd cynefinoedd. Mae'r ardal fawr o goedwigaeth yng Nghwningar Niwbwrch yn gyfyngiad arbennig ar adferiad dynameg naturiol y twyni.

Canfuom rai diffygion yn y prosesau rheoleiddio sy'n ymwneud ag effeithiau posibl y gwaith o adfer y twyni ar fadfall y tywod. Nid oedd y drwydded a gyhoeddwyd gan CNC at ddibenion cadwraeth yn cyd-fynd â'r gweithrediadau trwyddedadwy a oedd yn debygol o fod yn rhan o'r gwaith. Nid ymddengys bod datganiad dull wedi'i lunio er mwyn sicrhau bod rheolaeth y gwaith yn cael ei weithredu gyda mesurau lleihau risg addas, h.y. mesurau lliniaru er mwyn osgoi a lleihau'r lladd, yr anafu, yr aflonyddu a difrodi elfennau allweddol o gynefin madfall y tywod. Yn ogystal, fe ymddengys na roddwyd digon o ystyriaeth i gysoni amcanion rhywogaethau (h.y. dyheadau CNC ar gyfer madfall y tywod yn yr ardal hon) gydag amcanion safleoedd gwarchodedig (h.y. canlyniadau dymunol y Warchodfa Natur Genedlaethol). Pe bai'r holl brosesau hyn wedi cael eu gweithredu a'u hintegreiddio'n well, gellid bod wedi ymgymryd â'r gwaith o adfer mewn modd a fyddai wedi lleihau'n sylweddol y perygl o niwed i fadfall y tywod, wedi gwneud y gorau o'r manteision i fadfall y tywod, ac wedi sicrhau lefel uwch o gydymffurfiad cyfreithiol.

Yn y dyfodol, wrth gyflawni gwaith adfer y twyni, dylid mynd ati'n rhagweithiol i asesu'r risgiau byrdymor a hirdymor ynghyd â'r manteision i fadfall y tywod. Gall gwaith adfer fod yn gyson â'r gwaith hynod o gadarnhaol y mae CNC a'u partneriaid wedi'i gyflawni o ran adfer madfall y tywod yng Nghymru. Wrth gynllunio adfer y twyni dylid ystyried symudiad pellach tuag at sicrhau Statws Cadwraeth Ffafriol ar gyfer y rhywogaeth hon, ond nid ydym yn rhagweld unrhyw wrthdrawiad na ellir ei ddatrys. Ar gyfer gwaith adfer yn y dyfodol pan fo madfallod y tywod yn bresennol (ac yn wir, rywogaethau eraill sydd dan fygythiad yn yr un modd), dylid ystyried y trafodaethau sydd ymhlith ymarferwyr Ewropeaidd ynglŷn â rhinweddau cymharol dulliau o adfer ar raddfa fawr o'u cymharu ag adfer mosaig.

Awgrymwn broses ar gyfer asesu'r risgiau posibl sy'n gysylltiedig â gwaith rheoli, ynghyd ag opsiynau ar gyfer rheoli effeithiau negyddol tymor byr a thymor hir. Mae angen ymgorffori deinameg systemau twyni tywod ac effeithiau tebygol newid yn yr hinsawdd yn y gwaith o gynllunio ar gyfer rheoli poblogaethau madfall y tywod ar dwyni tywod. Rydym hefyd yn rhoi arweiniad ar faterion ehangach rheoli cynefinoedd

twyni tywod ar gyfer ymlusgiaid, ynghyd â nodiadau ar werth twyni tywod i herpetoffawna'n fwy cyffredinol.

2. Executive Summary

The sand lizard *Lacerta agilis* is Britain's rarest lizard and has been successfully reintroduced to Wales following regional extinction. It occurs on sand dune sites in Wales, and such habitats are increasingly subject to over-stabilisation. Re-mobilisation works are often recommended to remedy this situation, with documented benefits to dune system dynamics and dune specialist species.

Newborough Warren and Ynys Llanddwyn National Nature Reserve on Anglesey is a protected site supporting a large sand dune system. Through over-stabilisation, the extent of bare sand at Newborough Warren has declined by 94% since the 1940s, and its protected site status led to substantial re-mobilisation in winter 2014-15. The works were done using heavy machinery and involved the cutting of notches in the frontal dunes, combined with stripping of grassland to the rear.

A population of sand lizards occurs at Newborough Warren, thought to result from unauthorised releases (unlike most Welsh populations, which originate from a planned reintroduction programme). Despite its likely unauthorised origin and the implication that this could obviate Habitats Directive protection, the population is apparently considered by NRW legally equivalent to a native or formally reintroduced population. This appears to be a pragmatic decision in the light of reintroduction options for the species.

Concerns were raised that the re-mobilisation works directly impacted on the sand lizard population. The key issues were the risk of lizard mortality via groundworks, and the reduction in habitat extent and connectivity due to the creation of large areas of bare sand.

We collected information from a range of informed sources to assess the likely impacts of the re-mobilisation works on the sand lizard population at Newborough Warren. Habitat assessments and surveys for sand lizards were conducted in September 2015. Information was collated and analysed using GIS.

We found that the sand lizard population is likely to have been affected by the re-mobilisation works in several distinct respects, with both positive and negative outcomes. Firstly, it is almost certain that some animals were killed by the works themselves. Secondly, the immediate outcome of the works has resulted in a small net loss of high quality habitat and a reduction in within-site connectivity. We assessed the loss of habitat extent at approximately 17%, with much of this being the highest quality habitat on the site. High quality habitat now occurs in three small and one larger patch, as opposed to a single large patch before the works. Thirdly, there has been an increase in the long-term prospects for maintaining frontal dune habitats via aeolian dynamics, which should benefit the sand lizard population in the long term following any short-term impacts.

Surveys in 2015 demonstrated that the sand lizard population persists, and suggested it has a reasonable demographic profile. Sand lizards were found very close to areas subject to re-mobilisation, as well as in areas not directly affected. However, due to circumstances beyond our control these surveys were undertaken with constrained effort and sub-optimal timing and were therefore insufficient to thoroughly assess the current status and future prospects of the population.

On the basis of current information, we tentatively conclude that the Newborough Warren sand lizard population will persist in the long term despite the short-term negative effects of re-mobilisation works. Nevertheless, we strongly recommend further surveys to assess the situation more thoroughly. As a precautionary measure, we recommend options for enhancing habitat as a way to offset short-term reductions in habitat connectivity. The large area of forestry at Newborough Warren is a particular constraint to restoring natural dune dynamics.

We found some short-comings in the regulatory processes relating the potential impacts of the re-mobilisation works on sand lizards. The licence that NRW issued for conservation purposes was not consistent with the licensable operations likely to have been involved in the works. There does not appear to have been a method statement to ensure management was implemented with suitable risk reduction measures, i.e. mitigation measures to avoid and reduce killing, injuring, disturbance and damage to key elements of sand lizard habitat. Moreover, there appears to have been inadequate consideration in aligning species objectives (i.e. NRW's aspirations for sand lizards in this area) with protected site objectives (i.e. the desired outcomes of the NNR). Had all of these processes been better implemented and integrated, the re-mobilisation works could have been undertaken in a way that substantially reduced the risk of harm to sand lizards, maximised the benefits to sand lizards, and ensured a higher level of legal compliance.

Future sand dune re-mobilisation works should proactively assess the short-term and long-term risks and benefits to sand lizards. Re-mobilisation can be consistent with the extremely positive work that NRW and partners have achieved in recovering the sand lizard in Wales. Further progression towards achieving Favourable Conservation Status for this species should be considered when planning re-mobilisation, yet we do not envisage unresolvable conflicts. The emerging discussions among European practitioners about the relative merits of large-scale versus mosaic restoration approaches should be considered for future re-mobilisation where sand lizards occur (and indeed other species with similar vulnerabilities).

We suggest a process for assessing the potential risks of management works, along with options for managing both short-term and long-term negative effects. The dynamics of sand dune systems and the likely impacts of climate change need to be incorporated into planning for managing sand lizard populations on sand dunes. We also provide guidance on broader sand dune habitat management issues for reptiles, along with notes on the value of sand dunes to herpetofauna more generally.

3. Part A: Main Report, Introduction

3.1 Background and aims of project

The sand lizard *Lacerta agilis* is Britain's rarest species of lizard. In the last century, the sand lizard has lost an estimated 80% of its range in the UK. The species was lost entirely from Wales in the 1960s. A collaborative reintroduction programme led by Amphibian and Reptile Conservation (ARC) and Natural Resources Wales (NRW) (and their predecessor organisations) re-established the species on coastal dune sites in North Wales in the 2000s. Monitoring has revealed encouraging signs that the reintroduced populations have established and, in some cases, expanded significantly.

Newborough Warren and Ynys Llanddwyn National Nature Reserve (NNR) on Anglesey, northwest Wales, incorporates a large sand dune system noted for its important flora, fauna and coastal landscape features. The area is also subject to other more or less coincident designations, Abermenai to Aberffraw Dunes SAC and Newborough Warren - Ynys Llanddwyn SSSI. For simplicity, in this report we refer to the area as Newborough Warren. During winter 2014-5, the site managers, Natural Resources Wales (NRW) undertook substantial works to re-mobilise the sand dune system at Newborough Warren. It has been estimated that the site has lost 94% of bare sand cover since the 1940s. Dune re-mobilisation (or de-stabilisation) is a habitat restoration method deployed at sites where coastal dunes have become over-fixed. It is increasingly used to recover sites suffering from over-stabilisation, with encouraging results.

Newborough Warren supports sand lizards, although they are thought to originate from an unauthorised release because no releases from the formal reintroduction programme have occurred there, and it is extremely unlikely that a native population would have gone undetected. The re-mobilisation works at Newborough Warren were subject to a European Protected Species licence, issued by NRW for conservation purposes. However, concern was subsequently raised by herpetologists because the re-mobilisation entailed substantial ground works on areas known to support sand lizards and common lizards. The main issue raised was that the re-mobilisation works could have harmed lizards and reduced the quality and extent of their habitat.

Interested third parties raised these concerns with NRW and suggested a review of the implications of the re-mobilisation works for sand lizards. This report describes the investigations undertaken by ARC in 2015 under contract to NRW and gives recommendations for future habitat management and restoration on coastal dune sites supporting sand lizards.

Map1: Newborough Warren showing area occupied by sand lizards. Orange squares are sand lizard presence records, 2010-2014. Note that the outlier record to the west is not thought to represent an established population. Mapping credits throughout this report unless otherwise stated: Sand lizard presence data courtesy of the NBN Gateway, and provided by The ARC Rare Species Database, with thanks to all the data contributors. The NBN and its data contributors bear no responsibility for the further analysis or interpretation of this material, data and/or information. Crown copyright and database rights 2011 Ordnance Survey [100017955]. Basemaps courtesy of Bluesky, Infoterra Ltd, COWI A/S, Getmapping PLC & Digital Globe, accessed via the OpenLayers Plugin for GQIS, and via Google Maps.

3.2 Sand lizard ecology

The UK is at the north-western edge of the sand lizard's large global range, which reaches south to Greece, east to Siberia, and north to the St Petersburg region of Russia. As is often the case with range-edge populations, the behaviour and ecology of sand lizards in the UK differs in some respects from that observed in the core range in continental Eurasia. This is especially the case with respect to thermal relations. Whereas higher ambient temperatures on continental Europe enable the sand lizard to thrive in habitats such as fields, woodland interfaces, hedgerows and parks where the species is often known as the "garden" or "fence" lizard (Blanke & Fearnley, 2015), in the UK the sand lizard occurs only at certain habitats with high insolation (sun exposure) in association with sandy soils. Not only does the short, dense vegetation that occurs at sandy heathland and coastal dune habitats provide cover from predators and invertebrate prey, but the sand lizard - an accomplished

excavator - can also easily access underground chambers in the sandy substrate in order to escape extremes of temperature.

It is not the aim of this report to describe sand lizard ecology in detail, but instead we set out some key points of relevance to the management issues at Newborough Warren NNR.

3.2.1 Habitat requirements

The sand lizard has very specific habitat requirements in the UK:

- Sandy substrate
- Slopes facing between southeast and southwest
- Slope angle of c30 – 40 degrees
- Bare sand occupying c5 – 35% of area for basking and egg laying
- Minimal shade from tree or tall scrub cover
- Varying vegetation height, 5 – 100cm
- Presence of dense patches of vegetation cover, especially heathers (*Calluna* and *Erica*) on heathlands, and marram grass *(Ammophila arenaria)* on sand dunes.

The two habitat types that support sand lizards in the UK are southern sandy heathland and coastal dune systems. Although both habitats provide the same broad resources, the two habitats differ in some important respects. These differences, combined with dispersal and colonisation history, have resulted in distinct “races” of sand lizard. Although these “races” have not been formally described as subspecies, there are recognised differences between the disjunct geographic areas occupied by sand lizards (see, e.g., Beebee & Griffiths, 2000; Simms, 1970; Russell, 2012). Sand lizards found in North Wales, which originate from founder stock sourced from the Sefton Coast, are often termed “dune race” sand lizards.

In order to thrive, the sand lizard requires specific environmental characters: high temperature and sunlight hours, and particular ground conditions for the deposition and incubation of eggs. The common (or viviparous) lizard *Zootoca vivipara* has different and generally less specific habitat requirements. Consequently, the sand lizard is less often found in areas with lower structural diversity (such as areas largely comprising young marram), compared to the common lizard. On coastal dunes, the highest population densities of sand lizards occur in dune situations where mature marram stands are regularly interspersed with bare sand (Beebee & Griffiths, 2000). Areas supporting such features are commonly termed “foci.”

The specific combination of a south-facing aspect, dense stands of marram and areas of exposed sand fulfils the foraging, thermoregulation, and egg-laying and incubation requirements of the sand lizard in the UK. This combination of environmental characters is most often found in the undulating ridges of the frontal dunes.

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Plate 1: Examples of coastal sand dune habitat supporting sand lizards in the UK. 1) Undulating topography and mature marram interspersed with bare sand, the combination of characters provided by the extensive frontal dunes of Ainsdale NNR on the Sefton coast which supports one of the highest densities of dune race sand lizards in the UK. 2) A south-facing bank used by sand lizards at the frontal dunes of Braunton Burrows, Devon.

Although the highest densities of sand lizards in dunes occur at frontal ridges where plentiful patches of suitable cover are interspersed with regular suitably sized areas of bare sand, good numbers of sand lizards can also occur at the inner, more fixed dunes as long as there are open sand patches for egg-laying. Small areas of open sand are usually provided by mechanisms such as the burrowing activities of rabbits or local human intervention (deliberate or incidental). In such situations further inland, the sand lizard makes regular use of interfaces between different vegetation structures.

Recent surveys on coastal dunes reveal sand lizards at the edge of eroded dunes and blow-outs in areas of more fixed dunes. In such situations, surveys tend to reveal adult females and juveniles, possibly indicative of the fact that these locations are being used as egg-laying sites. At Ynyslas NNR, Ceredigion, a considerable percentage of gravid female sand lizards detected to date have been along the vegetated edge of one particularly large parabolic dune.

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Plate 2: Examples of coastal sand dune habitat supporting sand lizards in the UK. 1) The edges of eroded dunes and "blow-outs" in the general area of more fixed dunes are also used by sand lizards. Photo: Mike Brown, North Merseyside Amphibian and Reptile Group (NMARG). 2) A mating pair of sand lizards detected at a particularly fixed area of the Birkdale dunes, Sefton Coast. These animals were on the fifth ridge back from the frontals, the only bare sand available being spoil piles produced by the burrowing action of rabbits. Photo: Ray Lynch, NMARG. 3) Frontal dune habitat at Ainsdale NNR supporting good numbers of sand lizards. 4) The inner, more fixed dunes at Ainsdale NNR also have good numbers of sand lizards present, although the animals can be more challenging to detect than those present at the frontals. Very little bare sand is available here other than that produced by rabbit activity. Photo: Mike Brown. NMARG.

Whilst bare sand is invariably essential for sand lizard reproduction in the UK, populations still manage to persist at inland areas on the Sefton Coast where there is minimal bare sand available. Golf courses, a school grounds, and road and railway embankments until recently all supported sand lizard populations, although the population density is likely to be low at those sites at which the only sand available is rabbit spoil and at which scrub is advancing. Monitoring by the North Merseyside Amphibian and Reptile Group (NMARG) suggests that the species has been declining at most of the inland sites, and the current status of at least two locations is uncertain. Encroaching scrub is a threat to the species at several locations, but fragmented populations of sand lizards can also be vulnerable to large-scale erosion. Although commonly seen at the edges of sandy pathways and the interfaces at areas of erosion and blow outs, sand lizards are noticeably absent from large areas of bare sand, at which they would be extremely vulnerable to predation from aerial predators.

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Plate 3: Sand lizards at coastal sand dune sites. 1) Adult male sand lizard frontal dunes, Ainsdale LNR, Sefton Coast. 2) Adult male sand lizard, frontal dunes, Ynyslas NNR, Ceredigion. 3) Gravid female sand lizard basking among marram at the edge of a large blow out, Ynyslas NNR, Ceredigion. 4) Adult male sand lizard, basking among marram 50cm below a well-used sandy pathway, Ynyslas NNR, Ceredigion. 5) Hatchling sand lizard, basking on warm sand at the top of a frontal ridge, Harlech, North Wales. 6) Early springtime male sand lizard at entrance to rabbit burrow, frontal ridge, Ynyslas NNR, Ceredigion.

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Plate 4: Sand lizard habitat and microhabitat. 1) Sand lizard reintroduction release area, Dyfi-Ynyslas NNR, Ceredigion. 2) Mature adult male sand lizard basking at entrance to rabbit burrow at a very fixed area of dunes, inner ridge, Ainsdale NNR, Sefton Coast. 3) Immature sand lizard basking at entrance to rabbit burrow, Ainsdale NNR, Sefton coast. 4) The first sand lizard hatchling recorded at Dyfi-Ynyslas NNR reintroduction site, Ceredigion. 5) Male sand lizard courting female among dense marram, Ainsdale LNR, Sefton Coast. 6) Gravid female sand lizard, inner dunes, Ynyslas NNR, Ceredigion.

On dune systems at which sand lizards are well established, animals are likely to occur throughout the site in open habitats at varying densities. In areas supporting less favourable habitat, it can be particularly challenging to detect sand lizards.

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Plate 5: Close-up views of sand lizards in situ. 1) Adult female sand lizard, frontal ridge, Braunton Burrows, Devon. 2) Sub adult sand lizard, frontal ridge, Braunton Burrows, Devon. 3) Adult female sand lizard, frontal ridge, Braunton Burrows, Devon. 4) Adult female sand lizard, inland fixed dunes, Birkdale corridor, Sefton coast. 5) Sand lizard hatchling, frontal dunes, Ainsdale LNR, Sefton Coast. 6) Juvenile sand lizard, frontal dunes, Harlech, North Wales.

3.2.2 Hibernation

Sand lizards typically emerge from hibernation during March, or occasionally in late February during exceptionally warm years. Males are the first to emerge, the first females beginning to emerge approximately two weeks after the males. The emergence of the females in particular can be protracted. Whilst some of the smaller females may emerge at the end of March/early April, larger mature females can emerge as late as the end of April, particularly on the Sefton coast. The southern colonies of sand lizards are active earlier in the year than the more northerly dune race of animals. When compared to the common lizard, which can function at lower temperatures than the sand lizard, the sand lizard has a relatively short active season.

Sand lizards hibernate for longer than other native reptiles. This is particularly the case in dune habitats. Adults often retreat into their hibernation burrows in late August or early September, regardless of the weather, although hatchlings can be active into October or even November (Beebee & Griffiths, 2000).

3.2.3 Egg-laying (oviposition)

Egg-laying reptiles such as the sand lizard often have specific requirements for incubation sites. In the UK, the sand lizard invariably lays eggs in bare sand. Semi-compacted sand is almost always used as it has good thermal properties and drains well while remaining humid only a few centimetres below the surface. Sites chosen for egg-laying are almost always in an exposed, sunny location, just far enough from nearby vegetation to avoid roots and shading, but not so far (usually less than 30 cm) that the female has to cross a large expanse of open ground. Small sand patches or the semi-compacted sandy edges of paths, tracks and firebreaks are, therefore, most often selected.

The period during which female sand lizards deposit their eggs can also be protracted, as demonstrated by the following quotes:

"The fourteen egg laying dates that I have for the sand lizard in Lancashire are all within the three week period between the end of the second week in June and the end of the first week in July; they are evenly scattered through this period but averaged a week earlier in 1964 than either 1963 or 1962." (Simms, 1970)

"Sand lizards are oviparous and the eggs develop rapidly within the mother in May and early June. During this time she basks extensively. Usually sometime in late May female sand lizards go off their food, presumably because the bulky eggs compress their digestive tract, and begin to dig test burrows. When eventually satisfied that she has found the right spot, ideally between 4 and 10cm below ground level in a sand patch, but within 40cm of adjacent vegetation, a clutch of 4 to 12 eggs is laid." (Beebee & Griffiths, 2000)

The bulk of egg-laying appears to take place in June; however this will vary according to location and weather. Last season (2015) the majority of clutches on the Sefton coast were deposited during late June. During previous years female sand lizards have deposited eggs as early as 3 June (Paul Hudson, pers. comm.) and

during exceptionally good years with abundant hours of sunlight even earlier clutches are possible, with reports of spent females in late May (Mike Brown, pers. comm.). Although such early clutches are probably exceptional occurrences on the Sefton coast, the North Wales dune sites are further south and so may possibly produce earlier clutches during particularly good weather years; this timing is a factor worth considering during habitat management planning.

3.2.4 Population dynamics and dispersal

Male sand lizards have fairly limited home ranges of only a few hundred m^2, which can overlap considerably, and the ranges of females are often even smaller (Blanke & Fearnley, 2015). If habitat conditions are especially suitable, adults may be remarkably sedentary and rarely cross suboptimal habitat. Individual lizards can be regularly seen in the same spot on repeated occasions, and often in successive years. Sand lizards show no territorial behaviour but a dominance hierarchy develops among the males each spring when they compete for females.

The sand lizard is unable to negotiate very steep inclines and is extremely vulnerable and exposed to predation at areas of open sand, instead opting to travel through the vegetation at edges of erosion rather than attempt risky movements across large areas of exposed sand. With this consideration in mind, notches cut into the frontal dunes to allow the free movement of sand to increase should be comparatively moderate in size with gradual sloping sides at locations at which sand lizards are present.

In the northern part of its range, the sand lizard may occur in relatively isolated, small relict populations which are vulnerable to extinction when exposed to certain pressures. Long-term studies on inland dune populations in Sweden have examined this in depth (see Berglind, 2005). Essentially, populations in that study were at moderate risk of extinction through stochastic factors such as cool summers. Both population modelling and direct observations underscored the importance of maintaining interconnected patches of open habitat through management.

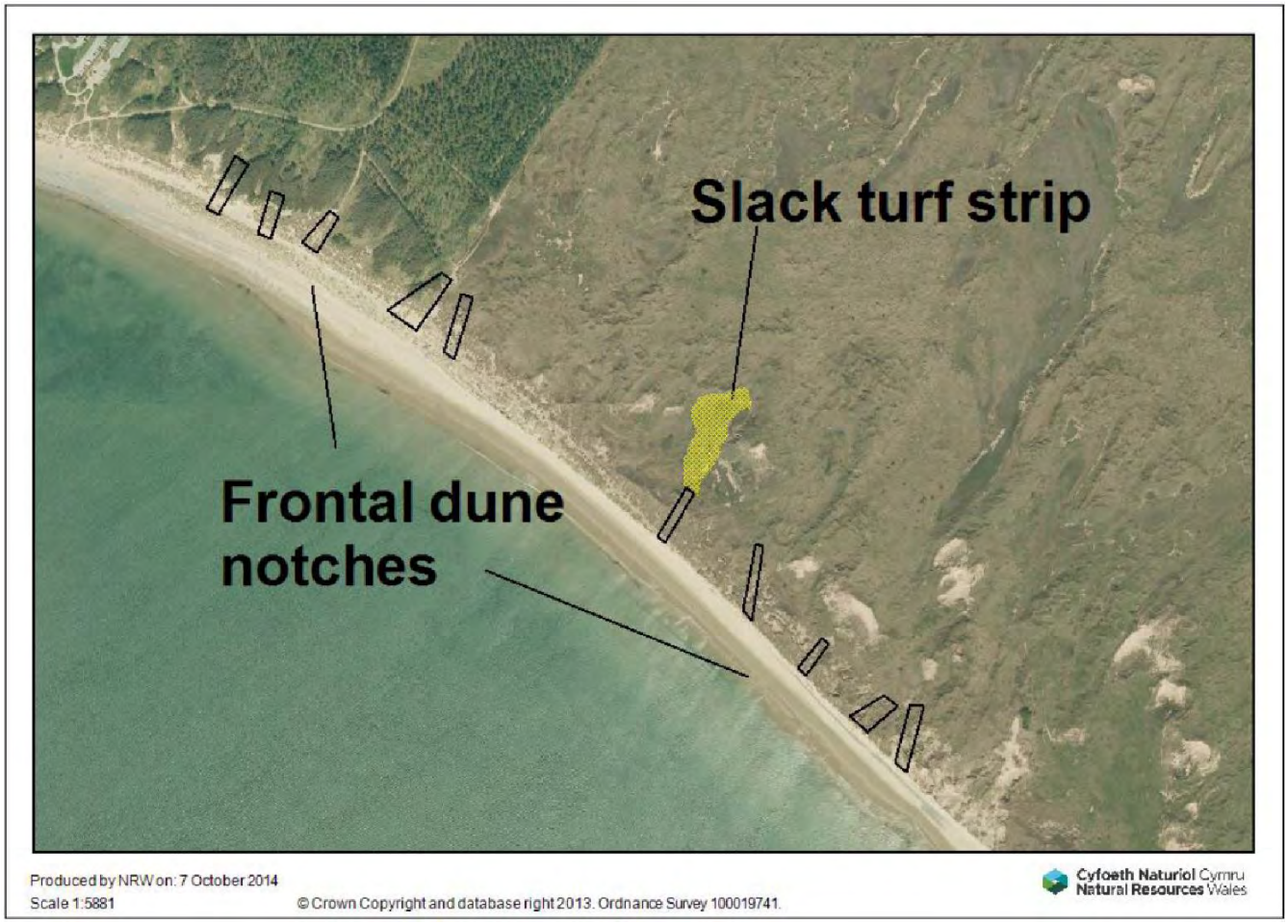
The Newborough Warren population appears to have resulted from an unauthorised release. Whether the population is genetically diverse is unknown; if not, it is possible that it will be less able to accommodate future pressures.

3.3 Dune re-mobilisation works at Newborough Warren in winter 2014-15

In order to increase the mobility of sand at Newborough Warren NNR, notches were cut into the frontal dune ridges during winter 2014-15 at nine locations, details of which are given in section 3. This management was accompanied by the clearance of dune grassland vegetation to the rear of the notches. Map 2 shows the location of the works.

The areas of bare sand to the rear of the first five notches cut into the frontal dunes at the Western end of the management works are extensive. This area now comprises sparsely vegetated, predominately bare sand encompassing almost the entirety of the area to the rear of the first five notches. Extensive areas of grassland

vegetation were also removed during management to the rear of the remaining four notches at the southern end of the management works locations.



Map 2: Locations of dune re-mobilisation works, winter 2014-15. Extracted from: *EPS methodology and contract specification brief*, G Williams.

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Plate 6: The short-term outcomes of re-mobilisation works. 1) Extensive areas of bare sand to the rear of the notches with sparse early stage vegetation regeneration evident. 2) View to the rear of multiple notch management at the western end of the works. 3) Extensive bare sand areas to the rear of the management locations at the southern end of the works.

4. Methods

4.1 Recent sand lizard status, habitat condition and habitat associations

We investigated the recent history of sand lizards at Newborough Warren by examining records and consulting specialist surveyors. Records were primarily from ARC's Rare Species Database. ARC staff examined photographs and notes on habitat associations and compared the situation at Newborough Warren with other dune sites.

4.2 Sand lizard survey and habitat condition assessment in September 2015

4.2.1 Methods and effort

Six full days of visual searching was undertaken at Newborough Warren NNR from 10-19 September 2015. Although visual search can result in very low detection rates for some reptiles and is also highly weather dependent, it is most suited to detecting sand lizards. When surveying specifically for sand lizards, it is critical to select appropriate habitat features for survey. In this survey no artificial cover objects (ACOs) were used; although often valuable for other reptiles, the method is inappropriate for sand lizards in the conditions present at Newborough Warren.

The time of year strongly influences detection probability. Late April and May is the most productive survey period for detecting sand lizards on dune systems. There tends to be a male bias, because males are at their most active and conspicuous at this time. By contrast, the results of surveys undertaken in June invariably reveal a higher proportion of females. These differences are due to changes in behaviour, especially related to reproduction and thermoregulation.

Surveys from mid-June to August tend to result in very low detection. Sand lizards remain concealed in dense vegetation or in subterranean burrows during the hotter parts of the year, and sightings at this time of year are generally restricted to early morning and late afternoon or early evening survey. There may be brief, chance encounters with animals moving between patches of cover during the warmer parts of the day.

A wide range of factors can affect survey results such as weather conditions, physiological state of reptiles, time of day, seasonality and habitat condition. September, although often an improvement on July and August, is rarely as productive as late April or May. This is partly because some animals may have entered hibernation as early as the end of August. Comparison of previous surveys at both southern heath sites and more northerly coastal dune situations suggests that early hibernation occurs most often at the dune locations.

Experience has also repeatedly demonstrated a noticeable behaviour change during September which also has the potential to affect survey results. Whilst animals disturbed from their basking spots during a spring day are likely to return within a short time, thus enabling an observer to detect them, there seems to be a reduced likelihood of animals doing this in September. Another significant behavioural change demonstrated by sand lizards on dune systems during September is the general

move from direct insolation to mosaic basking (cryptic basking in partial cover). Seasonality being a prior consideration, the 2015 survey at Newborough focussed on areas that provided insolation yet were either close to or partially obscured by cover.

Detection probability can vary over very short timescales, influenced mainly by changing weather conditions, and this is especially notable during September on sand dunes. Therefore it is advantageous for the surveyor to be either directly at or in very close proximity to the site in order to use the viewing windows effectively. The Newborough Warren survey took the form of arriving on site at 08.00 with light waterproofs and sufficient food and water to stay on the dunes until 18.00. Whilst common lizards were detected along the entire length of the dunes during a time range of 09.40 to 18.00, sand lizards were detected along a comparatively smaller stretch of the dunes and only during a time range of 10.04 to 16.39.

Full survey was undertaken to determine the range of the population both along the dune frontage and inland where suitable habitat occurs, specifically:

1) Traeth Llanddwyn: From the entrance onto the beach from the main NRW beach car park along the length of the frontal dunes towards Abermenai Point.
2) Traeth Penrhos: From the southern extremity of dunes near Ynys Llanddwyn north towards the Cefni Saltmarsh.

Wherever possible each sand lizard was observed, photographed, and GPS locations were noted along with details of sex and life stage. Where possible and appropriate, adult animals were hand caught and a photographic record of the back pattern obtained. No such attempts were made with juvenile or immature animals.

4.3 Assessment of implications for sand lizards of dune re-mobilisation

4.3.1 Implications for sand lizards at Newborough Warren NNR

We assessed the changes in habitat extent, quality and connectivity brought about by the works. This was done by assessing habitat condition during September 2015, and comparing this with records, notes and photographs relating to the pre-works state. Records were entered onto GIS (QGIS 2.8.1, using TomBio Productivity Tools and OpenLayers plugins), and analysed using georeferenced aerial photos. We discussed key issues with the site manager, NRW specialist staff, ARC staff and reptile surveyors familiar with Newborough Warren. Using the known 2015 and inferred 2014 positions, along with information on the management methods, we assessed the implications in terms of direct and indirect effects, in both short and longer terms.

4.3.2 Implications for guidance on habitat restoration and management

We assessed existing guidance on sand dune management and restoration to check for any gaps to help land managers assess and plan works on sites supporting sand lizards. In discussion with NRW prior to the contract award, we had identified that there was a need for new guidance, taking into account the findings of our

investigations in 2015. Therefore, the contract included production of a suggested annex to the *Reptile Habitat Management Handbook* (Edgar et al, 2010).

4.3.3 Implications for regulation and conservation planning

We assessed the implications of our findings at Newborough Warren for the interplay between sand lizard conservation, habitat management regulation and conservation planning more broadly. These points are covered in the Discussion section (Page 39).

5. Results

5.1 Recent sand lizard status, habitat condition and habitat association

The history of sand lizards at Newborough Warren is uncertain, with unconfirmed reports starting in 2012. This followed the discovery of a population at Aberffraw in 2010. Both populations are thought to have been established via unauthorised releases. It is, however, considered likely that these areas had originally been colonised naturally by sand lizards, only to go extinct in the 19th or 20th centuries, as happened with other Welsh populations.

The habitat at which animals were first detected at Newborough Warren comprised a south-east facing bank approximately 150 m in length, which flanked a pathway to the front of the forestry boundary. The bank was densely vegetated with marram but regularly interspersed with patches of bare sand. The same area of habitat is included within the area of the 2014-15 management locations 4 (SH 40963 63095) and 5 (SH 41008 63056). Sand lizards were observed in this management area in 2013-14.

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Plate 7: Comparison of before and after re-mobilisation management at a known sand lizard "focus" (hotspot). 1) The area of management location 4 prior to works being undertaken (note wooden marker post). 2) Detail of the habitat prior to management at location 4. A south east facing aspect and dense marram clumps interspersed with small areas of bare sand evidently combined to create ideal sand lizard habitat. 3) The area of management location 4, after management, September 2015 (note wooden marker post). 4) Area to rear of management location 4, after management, September 2015.

Although management locations 4 and 5 comprised the focus of sand lizard sightings prior to winter 2014-15, animals were also detected along the frontal dunes in a southerly direction for a distance of 800m during 2013 and 2014. Prior to re-mobilisation management, habitat in this area comprised undulating topography densely vegetated with marram but regularly interspersed with patches of bare sand (Mike Brown & Paul Hudson, pers comm). This combination of factors constituted optimum frontal dune sand lizard habitat, directly comparable with known hotspots for this species on the Sefton coast.

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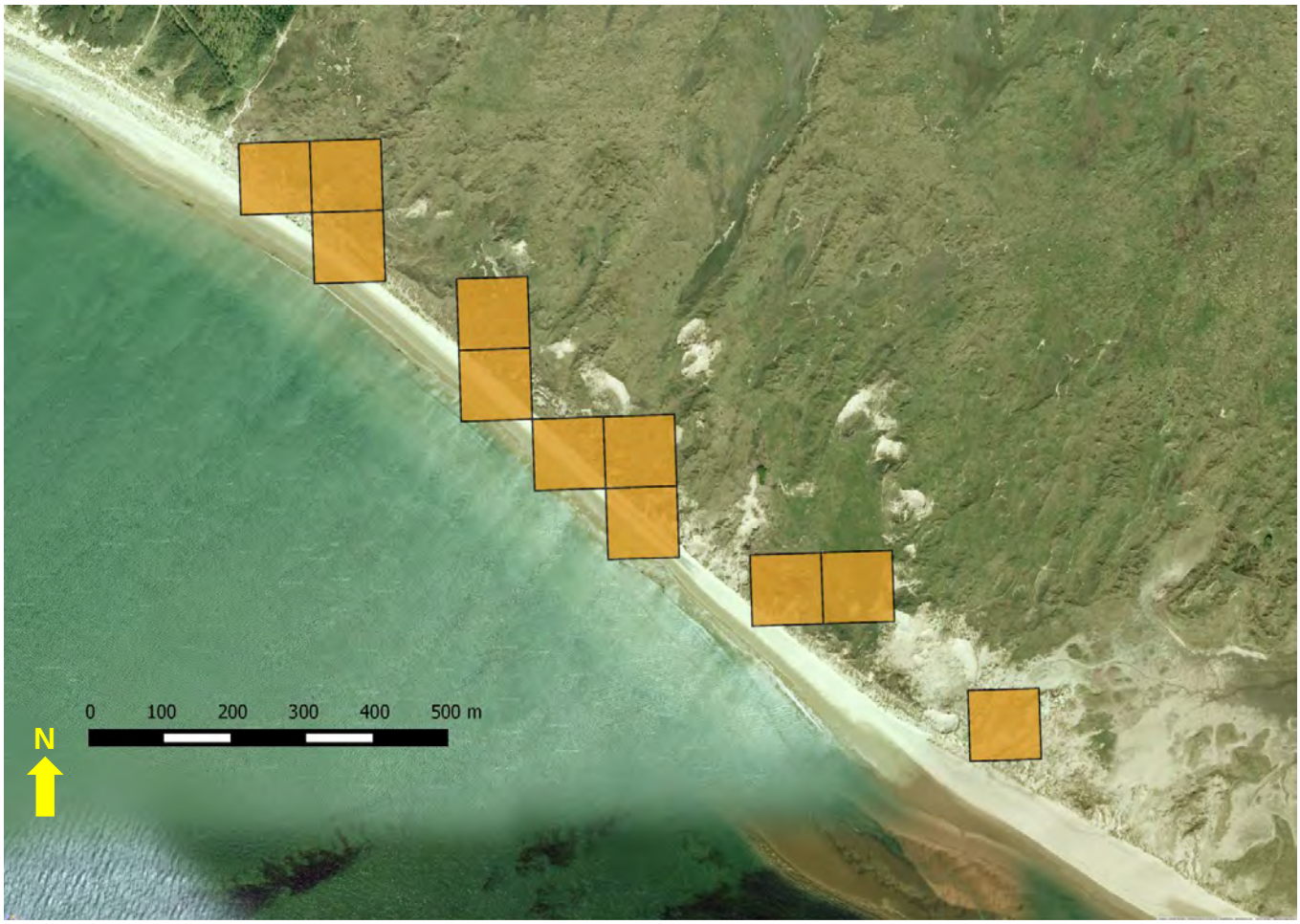
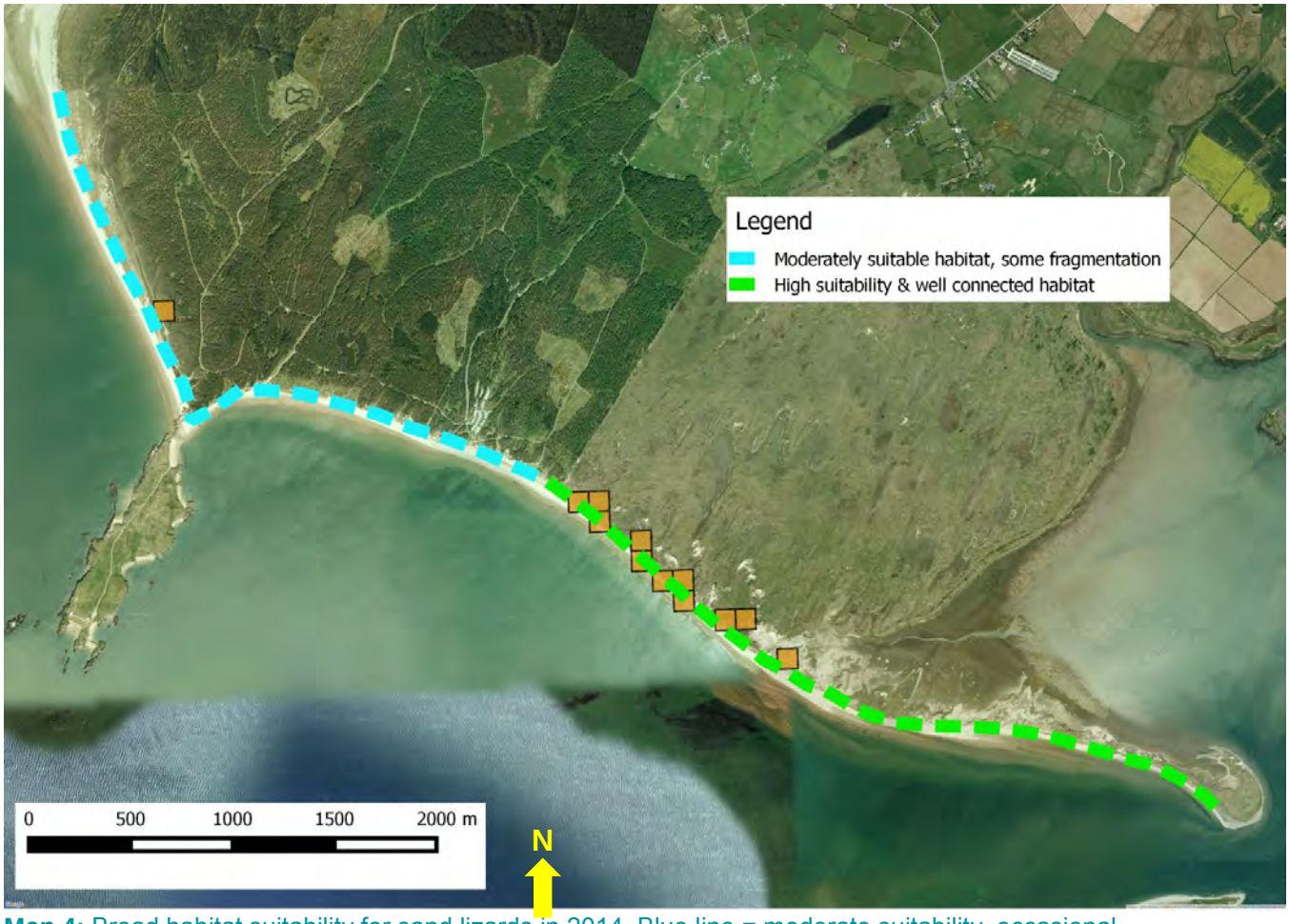
Plate 8: Occupied habitats before and after re-mobilisation management. 1) Looking west from management location 8 prior to management; extensive optimal dune habitat, which likely had a wide distribution of sand lizards. Paul Hudson, NMARG. 2) Management location 5, September 2015. 3) Looking south from management location 5 prior to management. Paul Hudson, NMARG. 4) Detail of the habitat south of location 5 prior to management, at which sand lizards were previously recorded. Structural diversity, dense marram and bare sand patches provide opportunities for thermoregulation, foraging, egg-laying and incubation. Paul Hudson NMARG.



Map 3: Locations of sand lizards up to the end of 2014, at 100m resolution. Note that some additional records may not be shown on this map, but they do not alter the broad distribution pattern.



Map 4: Broad habitat suitability for sand lizards in 2014. Blue line = moderate suitability, occasional fragmentation. Green line = high suitability, good connectivity. Orange squares = sand lizard records 2010-2014.

Map 5: Inferred habitat suitability for sand lizards in 2014 in the main occupied area and re-mobilisation works area. The black hatching shows inferred high quality sand lizard habitat. Orange squares are sand lizard records, 2010-2014. Inferences made from records, photographs and consultation with surveyors.

5.2 Sand lizard surveys in September 2015

We made 10 observations of sand lizards over 6 days of survey effort between 10 September and 19 September 2015. A daily maximum of 3 sand lizards was observed, and both sexes and all age classes were seen. It is possible that we found fewer than 10 individuals, as some observations could have been repeat sightings of juvenile lizards, but we are confident that we found a minimum of 9. Common lizards were more frequently observed than sand lizards, with up to 11 sightings per day. Survey conditions ranged from good to excellent.

Sand lizards were always detected at areas of frontal dune habitat, with the following particular habitat associations: south-east facing banks sheltered from the wind and vegetated with dense marram clumps, interspersed with areas of bare sand. Full details of the survey are given in Part B, Chapter 10, along with photographs of habitats in which sand lizard observations were made.

Given that surveys were undertaken in September, which is not optimal timing for this species, we recommend that further surveys are undertaken in April-June. This would allow a more thorough assessment of the distribution and status of the population.

Map 6: Sand lizard records from surveys in September 2015. Ten observations plotted, relating to a minimum of nine different individuals. See text for explanation, and Part B for more detail.

5.3 Habitat condition in September 2015

This section describes the habitat condition as observed during our site visits in September 2015, particularly in respect of the outcome of re-mobilisation works. Some comments on the possible effects on sand lizards are mentioned here, and these points are then expanded upon in the recommendations for short-term and long-term management (see later).

5.3.1 Locations 1, 2, 3, 4 and 5

Location 1 (SH 40753 63240), Location 2 (SH 40791 63245), Location 3 (SH 40856 63155), Location 4 (SH 40963 63095), Location 5 (SH 41008 63056)

Rejuvenation works undertaken at locations 1 to 5 comprise notches cut into the frontal dune ridge that are directly linked to large areas of bare sand at which grassland vegetation has also been removed. At these locations connectivity and dispersal potential for sand lizards is currently (2015) very poor both in the frontals and further inland. Whilst the aspect of the sloped sides of the notch would be

traversable by sand lizards if vegetated, currently the gradient predominately comprises bare, loose sand which cannot be traversed by sand lizards.

One option to consider to improve connectivity in the short term would be to re-profile the sloped sides of the notches to a shallower gradient with a mini digger on tracks. However, being mindful both of the amount of time that has elapsed since the management was undertaken and the likelihood of a subsequent reduced population of animals, it may be more advantageous to avoid further disturbing the habitat and simply allow the sloped sides of the notches to re-vegetate over time whilst monitoring both the rate of recovery of the vegetation structure and the distribution of the sand lizards.

An alternative and perhaps more realistic course of action both in terms of practicalities and costs incurred would be to consider improving connectivity and dispersal routes slightly further inland. Felling shading conifer trees at the interface between forestry and dune edge to a depth of 5-10 m would potentially provide a corridor of open habitat with opportunities for thermoregulation, which would potentially enable reptiles to disperse along the resulting inland sun-lit interface whilst connectivity in the frontal ridges remains fragmented.

The notch cut into the frontals at location number 5 is currently a little wide for sand lizards to traverse safely but is displaying signs of early stage vegetation regrowth on the sloped sides of the notch particularly to the rear of the notch banks, slightly further inland. Currently there is low dispersal and connectivity potential available which will improve as the vegetation regenerates over time. Again, the thinning of trees at the rear interface between dune and forest could potentially provide an alternative dispersal route by increasing available inland connectivity.

Locations 4 and 5 comprise an area at which a comparatively high percentage of sightings of sand lizards were recently previously recorded by specialist reptile surveyors and is likely to have been the area at which the most significant impact was incurred to the population during the winter management works. Fortunately, the area between notch number 5 and the next area of works, notch number 6, is the largest block of suitable sand lizard habitat within the area of management that currently remains undisturbed. Three sightings of juvenile animals were recorded in this block of habitat during the September 2015 survey.

1) View of notch number 1 from beach.

2) Rear view of notch number 1.

3) View of notch number 2 from beach.

4) Rear view of notch number 2.

5) View of notch number 3 from sea front.

6) Rear view of notch number 3.

7) Large area of bare sand reaching to forest Edge.

8) Forestry interface to rear of notch number 3.

Plate 9A: Habitats after re-mobilisation management, photographed in September 2015.

9) View of notch number 4 from beach.

10) Rear view of notch number 4.

11) The large area of bare sand extending as far as the forest edge to the rear of notch number 4. Removing conifer trees along the rear interface would potentially create an inland connectivity corridor along which sand lizards could disperse, whilst the sloped sides of the frontal notch are allowed to re-vegetate over time.

12) View of notch number 5 from sea front.

13) Rear view of notch number 5.

Plate 9B: Habitats after re-mobilisation management, photographed in September 2015.

5.3.2 Locations 6, 7, 8 and 9

Location 6 (SH 41132 62960), Location 7 (SH 41265 62861), Location 8 (SH 41260 62845), Location 9 (SH 41260 62845)

The dispersal routes for sand lizards at the frontal ridge at locations 6 to 8 are currently (2015) dis-connected. The combined lack of available vegetation structure and steep gradient of the notch sides result in a terrain that sand lizards are unable to travel across. Connectivity will improve as the marram regenerates on the banks of the sloped sides over time.

Dispersal is still possible at inland interfaces with the remaining existing vegetation, although animals would need to travel a significant distance to be able to take advantage of the remaining connectivity. Connectivity is likely to improve over time both at the inland ridges and at the frontal ridges as the vegetation structure regenerates. The recommended course of action would be simply to allow the notch sides to re-vegetate over time.

The existing habitat that continues along the frontal ridge immediately southwards of notch number 9 is also the area at which the majority of sand lizards were detected and recorded during the September 2015 survey.

14) View of notch number 6 from sea front.

15) Rear view of notch number 6.

16) View of notch number 7 from sea front.

17) Rear view of notch number 7.

18) View of notch number 8 from sea front.

19) Rear view of notch number 8.

Plate 10A: Habitats after re-mobilisation management, photographed in September 2015

20) View of notch number 9 from sea front.

21) Rear view of notch number 9.

22) Detail of slope angle at notch number 9.

23) Sand lizards will be able to negotiate this incline once the vegetation structure has regenerated.

Plate 10B: Habitats after re-mobilisation management, photographed in September 2015

5.4 Comparing habitat condition before and after management

Maps 7-9 provide an overview of the changes in habitat condition resulting from the re-mobilisation management in winter 2014-15. The main qualitative changes are a substantial increase in the amount of open sand, a reduction in the amount of humic sand, a reduction in the extent of fixed turf, a reduction in vegetation cover (especially marram and other dune grasses), and an altered topography (notably in the form of notches cut into frontal dunes).

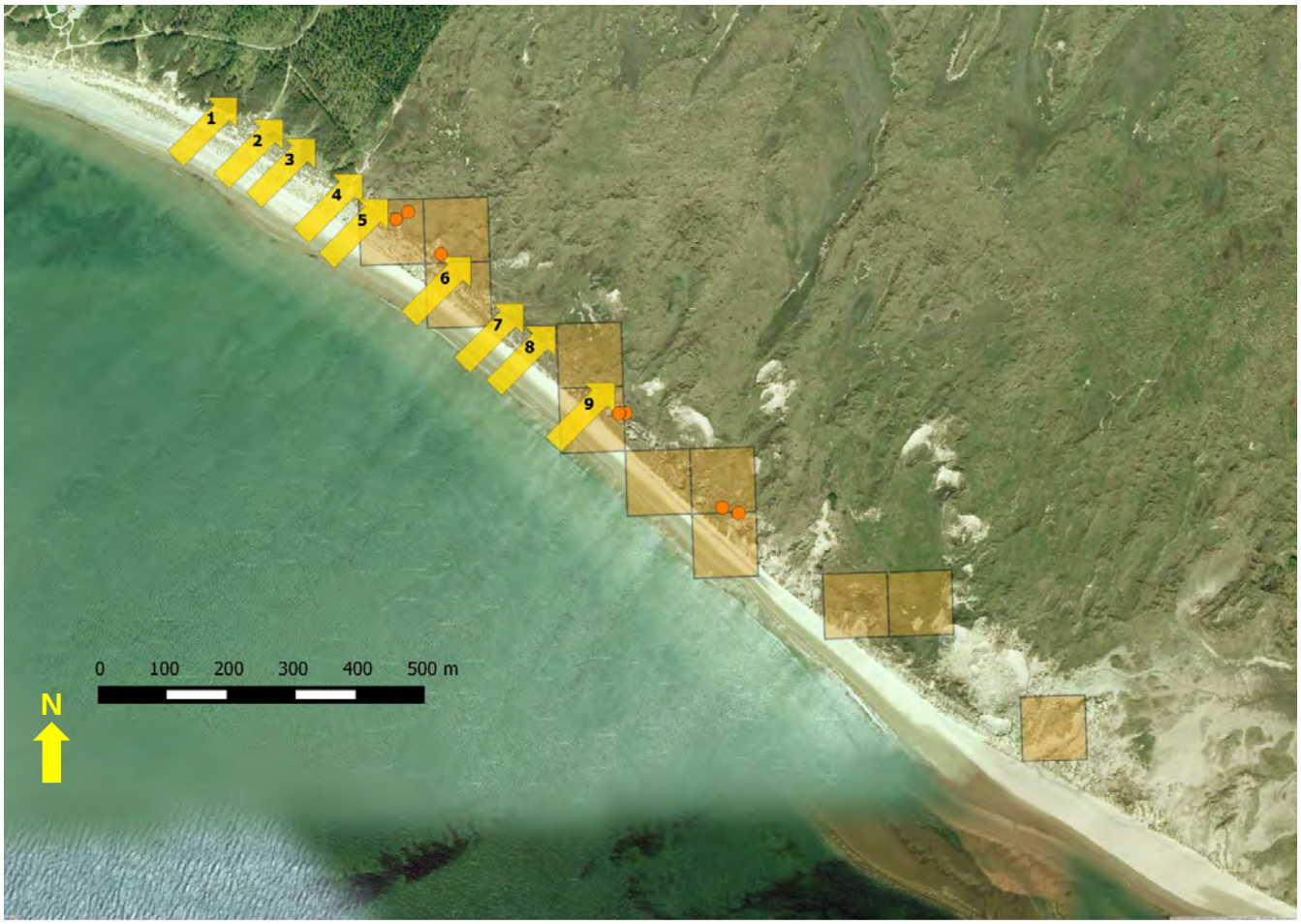
In terms of sand lizard habitat, these changes have resulted in two short-term effects: a reduction in the extent of highly suitable habitat, and fragmentation into patches with reduced dispersal potential between patches. The mapping exercise indicates that the amount of high auditability habitat decreased from approximately 13.7ha to 11.4ha (Map 9). This represents a reduction of 2.3ha, i.e. a 17% decrease compared to the pre-management state. However, suitable habitat is developing to the rear of the foredune ridge, resulting in a projected increase in suitable habitat. It appears that the area affected by the works represented some of the highest quality habitat for sand lizards. Whilst before management the area occupied comprised a single large block of habitat, the state afterwards comprises one large block along with three smaller patches, with substantially reduced dispersal opportunities between

them (Map 9). There will also be some short-term increase in habitat quality associated with the removal of vegetation providing excessive shade, although this is minimal compared to the likely reduction in favoured habitat. Note that the areas of habitat stated above are based on the minimal information available, and not a detailed survey, so they are subject to some uncertainty.

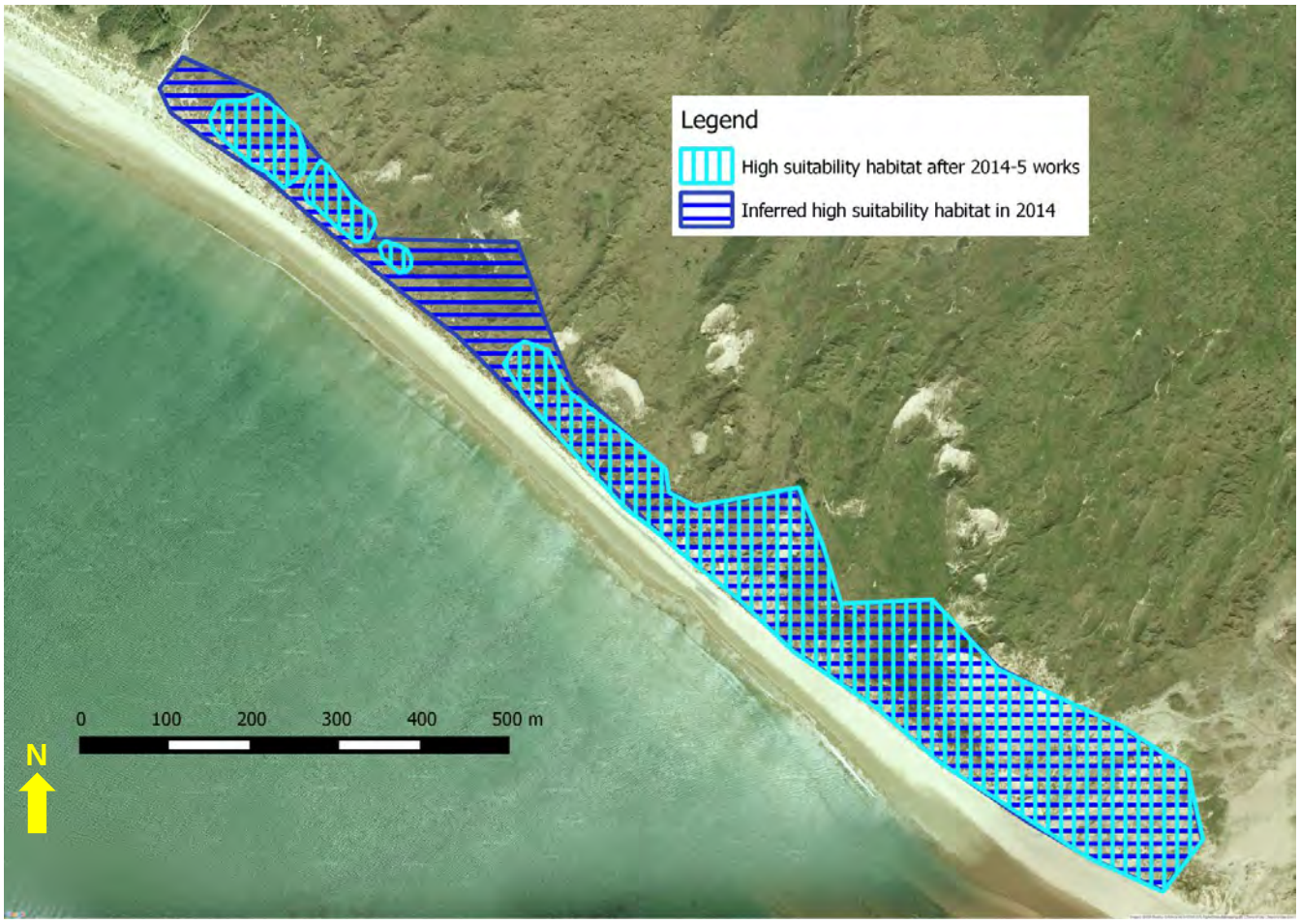
Whilst the immediate effect of the re-mobilisation is substantially negative in terms of extent of high suitability habitat, the condition of the habitat will clearly change in time. In the medium term, vegetation in the denuded areas will regrow and provide better quality habitat for sand lizards.

Map 7a: Habitats shortly before re-mobilisation works. Image is a screenshot from web app created by DTM Technologies, passed to ARC via NRW (URL: https://dtm-tech.maps.arcgis.com/apps/webappviewer/index.html?id=4a1ef914043640e98de98a82a8fb262b)

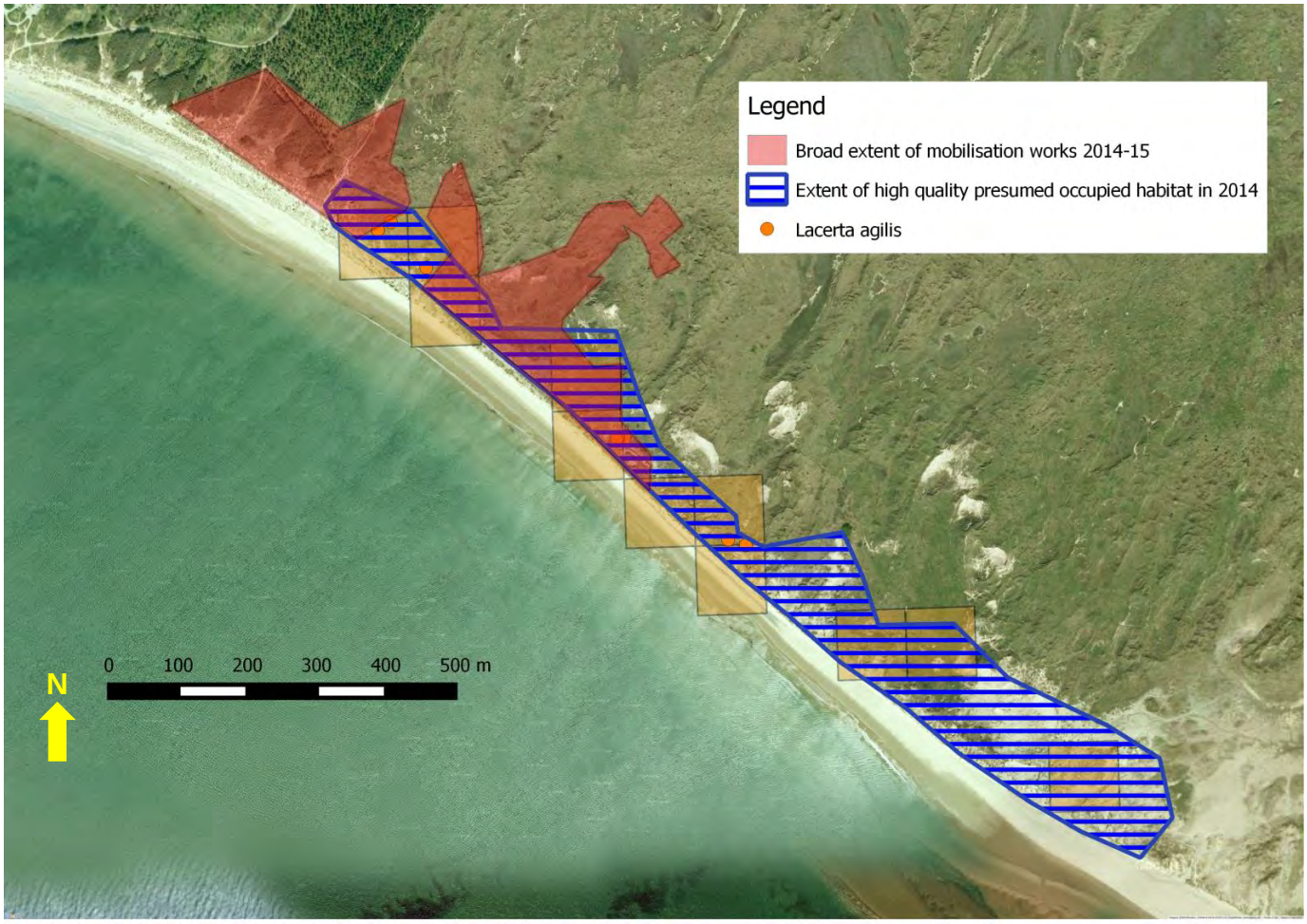
Map 7b: Habitats shortly after re-mobilisation works. Image is a screenshot from web app created by DTM Technologies, passed to ARC via NRW. (URL: https://dtm-tech.maps.arcgis.com/apps/webappviewer/index.html?id=4a1ef914043640e98de98a82a8fb262b)



Map 8: Location of re-mobilisation notch works in relation to sand lizard records. Yellow arrows = location of notches. Orange dots = September 2015 sand lizard records. Orange squares = 2010-2014 sand lizard records.



Map 9: Suitability and connectivity of habitat for sand lizards, before and after re-mobilisation works in winter 2014-15 (main area likely to be occupied by sand lizards only.) Dark blue hatching = area of high sand lizard habitat suitability in 2014, inferred from investigations. Light blue hatching = area of high suitability habitat as observed in September 2015, following re-mobilisation works.



Map 10: Overlap between winter 2014-15 re-mobilisation works and sand lizard habitat. Blue hatching = extent of high quality habitat presumed to be occupied by sand lizards in 2014. Red shading = broad extent of re-mobilisation works in winter 2014-15. Orange squares = 2010-4 sand lizard records. Orange dots = September 2015 sand lizard records.

6. Discussion

6.1 Effects of dune re-mobilisation works on the sand lizard population at Newborough Warren NNR

Sand lizards typically demonstrate a clustered distribution within a site. Their localised distribution often reflects the availability of microhabitats and features (Blanke & Fearnley, 2015). In frontal dune habitats - as at Newborough Warren prior to the management works of winter 2014-15 - these favoured habitat patches normally occur throughout the site, and with connecting habitat that allows dispersal between these patches. In these cases, where there is broad coverage of optimal and connecting habitat, the distribution of lizards can be comparatively even.

The 2014-15 winter re-mobilisation management at Newborough Warren was undertaken in areas of optimal habitat known to be used by sand lizards. There are two types of possible effect resulting from this activity: effects on individual lizards, and effects on habitat.

Although over-wintering areas are not understood precisely at this site, the areas affected by the management were very likely to be used for hibernation. The lizards were therefore likely to be taking refuge in voids below the ground surface at this time. The works were undertaken using heavy plant and entailed rapid, substantial movement of sand and vegetation, at a time when lizards could not escape. It is therefore very likely that the re-mobilisation works led directly to the killing, injuring and disturbance of hibernating sand lizards. Mortality is likely to have been highest in locations 4 and 5, the areas generating most observations in 2013-14.

Maps 7-10 indicate, however, that individuals in much of the occupied habitat would not have been at risk of direct harm. Map 10 shows that only parts of the northern half of the occupied area were directly impacted. Our surveys in September 2015 confirm that sand lizards persist at the site, including in areas subject to the management works. Furthermore, the population includes a mix of age classes, including juveniles. Nonetheless, the works impacted an area thought to support one of the highest density patches (management locations 4 and 5), and mortalities here could have a significant albeit highly localised impact.

The re-mobilisation works have resulted in changes to habitats occupied by sand lizards at Newborough Warren, in line with the management objectives. For sand lizards, the short-term outcome is that there is now a moderately lower extent of highly suitable habitat, and it is more fragmented (see Map 9). We calculate that the area of highly suitable habitat has decreased in the immediate post-management period by approximately 17%, from 13.7ha to 11.4 ha (note that these are very approximate figures, subject to some uncertainty).

Such a reduction in the extent and connectivity of highly suitable habitat could potentially have several effects. Individual lizards may be disadvantaged, for example experiencing an increased risk of predation, reduced prey abundance, or reduced opportunities for mate-finding. This could lead to reduced chances of survival and reproduction, which in turn could affect population size and viability.

There is limited scientific information against which to assess these findings. Berglind (2005) showed via a modelling approach that extinction risk was reduced to a reasonable level when habitat patch size was >5ha. Given that some of the remaining patches at Newborough Warren are now considerably smaller than this, we suggest it is important to reconnect them and/or to increase patch size. The projected large increase in the extent of suitable habitat due to re-mobilisation are encouraging, although the viability of sand lizard populations restricted to small patches needs to be integrated into the planning of any future restoration works.

Ideally we would estimate the population size at Newborough Warren and assess the potential impacts of removing a proportion of individuals on viability. Unfortunately, population estimation is notoriously difficult for sand lizards (see discussion in Blanke & Fearnley, 2015), and our current data do not allow even an approximation.

Importantly, populations which are large and with individuals dispersed over a wide area are more likely to be resilient to negative impacts from management works. For this reason, it is likely that the Newborough Warren population will be robust to the winter re-mobilisation works, since much of the occupied area was not directly affected. Given that some of the highest quality habitat was affected, however, further surveys should assess occupancy across the site to test this assumption.

The re-mobilisation works created open sand at the rear of the frontal dunes, and the edges of these areas may include improved microhabitat conditions for sand lizards. On the whole, though, the works did not result in significant short-term benefits in terms of habitat enhancement. The situation is different for long term prospects (discussed below).

It is important to emphasise that, with the available evidence, we cannot confidently state the magnitude or significance of these potential negative short-term impacts. Direct mortality is highly likely, as is reduction in dispersal and survival chances for some lizards. However, we tentatively conclude that it is unlikely that the re-mobilisation works will negatively affect the short-term or long-term prospects for the population. This is because, from our investigations, we have found that (a) the majority of the occupied habitat was not directly negatively affected by the works, and remains in good condition for sand lizards, (b) some of the habitat that has been reduced in quality for sand lizards is likely to improve in the long term, (c) a reasonable proportion of the population is unlikely to have been directly harmed by the works.

We recommend further surveys are undertaken at Newborough Warren in 2016-17 in order to assess more thoroughly the status and prospects for the population. Such surveys should be designed with specific aims of assessing the local status of sand lizards, along with habitat condition (see 4.6.1 for details).

The long-term effects of the re-mobilisation works are likely to be positive for sand lizards at Newborough Warren, with the important proviso that the population persists through any short-term impact of the works. The re-mobilisation should create a more dynamic dune system, which should be beneficial to sand lizards.

The wider integrity of the site is important context here, with particular reference to the large afforested area known as Newborough Forest (this falls within the SAC and SSSI, but not the NNR). The afforested area represents a significant loss of sand dune habitat and has impacts on the adjacent dune areas via a number of processes, including altered hydrology, wind shear, and dune cliffing (e.g. Bristow, 2003). The condition of the SAC interest features reflects these adverse impacts. This decline in condition in turn affects the status of the dune specialists on the site. The effects the forest area may compound the impacts of re-mobilisation management, since the area of frontal dunes is less than it might be, and because the rate and extent of dune stabilisation is accelerated. From the perspective of sand lizards and other dune specialist species, felling areas of the forest, at least along the seaward edge, would be highly beneficial, since it would increase the area of dunes and help to restore natural dune dynamics. Moreover, we recommend that the likely impacts of climate change and sea level rise are factored into these considerations, noting that dunes are also inherently dynamic.

We recognise that there are several interests to balance, notably tourism, forestry, recreation, and nature conservation (of which SAC & SSSI objectives and protected species are just two elements, each complex in their own right). We understand that there have been debates over how to achieve this balance but given that this report has a particular focus on reptiles, we strongly favour a reduction in forest area and a restoration of the dune system.

6.2 General issues raised by dune re-mobilisation impacts on sand lizards

Sand dune systems across northern Europe are suffering from over-fixation (e.g. Provoost et al, 2011). Open dune conditions are being replaced by those representing later successional stages, especially fixed dune grassland, scrub and eventually woodland. Historical aerial photos and reports demonstrate a substantial loss of open sand in recent decades (e.g. see Map 11; Provoost et al, 2011). Dunes sites typically comprise a declining representation of pioneer habitats such as embryo dune slacks and bare sand. This is now a serious issue affecting the condition of sites designated as SSSIs or SACs for their sand dune interest (JNCC, 2013; Howe, 2014). At Newborough Warren, the amount of bare sand has declined by 94% between the 1940s and the present day (Howe, 2014). There is a wider debate here about how to arrive at an appropriate target state. Setting the 1940s as a target could be contentious since it reflects a very particular set of socio-economic and environmental conditions; indeed there is a query over whether opting for a particular date is prudent, but we do not discuss these issues further here. As well as the reduction in habitat quality, this is increasingly recognised as a serious issue for dune species, with noted declines in specialist invertebrates and plants that favour pioneer conditions (e.g. Howe et al, 2009). Having a long coastline with substantial designations, the issues are especially important for Wales, where the reduction in biodiversity value due to stabilisation is well documented (e.g. Rhind et al, 2013).

Although perhaps not yet as widely recognised in the UK, stabilisation has important implications for amphibians and reptiles on sand dunes. The natterjack toad is at risk from over-fixation of dunes, since it requires open areas for foraging and burrowing. Studies on the Irish Sea coast indicate this is an issue at some natterjack sites, for example Drigg dunes in Cumbria. In several European states, the threat to sand

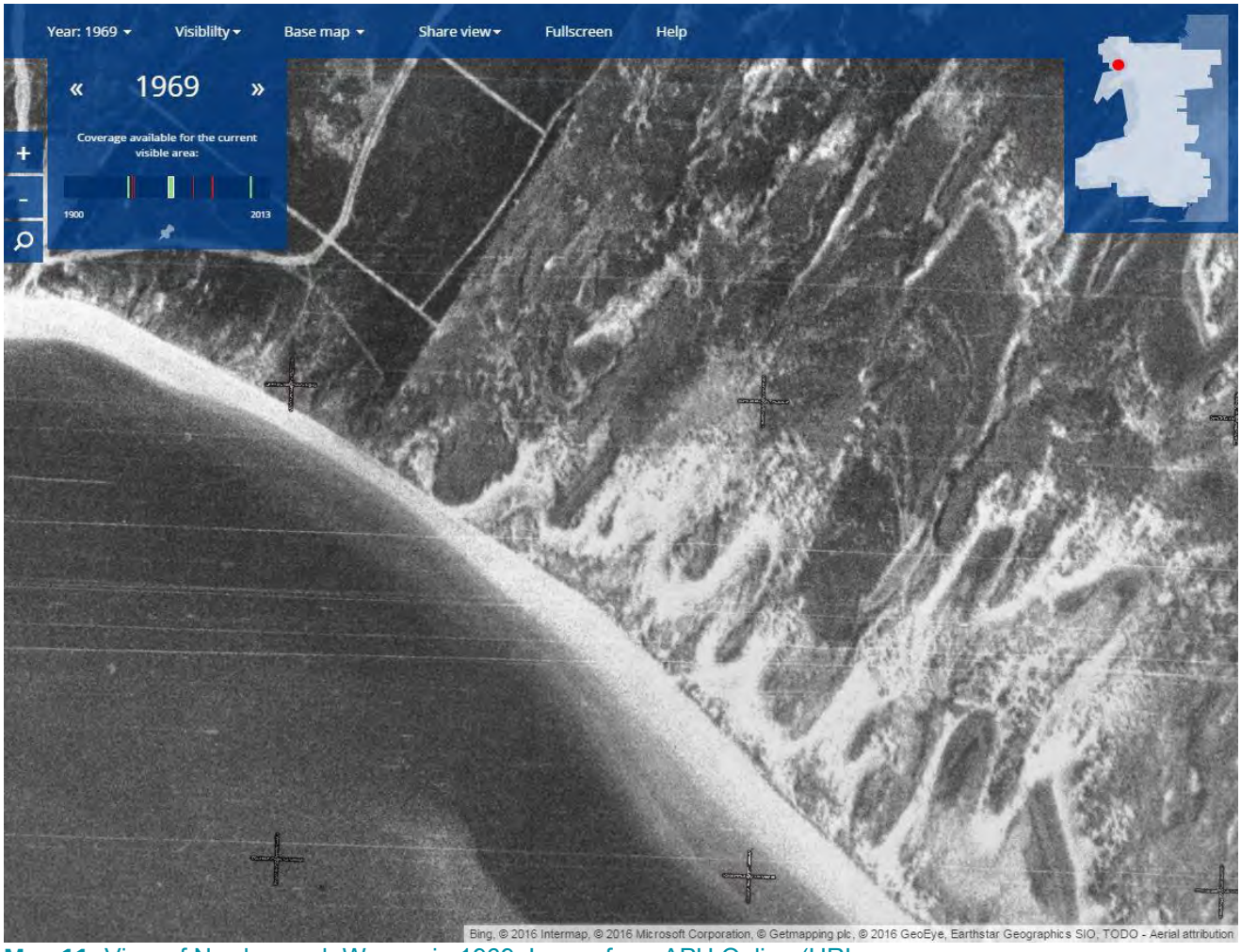
lizards from dune over-stabilisation has been recognised both in conservation planning (e.g. Edgar & Bird, 2006) and in the academic literature (e.g. Wouters et al, 2012).

Broadly speaking, therefore, conservation authorities favour action to counter the loss of open sand conditions on coastal dunes. A central tenet of this is to restore aeolian dynamics, i.e. changes in habitat characters as a result of wind action. Management and restoration action aims to re-mobilise fixed dunes, with episodic restoration activities sometimes involving dramatic interventions achieved by large-scale earthworks.

Both ongoing management and episodic restoration work may have implications for sand lizard conservation. Much casework tends to focus on the risk of harm to individual lizards from management operation, and the risk of breaching legislation aimed at protecting lizards. These are important considerations, yet the more fundamental issue for sand lizard conservation in the long term is whether sand dune populations will be created and maintained in line with sound conservation goals. This, in turn, relates to the desired end-state of the management and restoration activities, and the response of sand lizard populations. The projected continual loss of habitat due to sea level rise can be offset, to some extent, by re-mobilisation works, which effectively moves suitable habitat inland. One caveat here is that very small, isolated populations can be extirpated by especially intensive management (either as a direct result, or in combination with other pressures), although this appears to be a rare event for UK sand lizard populations.

The extent to which a single species could or should drive management objectives and methods is an interesting area for debate. When a particular species requires conditions that conflict with broader species or habitat objectives, there should be a compelling case to outweigh those other considerations. It is likely that such a situation is very rare, for example when dealing with highly sensitive species that occur on a very small number of sites nationally. In the case of sand lizards, their requirements are sufficiently similar to other typical sand dune species that the broad objectives should not conflict; it should be possible to maintain viable and substantial populations alongside a range of other dune specialists. There may be minor conflicts with methods, but these should be overcome with careful planning and implementation.

The general issue of monitoring the response of species to habitat management has received more interest recently (see e.g. Fuller et al, 2016 for a discussion of the issues for nature conservation in general, and Smith & Sutherland 2014 for amphibians as an example taxon). Such moves are highly welcome, and we suggest that setting targets for management outcomes also needs to be further developed, alongside monitoring.



Map 11: View of Newborough Warren in 1969. Image from APU Online (URL: **aerialphotos.wales.gov.uk/)**

6.3 Implications for guidance on habitat restoration and management

Information collected through this project and combined with experiences at other sites has been used to produce guidance on dune management works. We have produced general considerations, along with a proposed annex to the *Reptile Habitat Management Handbook* (Edgar et al, 2010). This detailed guidance is given in Part D Chapter 12, and in summary it recommends the following:

- Survey to inform management planning, and to monitor outcomes (guidance on methods is provided)
- Ensure there is a clear management outcome in terms of the status of sand lizards on site
- Ensure this outcome for sand lizards is consistent with other objectives and constraints for the site
- Consider options for reducing harm to sand lizards caused by management, by carefully choosing the location, timing, intensity and methods
- Undertake management in a way that optimises habitat condition for sand lizard within other site constraints
- Consider procedural and licensing requirements.

Moulton & Corbett (1999) contains useful guidance on sand lizard habitat management, although there is little specific guidance relating to the type of dune restoration under discussion in this report.

6.4 Implications for regulation and conservation planning

6.4.1 Key drivers and constraints for habitat works on sand lizard sites

Habitat management is very rarely undertaken without considering a wider range of potentially conflicting drivers and constraints; it is exceptional to undertake "single-species management", in which the outcome for a single species over-rides all other concerns. Instead, planning and undertaking habitat management on the majority of sand lizard sites needs to be viewed in context.

Newborough Warren is a good case study in this respect. It has several designations (SSSI, SAC and NNR) which recognise its special habitat and species interests. In order to achieve favourable condition, the site requires re-mobilisation works, among other actions. Coastal sand dunes are one of the Priority Habitat Types listed under Section 42 of the NERC Act 2006. Aside from nature conservation, the site is used for recreation by people, and part of the site has been afforested.

With regard to sand lizards in particular, a number of issues arise:

- The strict protection under the Conservation of Habitats & Species Regulations 2010 (implementing Article 12 of the Habitats Directive), and to a minimal extent the Wildlife & Countryside Act 1981 (as amended)
- The aim of the Habitats Directive to achieve Favourable Conservation Status (FCS) for sand lizard, given its listing as an Annex IVa species
- Status as a species of principal importance for biodiversity in Wales under Section 42 of the NERC Act 2006, and consequent consideration under biodiversity arrangements in Wales (overseen by the Wales Biodiversity Partnership).

With regard to species protection, it is worth noting that the Habitats Directive provisions arguably might not apply to sand lizards at Newborough Warren. EC guidance states that populations resulting from unauthorised introductions outside the natural range are not protected (EC, 2007). Although Newborough Warren is most probably within the natural range, the population is almost certainly not native and has probably arisen from unauthorised releases. Nonetheless, it appears that NRW has taken a pragmatic approach, and considers the population equivalent – at least in species protection terms - to a native or reintroduced population. This is evidenced by the fact that a licence was sought for the re-mobilisation works to allow derogation from the protection afforded to sand lizards (see discussion below). This position is also consistent with the fact that the site has been identified as a priority in a list of potential sand lizard reintroduction sites (Edgar, 2007); it is reasonable to suppose that at some stage in the future, animals would have been released there as part of an authorised introduction, subject to approval. There may be some debate about whether it is appropriate to confer such status on animals arising from an unauthorised release. This could be viewed as giving tacit approval to such activities and devaluing formal reintroduction planning. There is a good case to argue that

were the animals to have originated from a formally planned reintroduction, the issues arising from re-mobilisation would not arise, or would be of less concern, because the objectives for sand lizards would be more likely to be considered alongside other objectives. However, it is not the purpose of this report to examine this point in depth. It is also worth noting that common lizards are abundant on site and are protected by law although to a lower level compared to sand lizards.

Site management planning is the key area where the above issues should be addressed operationally. In our experience, it is rare to see management plans that bring all of the issues together holistically. More typically, some issues are not addressed, or receive less emphasis. Often this appears to be due to the complexity of addressing multiple objectives for a wide range of species and habitats, along with other constraints unrelated to conservation. In the case of Newborough Warren, management planning notes assessed as part of this project do mention sand lizards and the potential benefits of the re-mobilisation works, but only in a very brief sense. We have not found any detailed discussion in the documentation of the particular benefits and risks as they relate specifically to sand lizards. NRW has stated that whilst implementation of the re-mobilisation works was informed by the presence of sand lizards, the over-arching objective was to use a landscape-scale approach to habitat management. NRW considers the long-term outcome to be beneficial to sand lizard as well as other habitat and species features of the site.

This position is common and reflects the inherent complexities and tensions of managing sites with potentially conflicting interests. Of particular note is the tension between undertaking habitat management works using activities that might directly harm individuals, and the value in achieving a habitat condition that will in fact benefit the species in the long term. A further complication here relates to the desired end-state for a site with a range of species each having somewhat different needs. It is no wonder that site managers face challenges in balancing such tensions. These issues are discussed further below.

The licence granted by NRW to the site manager (ref: 60218:OTH:CA:2015) was issued under Regulation 53(2)(c) of the Habitats Regulations and Section 16(3)(c) of the Wildlife & Countryside Act 1981, i.e. the derogations relating to conservation. This is an appropriate derogation, although there are concerns over the wording of the licence. The licensable operations relating to sand lizards are listed as:

- *to take and to transport and re-locate to a safe place away from the working area;*
- *disturb access to resting places, breeding sites or places used for shelter or protection whilst undertaking on-going habitat management works including restoration of supporting habitat to remove man-made structures, excavate slack habitat and increase area of windblown sand.*

There does not appear to be any supporting method statement or guidance to elaborate on how these operations would be undertaken (although there is a range of appropriate general conditions). The licensable operations themselves are problematic as worded. The licence appears to allow the removal of sand lizards from the working area, yet this would rarely be possible or appropriate when dealing with hibernating animals. The second licensable operation, disturbing access to

resting places (etc) appears to be confused since the wording is inconsistent with the offences it presumably seeks to derogate against. There is no offence to “disturb access,” although there are offences relating to both disturbance and obstruction of access to structures used for shelter or protection (but not, at least explicitly, to obstruction of access to breeding sites or resting places). This leaves a confusing situation for the licensee as to precisely how he/she is permitted to act. The offences which might have been intended here are:

- disturb while occupying a structure or place used for shelter or protection (S.9(4)(b), 1981 Act)
- obstruct access to a structure or place used for shelter or protection (S.9(4)(c), 1981 Act)

It seems that the licence was not intended to allow the damage or destruction of breeding sites or resting places, which is an offence of strict liability under Regulation 41(1)(d). Arguably the works at Newborough Warren did involve damage to breeding sites and resting places, although it may be possible to use the Continuing Ecological Functionality rationale to reason that no derogation was required if the action were considered in a wider context; this is a legally complex area (see EC, 2007). There is indeed a wider discussion to be had about whether and how habitat management operations should be subject to licence, but we refrain from exploring that in depth here given that a licence was issued and so the principle was established in this instance.

Taken at face value, the licence was apparently intended to allow only the removal to safety of sand lizards encountered during the works, and to hinder access to important habitat features. This leaves open the question of how the other actions which would normally be an offence were authorised (killing, injuring or disturbing individuals, and damaging or destroying breeding sites or resting places). If any of these activities occurred - and it is plausible that they did and yet were predictable and avoidable - they would probably constitute an offence. Only a court could decide if an offence were in fact committed. For the avoidance of doubt, we make these statements simply to illuminate and help resolve the legal issues; we strongly recommend against any criminal investigation at Newborough Warren since this would not be helpful.

There are a number of possible explanations for the unusual omissions from the licence:

- The applicant applied only for the operations listed;
- NRW considered the offences unlikely to occur;
- NRW considered that a defence would apply;
- NRW considered that no licence could be issued for those operations under a Regulation 53(2)(c) /S.16(3)(c) licence.

Note that great crested newt was also listed on the licence, with identical wording in relation to licensable operations.

6.4.2 Reconciling designated site and protected species issues

Two key tensions are at the heart of debates over protected site management that carries a risk of directly harming animals and reducing habitat suitability:

- Using activities carrying a risk of direct harm to individuals of protected species (legal and ethical considerations) and undertaking management which will in fact benefit the population in the long term.
- Determining a management goal in line with the objective of the protected site, which balances the needs of multiple species and habitats, each with differing needs.

These are familiar issues for those working on amphibians and reptiles. On reserves managed by Amphibian and Reptile Conservation, for example, we use measures to reduce the chance of harming either the target species or others occurring on site. This is done by altering the timing, location, intensity and methods of management works. Edgar et al (2010) contains detailed advice on how this is done for management aimed at heathland reptiles, for example using a calendar to show optimal timings for each method. Even after such changes in methods, it is impossible to avoid all risk of harm. When restoring great crested newt breeding sites, at many sites it is inevitable that some animals are inadvertently killed when using heavy plant, yet the scale of such mortality can be substantially reduced through appropriate timing and skilled operation of machinery. Similar tensions arise in managing ditches for protected snails, and woodlands used for roosting by bats.

In these sorts of cases, it can be instructive to attempt to balance the risk of harm to individuals with the benefits to the population of habitat enhancement. Typically the risks to individuals can be minimised via careful management planning. In addition, large populations with individuals spread over a wide area should be more resilient to adverse impacts of management. However, there are circumstances where particular sensitivities arise, notably for small and isolated populations of species with poor dispersal, low population density and/or especially narrow habitat requirements. In such cases, even low levels of management-related mortality can compromise the viability of the population. It is our judgment that at Newborough Warren, the sand lizard population was probably above the critical minimum size and extent where such considerations apply. This is evidenced by the continued persistence of the population, but we recommend that this tentative conclusion be more thoroughly assessed by further survey.

When faced with a high likelihood of direct harm from a management operation which is otherwise justified by its likely habitat outcomes, the site manager faces several broad options, which may possibly be combined (roughly in order of acceptability):

a) Modify the operation to substantially reduce the chance of harm, via altering the timing, location, intensity and/or methods;
b) Undertake the operation along with specific passive displacement, capture or exclusion operations to reduce the risk of harm (typically under licence; methods similar to mitigation for construction projects);
c) Undertake the operation with on-site enhancement to offset the effects of harm (harm would typically require a licence)
d) Abandon the management operation altogether (rarely appropriate unless a review of the management objective is indicated);
e) Undertake the operation knowing that there will be direct harm, along with “compensation” in another area to offset that harm (a legally complex area when European Protected Species are involved).

The precise circumstances at a given site will guide the selection of the appropriate option(s). In relation to re-mobilisation works on sand dunes, we recommend that the typical option would be to modify methods (a). In some cases, it may be appropriate to undertake specific operations (b) in particular high risk locations where the management objective has a high level of support, yet there is little prospect of reducing the risk of direct harm from methods. Passive displacement is one experimental option to consider. This involves mowing an area several months in advance of the works, and then keeping it at bare to reduce occupancy leading up to the management operation. This might reduce the chance of lizards occupying the area to be affected. However, sand lizards have a strong homing instinct and so to be effective, the target area must be retained in a highly unsuitable state. Enhancement of nearby areas must be undertaken to offset the local impacts. Passive displacement should not be relied upon in highly sensitive situations, since there is evidence in some situations individual sand lizards may return, even crossing apparently hostile habitat. The operation may require a licence.

Setting an appropriate management goal is the fundamental issue yet is rarely recognised as such since many debates unfortunately tend to focus on methods. On SSSIs, goals tend to be anchored to the Conservation Objectives, which in turn relate to the notified interest features, yet these are rarely well constructed in relation to species outcomes. Populations resulting from reintroductions can add an extra layer of complexity, since the species is rarely recognised in protected site documentation. In practice, the issues tend to be resolved by a combination of site management planning and site manager discussions with advisors. Even then there can be debate over the relative coverage of habitat types, and the desired species distribution and abundance. ARC's view is that landscape-scale species targets, decided using a combination of local-national considerations, would assist such discussions. In turn these would help set and balance species outcomes at the site level.

Particular challenges can arise at sites supporting a range of species that favour different successional states. This is sometimes the case, for example, on lowland heaths supporting adders *Vipera berus*. Site management objectives tend to favour substantial reduction in scrub and tree cover, i.e. setting succession back so that heather and other low shrubs are the predominant vegetation type. On the other hand, adders favour a higher level of cover, typical of heaths often considered to be too highly encroached by scrub. To resolve the situation, fundamentally there needs to be agreement over the end-state of the habitat. An approach that creates a mosaic of habitat types can assist here, since it should cater for a range of species needs. This is, in turn, easier with larger and more structurally complex sites.

Such approaches, though, pose problems at small sites that are generally recognised as being at one end of the successional spectrum. Hence, a woodland would typically not support high levels of a species with an absolute requirement for extensive areas of grassland and attempting to introduce such elements over a small spatial scale would likely result in unresolvable conflict.

Sand dunes are the other end of the successional spectrum. Coastal sand dunes are pioneer habitats and as such, attempting to introduce a mosaic of other successional stages can be problematic. When dunes start to become more stabilised (which tends to happen through direct or indirect human intervention), species that favour

later stage succession can become more established. This is one element underlying the discussion over management impacts on sand lizards at Newborough Warren, and possibly other dune sites. Sand lizards may reach higher densities in the more fixed, vegetated areas of the frontal dunes. One could attempt to manage the dunes to reach and then maintain an optimal quality and quantity of habitat for sand lizards. This would, however, have implications for other dune species. Furthermore, there is a balance in allowing succession to proceed, since the dunes would eventually decline in quality for sand lizards, as is observed at other sites. To resolve this issue clearly needs a balancing of the habitat requirements of sand lizards, their target population levels, and other objectives for the site in question. Ensuring that all occupied sites have sand lizard as a notified SSSI feature would help ensure their requirements are taken into account.

It would be useful for government to provide further guidance on how to navigate these complex issues, particularly as they relate to protected sites and protected species licensing. The current lack of clarity leaves site managers in an unfortunate position, since they may be caught between undertaking management action, and curbing it to avoid enforcement action. Academic studies and documents arising from EC-funded projects offer some broad guidance on resolving conflicts but tend to focus on tensions between conservation and other land uses rather than differing conservation objectives (e.g. Eurosite, 2009; Redpath et al, 2013.) Edgar et al (2010; Chapter 6, pp27-30) give advice on resolving management conflicts on sites supporting reptiles.

6.4.3 Recommendations for future re-mobilisation projects

Re-mobilisation is planned, or at least suggested, at other Welsh sand dune sites supporting sand lizards (Pye & Blott, 2012). This species is currently (July 2016) known from seven sites in Wales (see Map 12): Presthaven Sands/Talacre Warren, Barkby Beach/Gronant Dunes, Morfa Harlech NNR, Tywyn Burrows (Aberdyfi), Ynyslas Sand Dunes (Dyfi-Ynyslas NNR), Abberfraw and Newborough Warren. The first five populations result from authorised introductions, while the latter two populations probably result from unauthorised releases. Further reintroductions are likely in future, subject to discussion with landowners and resourcing. Such reintroductions would help to restore the range of the species (Map 12) and increase the total population size in Wales, providing an important step towards achieving Favourable Conservation Status.

There are currently discussions among sand dune managers about the relative merits of large-scale interventions, as the re-mobilisation works undertaken at Newborough Warren, versus smaller scale restoration activities. In the Netherlands, “mosaic management” involving a patchwork of small-scale interventions including turf stripping and mowing appears to benefit the recovery of insects (e.g., see discussions in Geelen et al, 2015). Although this has mainly been discussed in relation to dune grasslands inland of the frontals, there are good reasons to believe that a similar approach could be applied to any areas of the dune system supporting sand lizards. There is an emerging discussion of the need to consider the interactions of spatial scale (small vs large) of management and the desire to restore pattern or process when planning dune interventions (Van Til, 2015). This certainly has relevance to management objectives for species like the sand lizard.

As a first step, we recommend that NRW discuss the sensitivities over re-mobilisation with all site managers at these sites, for example by sharing this report. We also suggest that continued efforts are made to ensure a high standard of monitoring and data sharing, by engaging with site managers, Local Records Centres, ARC, volunteers and others. Re-mobilisation works could bring benefits to the sand lizard populations at these sites, yet it may also carry risks as explained above. We suggest the approach in the flowchart below when planning re-mobilisation works at sand dune sites supporting sand lizards or proposed to be used as reintroduction sites.

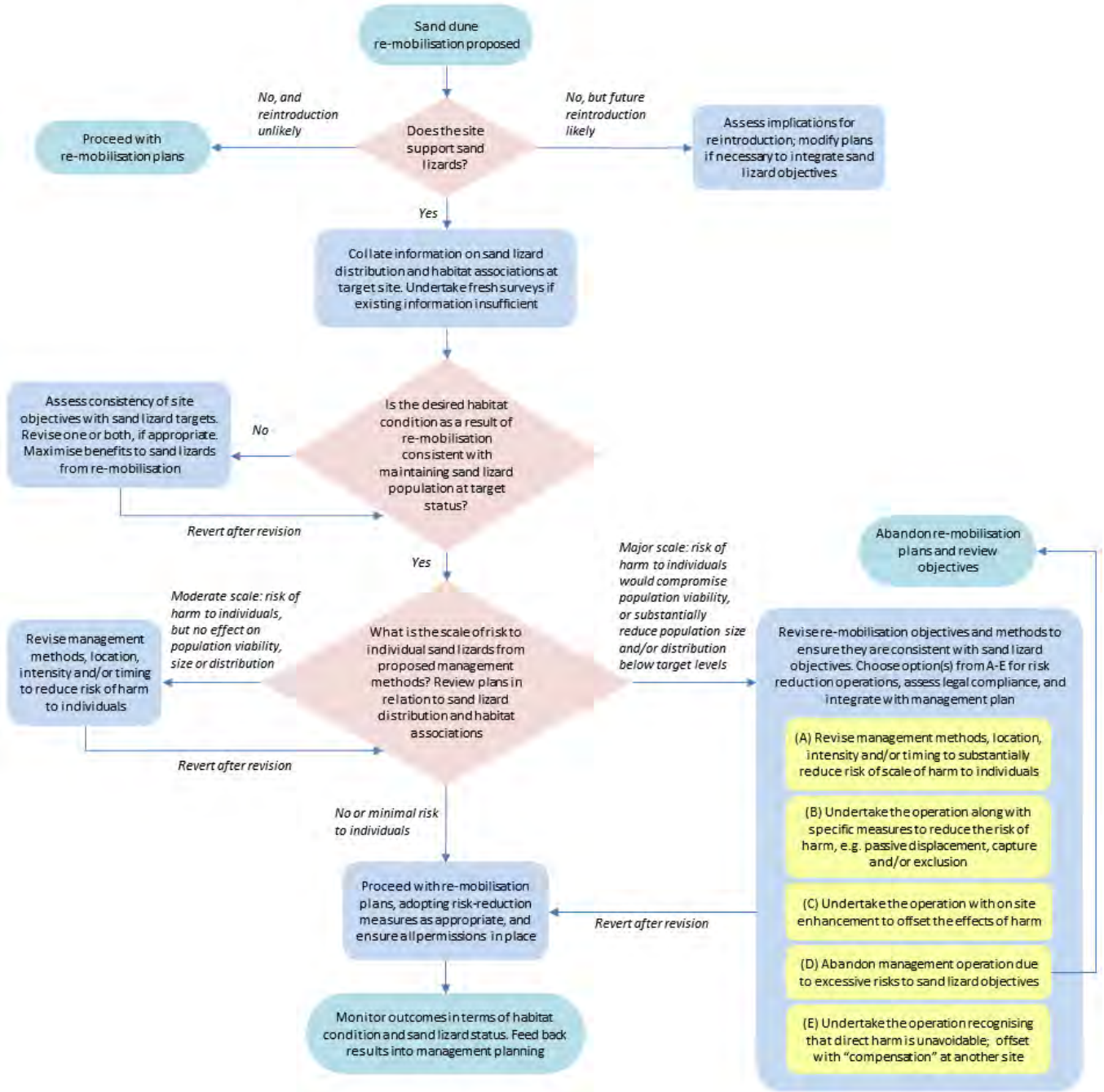
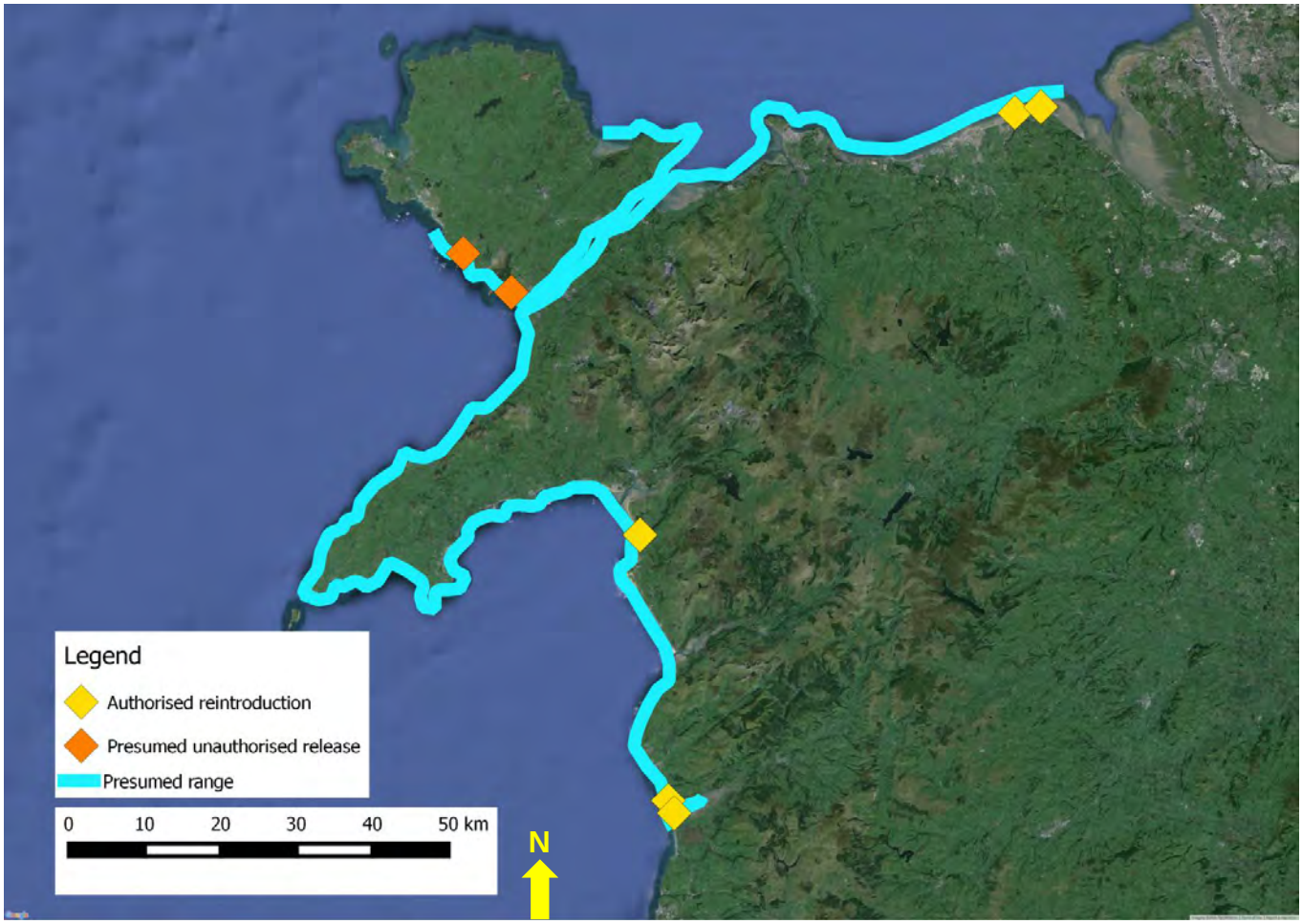


Figure 1. Flowchart for assessing options when re-mobilisation is proposed for sand dunes supporting sand lizards or proposed as potential reintroduction sites. Note that considerations for other protected species are omitted for the sake of clarity.



Map 12: Sand lizard populations in Wales. Yellow symbol = authorised reintroduction (n=5). Orange symbol = presumed unauthorised release (n=2). Blue line = presumed former range; note: distribution would have been discontinuous within this range. Presumed range simplified and re-drawn from Edgar (2007).

Part D, Chapter 12 of this report provides detailed guidance on management operations on sand dune sites.

6.5 Recommendations for future investigations

This project has achieved a great deal in a limited amount of time, yet further investigations would assist with resolving management conflicts on sand dunes where sand lizards are present:

6.5.1 Further surveys at Newborough Warren

We recommend further surveys are undertaken at the earliest opportunity in order to assess more thoroughly the status and prospects for the population. The surveys would have the following specific aims: (a) to determine the local distribution of sand lizards in the known occupied area (including the areas subject to 2014-15 works); (b) to gauge the abundance of the population via an effort-related index; (c) to assess the demographic profile of the population; (d) to assess breeding success; (e) to assess habitat condition.

These aims would best be met by surveys over two periods, April to early June and September. The spring surveys should comprise at least 8 visits in good conditions, spread through the season so that both males and females can be detected with confidence. September survey should attempt to detect young of the year, to give an indication of reproductive success almost two years since the re-mobilisation works. Surveys should cover areas both affected and unaffected by the mobilisation works. Habitat condition surveys should assess the state of the habitat for sand lizards, paying particular attention to the potential for dispersal between "foci". If the short-term measures recommended in this report are undertaken, the outcomes of those measures should be specifically assessed.

6.5.2 Surveys at other sand dune sites supporting sand lizards

Sand lizard populations on other Welsh dune sites are monitored to a greater or lesser extent. We recommend that a minimum standard for survey effort is established, and the results communicated to all relevant stakeholders, notably site managers. A review of sand lizard records from all sites would be valuable, in order to assess progress towards FCS in Wales (as envisaged in Edgar, 2007) and to evaluate the benefits and risks posed by re-mobilisation.

6.5.3 Further spatial analysis

Results from high resolution LiDAR surveys could be used to assess the effects of re-mobilisation works on sand lizards at Newborough Warren. During the course of this report we received some LiDAR information from NRW but we have not had time to include this in our analysis. It would require a modest amount of time to acquire full coverage of the Newborough Warren site and to geo-reference the images so that they can be used in GIS.

6.6 Conclusions

There are sound conservation reasons for the re-mobilisation works at Newborough Warren NNR, given the extent of over-stabilisation, the loss of biodiversity value and the ambitions for protected site condition. The sand lizard population is likely to have been affected by the works in several ways, both positive and negative. Firstly, some animals are likely to have been killed by the works themselves. Secondly, the immediate outcome of the works has resulted in a small net loss of high quality habitat and a reduction in within-site connectivity. Thirdly, there has been an increase in the long-term prospects for maintaining frontal dune habitats via aeolian dynamics, which should benefit the sand lizard population in the long term. Surveys in 2015 demonstrated that the sand lizard population persists and suggested that there is a reasonable demographic profile. However, these surveys were necessarily undertaken with sub-optimal timing, and were therefore insufficient to thoroughly assess the current status and future prospects of the population. On the basis of current information, we tentatively conclude that the population will persist in the long term despite the abrupt negative effects of re-mobilisation works. However we strongly recommend further surveys at the first opportunity to assess the situation more thoroughly. We recommend measures for enhancing habitat as a way to offset short-term reductions in habitat connectivity.

We found some short-comings in the regulatory processes relating to the re-mobilisation works. In particular, the licence issued for conservation purposes was not consistent with the licensable operations likely to have been involved in the works. There does not appear to have been a method statement to ensure operations were implemented with appropriate risk reduction measures. The integration of species targets with protected site objectives was apparently also lacking. Had all of these procedures been better managed, the re-mobilisation works could have been undertaken in a way that substantially reduced the risk of harm to sand lizards, maximised the benefits, and ensured a higher level of legal compliance.

Future sand dune re-mobilisation works should assess both the short-term and long-term risks and benefits to sand lizards. Re-mobilisation can be consistent with the extremely positive work that NRW and partners have done to ensure the recovery of the sand lizard in Wales following its regional extinction. We suggest a process for assessing the potential risks of management works, along with options for addressing both short-term and long-term risks. We also provide guidance on broader sand dune habitat management issues for reptiles, along with notes on the value of sand dunes to herpetofauna more generally.

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9. Annex1: Use of sand dunes by herpetofauna other than sand lizards

9.1. Amphibians

The natterjack toad *(Bufo (Epidalea) calamita)* occurs at coastal dune locations at which shallow, warm ephemeral slacks are present. It occurs at around 60 sites in the UK. The natterjack toad is a habitat specialist that thrives in the warmer microclimates found at areas of sandy soil, but widespread species of amphibian can also occur at dune habitats. Kenfig Burrows (Kenfig NNR) in South Wales supports a fluctuating population of great crested newts *(Triturus cristatus)* that rely chiefly upon ephemeral ponds in which to breed at the site. However, the 2014 season was a noticeably good year for crested newt recruitment as the particularly wet summer allowed pools to hold water throughout the entire year. Most of the ponds dried up during 2015 but some animals were observed during late June that were very close to metamorphosis in the muddy remnants of an inner dune slack.

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Plate 11: 1) Natterjack toads spawning in frontal dune slacks at Ainsdale LNR on the Sefton coast. 2) A great crested newt found travelling toward a dune slack during a natterjack survey at Ainsdale, Sefton coast. Photo: Richard Pond. 3). A male natterjack toad in amplexus with a female common toad *(Bufo bufo*) at Birkdale on the Sefton coast. Photo: Dave Pennington (NMARG).

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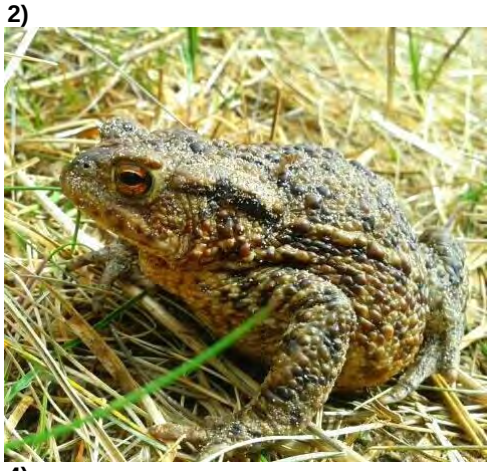

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Plate 12: 1) The natterjack toad has a distinctive gait that enables effective locomotion on sandy substrates, Ainsdale LNR, Sefton Coast. 2) Smooth newts and a natterjack toad beneath a pre-existing refuge, Birkdale dunes, Sefton coast. Photo: Dave Pennington (NMARG). 3). Suitable diurnal refuges for amphibians can be in short supply on dune systems. Where suitable refugia do occur, aggregations of animals such as these smooth newts at Birkdale dunes often gather. Photo: Dave Pennington (NMARG). 4) A common toad *(Bufo bufo)* at Birkdale dunes. Increasing stabilisation of dune systems allows colonisation of the habitat by widespread amphibian species which can displace resident natterjack toad populations. Photo: Dave Pennington (NMARG). 5) Common frog and smooth newt sheltering beneath a refuge, Ainsdale LNR, Sefton Coast. Photo: Dave Pennington (NMARG). 6) Common frog bedded down in damp sand beneath a refuge, Birkdale, Sefton coast. Photo: Dave Pennington (NMARG).

The widespread amphibian species are also able to colonize dunes that are in the process of stabilizing. At Ainsdale LNR and also the adjacent NNR on the Sefton Coast (traditionally a natterjack toad stronghold) advancing scrub at the inner dunes area and an increase in macrophytes at some of the freshwater slacks has resulted

in colonisation of habitat by widespread amphibian species that, until fairly recently, was prime natterjack toad breeding habitat unsuited to the widespread species. The natterjack toad currently (2015) has to contend with the common frog, common toad and smooth newt at a proportion of its breeding sites at this location, and it is likely that the natterjack will decline further among the inner more fixed dunes as a result of this. This situation is also further exacerbated by what appears to be a (misguided) introduction of great crested newts. It is interesting to note that great crested newts have now increased their spread effectively across the inner dunes at both sites.

9.2. Reptiles

Ideal reptile habitat consists of open areas and vegetation cover in close proximity to each other. Varied topography (south-facing slopes are particularly favoured) and diverse vegetation structure of differing heights, ages or types produce pockets of microhabitat. These microhabitats provide:

- A range of basking opportunities
- Shelter from predators
- Shelter from wind
- An abundance of prey
- Opportunities to cool down in humid, deeper vegetation when the weather is hot and dry.

Although the windswept and exposed nature of dune habitat may not appear an appropriate environment for ectotherms such as reptiles, dune systems can in fact support large reptile populations. Whilst the windward slopes of the outermost dunes can be cold and inhospitable to reptiles, the south-facing slopes of the ridges and hummocks that are sculpted by aeolian processes provide a warm microclimate that faces the sun and is sheltered from the very wind which created them. The inner, more stabilized dunes can support high population densities of widespread reptile species. Here, invertebrates and small mammals can be abundant and diverse topography and vegetation structure combine to provide all of the requirements necessary for reptiles; opportunities for foraging, basking and thermoregulation as well as shelter from predators and easy access to subterranean chambers at which respite from extreme temperatures can be found.

Plate 13: The second ridge behind the foremost frontal dune ridge at which common lizard, sand lizard, adder and the occasional grass snake have all been recorded this year (2015). Braunton Burrows, Devon.

Adder, grass snake and common lizard are found at the sand lizard reintroduction site on frontal dunes at Braunton Burrows, Devon (slow-worms are also present at the inner, more fixed dunes). These species can be found during early June and are present in the very foremost of the frontal dunes. The winter storms of 2014 caused significant erosion to the frontal dunes, and in 2015 reptiles of all four species were recorded basking centimetres from the edge of a sheer drop of 3 to 4 meters to the beach.

Plate 14: Erosion at Braunton Burrows (Devon) during the winter of 2014 has resulted in the loss of some frontal dune habitat, leaving a shear face at the beach interface. Four reptile species can be found basking at this abrupt interface.

9.3. Adder (Vipera berus)

The adder is a regular inhabitant of coastal locations, including dune habitats. Animals of all ages from neonates to adult are encountered at frontal dunes as well as the inner more stablized dunes. Communal hibernacula have been identified at both frontal and inner dunes. Gravid females regularly use the crest of the highest frontal ridges in order to bask in the late afternoon/early evening sun and have also been observed basking at the edge of parabolic dunes.

Survey visits to coastal dune habitats undertaken during spring 2015 have also identified communal adder hibernacula at ridges that were unexpectedly close to the foremost frontal ridges at sites in Devon, Ceredigion and Gower. Follow-on survey effort at the Welsh sites later in the season also found adders active throughout the frontal dunes during summer (July and August).

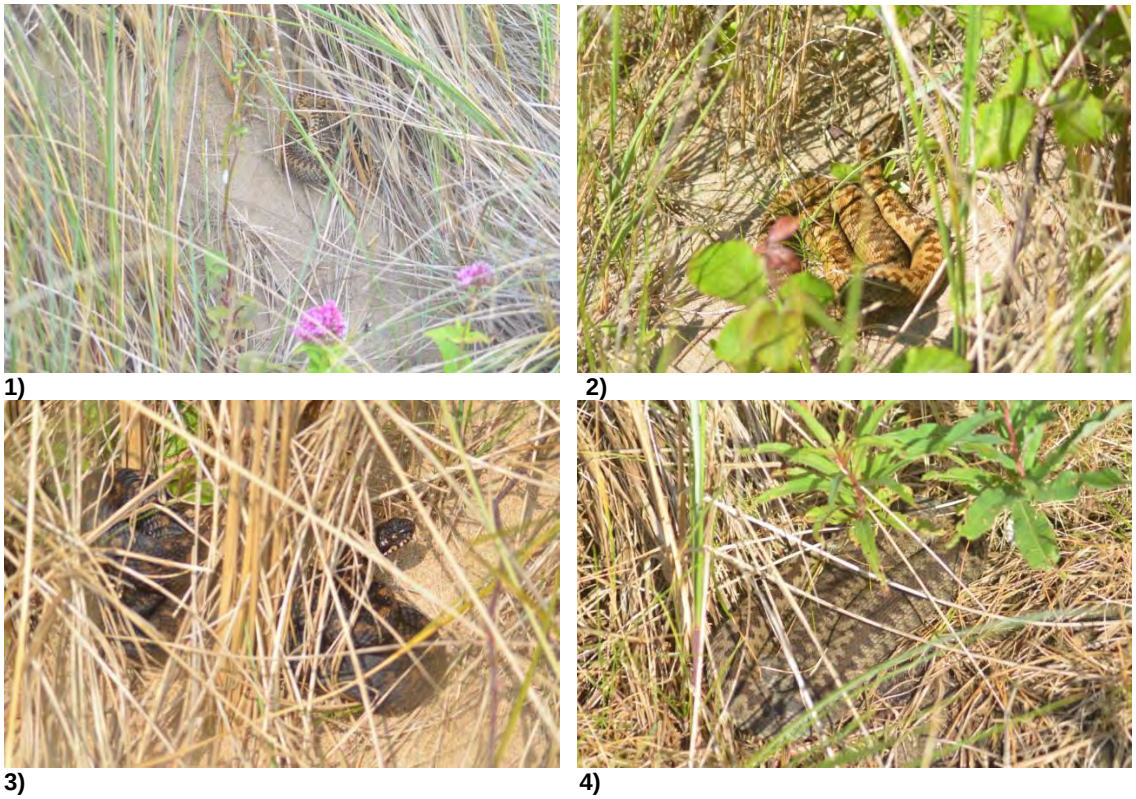

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Plate 15: 1) Gravid female adder using frontal dunes to bask in the late afternoon June sun. 2) Female adder, basking in early morning sunshine at frontal dunes, Braunton Burrows, Devon. 3) Pair of adders basking at communal hibernacula among the frontal dunes during early March, Broughton, Gower. 4) Female adder basking at area of communal hibernacula situated at the second ridge behind the frontal ridge, Ynyslas, Ceredigion.

9.4. Grass snake (*Natrix natrix*)

The grass snake is the widespread reptile species that tends to be detected least often on dune systems. However, where dune slacks occur at which amphibians can breed, grass snakes will certainly take advantage of dune gradients and heat traps. A large female grass snake was disturbed in May 2015 at Ynyslas, Ceredigion and one was also disturbed basking at the foremost frontal dunes at Braunton Burrows, Devon, in June 2015. At Oxwich Burrows, Gower, grass snakes can be found

throughout the dune system, which also has a good percentage of freshwater habitats available at the inner, more fixed dunes.

Plate 16: Grass snake sheltering beneath a survey refuge, inner dunes, Oxwich Burrows.

9.5. Common lizard (*Zootoca vivipara*)

The common lizard can reach high densities on both frontal and inner dune habitats. This species is likely to form a significant proportion of the diet of adders when both species are present.

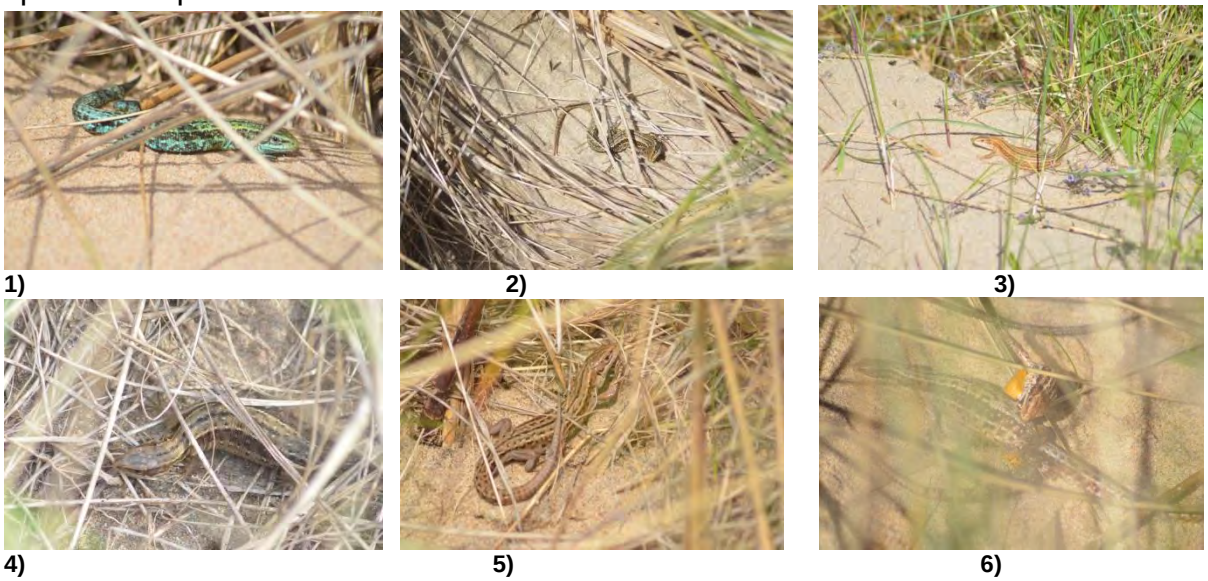

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Plate 17: 1) A particularly striking male common lizard on frontal dune habitat, Ainsdale LNR, Sefton Coast. 2) Male common lizard, frontal dunes, Ynyslas, Ceredigion. 3) Gravid female common lizard, frontal dunes, Ynyslas, Ceredigion. 4) Gravid female common lizard, frontal dunes, Braunton Burrows, Devon. 5) Male common lizard, foremost frontal dunes, Broughton, Gower. 6) Mating pair of common lizards, frontal dunes, Ainsdale LNR, Sefton Coast.

9.6. Slow-worm (*Anguis fragilis*)

The slow-worm is a semi-fossorial species, spending time hunting for soft-bodied invertebrates in the herb root layer. Frontal dunes usually appear to offer limited opportunities for slow-worms, the loose sand perhaps making locomotion difficult, and the animals are seldom found at frontal dune habitat. The inner stabilized dunes can support impressively high population densities, but in situations where entirely fixed dunes reach as far forward as the beach, slow-worms can also be present. At

Kenfig NNR, investigation of a pre-existing refuge (discarded chip board) revealed slow-worms present as far forward as is possible in the fixed frontals.

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Plate 18: 1) Sub-adult male slow-worms using a survey refuge to thermoregulate, inner dunes, Llanmadoc, Gower. 2) Gravid female slow-worm detected beneath a survey refuge, inner dunes, Oxwich Burrows NNR, Gower. 3) Slow-worms beneath a refuge at very fixed frontals, Kenfig NNR.

10. PART B: Results from 2015 site surveillance

10.1. Summary of observations

We made 10 observations of sand lizards over 6 days of survey effort between 10 September and 19 September 2015. A daily maximum of 3 sand lizards was observed, and both sexes and all age classes were seen. It is possible that we found fewer than 10 individuals, as some observations could have been repeat sightings of juvenile lizards, but we are confident that we found a minimum of 9. Common lizards were more frequently observed than sand lizards, with up to 11 sightings per day. Survey conditions ranged from good to excellent. Locations are shown in Maps 13-15.

Sand lizards were always detected at areas of frontal dune habitat, with the following particular habitat associations: south-east facing banks sheltered from the wind and vegetated with dense marram clumps, interspersed with areas of bare sand.

Given that surveys were undertaken in September, which is not optimal timing for this species, we recommend that further surveys are undertaken in April-June. This would allow a more thorough assessment of the distribution and status of the population.

10.2. Detailed results

10.09.2015. 8.00hrs – 18.00hrs. Survey conditions were ideal for the entirety of the day, full sun with occasional short spells of cloud cover which meant that at certain south-facing sheltered locations, the sand felt warm enough to the touch for sand lizards to bask from around 9.40hrs onwards. Lizards detected; *Zootoca vivipara* 8, *Lacerta agilis* 3.

Animal 1. Young adult male sand lizard, displaying scars from a possible recent predator attack, basking at base of marram stand at frontal ridge. The only adult sand lizard detected during the entirety of the survey, consideration of the seasonality of the survey suggests that the animal was very likely within the vicinity of the entrance to its hibernation site (SH 41402 62758) 10.04hrs.

Animals 2 & 3. Pair of juvenile sand lizards basking on bare sand at base of dense marram stand on south east facing bank. (SH 41056 63069) 14.28. No image available.

Plate 19: Two images of animal 1.

Plate 20: Frontal ridge habitat at which animal one was detected.

11.09.2015. 8.00hrs – 17.00hrs. Intermittent sun and cloud throughout the morning, deteriorating in the afternoon. Lizards detected; *Zootoca vivipara* 8, *Lacerta agilis* 3.

Animal 4. Juvenile sand lizard with partly truncated tail basking on bare sand amongst marram stands on south facing bank on frontal ridge. (SH 41393 62759) 12.19. No image available.

Animal 5. Immature sand lizard mosaic basking on bare sand amongst marram stands on south facing bank on frontal ridge. (SH 41391 62758) 12.25.

Animal 6. Immature sand lizard basking on bare sand amongst marram stands on south facing bank on frontal ridge. (SH 41547 62607) 12.48. No image available.

Plate 21: Animal 5. (SH 41391 62758).

Plate 22: Animal 7. Subadult male sand lizard (SH 41572 62598).

12.09.2015. 8.00hrs -18.00hrs. Survey conditions during the morning were unsuitable due to light rain followed by a dry but overcast spell. The time was utilized to map specific areas of management. The afternoon brought strong sun allowing further survey effort. Lizards detected; *Zootoca vivipara* 11, *Lacerta agilis* 2.

Animal 7. Subadult male sand lizard basking amongst marram stands on south facing bank on frontal ridge. (SH 41572 62598) 16.08hrs.

Animal 8. Juvenile sand lizard basking on bare sand at base of dense marram stand on south-east facing bank. (SH 41056 63069) 16.39hrs. No image available. N.B. this may possibly be a repeat sighting of one of the pair of juveniles seen at the same location on 10.09.2015.

16.09.2015. Weather conditions were ideal, full sun. 14.30hrs -18.00hrs.

Lizards detected; *Zootoca vivipara* 5, *Lacerta agilis* 1.

Animal 9. Well-developed juvenile sand lizard basking on dead marram thatch. 15.47hrs. (SH41124 63013).

Plate 23: Animal 9. (SH41124 63013)

17.09.2015. 8.00- 17.00hrs. Intermittent sun and cloud in the morning progressing to longer sunny periods in the afternoon. Lizards detected; *Zootoca vivipara* 8, *Lacerta agilis* 0.

Plate 24: Common lizards

18.09.2015. 13.00hrs – 18.00hrs. Intermittent showers in the early morning, bright and overcast mid-morning progressing to longer sunny spells in the afternoon. Lizards detected; *Zootoca vivipara* 6, *Lacerta agilis* 0.

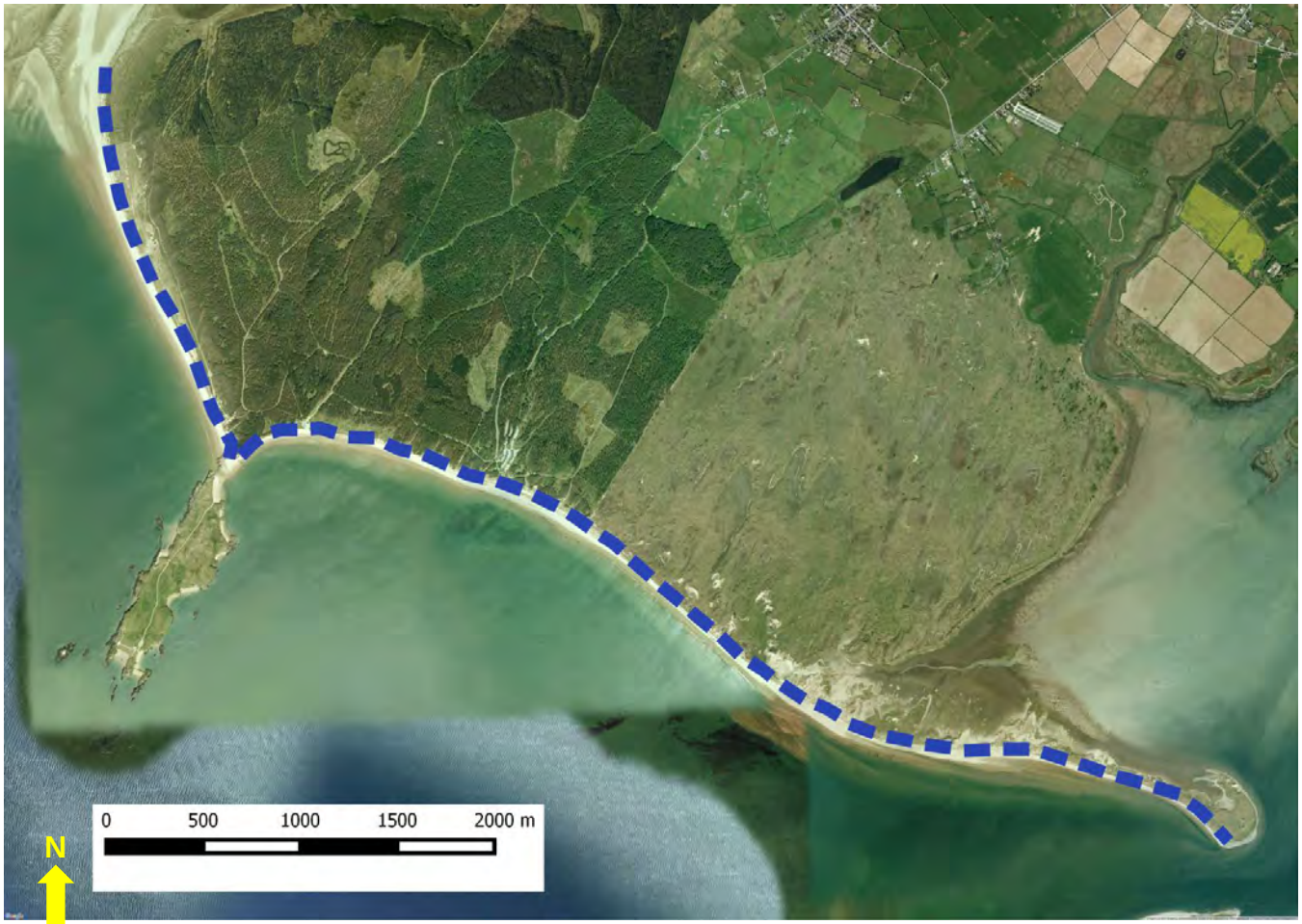
19.09.2015. 8.00hrs – 16.00hrs. A heavy sea mist in the morning lifted at 9.30hrs. Strong sun continued for the entire day. Lizards detected; *Zootoca vivipara* 5, *Lacerta agilis* 1.

Animal 10. Immature female sand lizard mosaic basking at bank with dense marram stands. 10.18hrs. (SH 41075 63080).

Plate 25: Animal 10. (SH 41075 63080).

Plate 26: Habitat at which animal 10 was detected.

Plate 27: Comparison of length of torso (measurement taken from base of front limb to base of rear limb) between female animal 10 (left) and male animal 7 (right).



Map 13: Extent of surveys in September 2015. Dotted blue line shows surveyor route. Note that moderately higher survey effort was directed toward the area heading south-east of the forestry block.

Map 14: Locations of sand lizard and common lizard sightings, September 2015 (entire survey area). Orange dot = sand lizard. Purple dot = common lizard.

Map 15: Locations of sand lizard and common lizard sightings, September 2015 (area of sand lizard sightings only). Orange dot = sand lizard. Purple dot = common lizard.

Table 1: Sand lizard observations, September 2015

Individual number	Date	Age class	Sex	Co-ordinates
1	10.09.2015.	adult	male	SH 41402 62758
2	10.09.2015.	juvenile	unknown	SH 41056 63069
3	10.09.2015.	juvenile	unknown	SH 41056 63069
4	11.09.2015.	juvenile	unknown	SH 41393 62759
5	11.09.2015.	subadult	female	SH 41391 62758
6	11.09.2015.	subadult	unknown	SH 41547 62607
7	12.09.2015.	subadult	male	SH 41572 62598
8	12.09.2015.	juvenile	unknown	SH 41056 63069
9	16.09.2015.	juvenile	unknown	SH41124 63013
10	19.09.2015.	subadult	female	SH 41075 63080

Table 2: Common lizard observations, September 2015

Individual number	Date	Age class	Sex	Co-ordinates
1	10.09.2015.	adult	male	SH41393 62759
2	10.09.2015.	adult	male	SH40691 63296
3,4 & 5	10.09.2015.	juvenile x 3	unknown	SH40603 63325
6	10.09.2015.	adult	female	SH41467 62692

7 & 8	10.09.2015.	juvenile x 2	unknown	SH41572 62598
9, 10 & 11	11.09.2015.	juvenile x 3	unknown	SH41730 62576
12 & 13	11.09.2015.	adult x 2	male	SH41851 62420
14	11.09.2015.	adult	male	SH 42708 61989
15	11.09.2015.	subadult	unknown	SH 43143 61940
16	11.09.2015.	adult	female	SH 42525 62018
17	12.09.2015.	adult	male	SH 42921 61999
18	12.09.2015.	adult	female	SH 41893 62383
19, 20 & 21	12.09.2015.	juvenile	unknown	SH41851 62420
22 & 23	12.09.2015.	juvenile x 2	unknown	SH41730 62576
24	12.09.2015.	subadult	female	SH 41522 62642
25	12.09.2015.	adult	male	SH 40116 63554
26 & 27	12.09.2015.	adult	male	SH 40399 63413
28	16.09.2015.	adult	female	SH 41064 63207
29	16.09.2015.	juvenile	unknown	SH 41074 63155
30	16.09.2015.	juvenile	unknown	SH 40814 63273
31	16.09.2015.	subadult	unknown	SH 39678 63666
32	16.09.2015.	adult	female	SH 39678 63666
33	17.09.2015.	adult	male	SH 41387 63770
34	17.09.2015.	adult	unknown	SH 38794 64401
35	17.09.2015.	juvenile	unknown	SH 38690 64697
36 & 37	17.09.2015.	juvenile	unknown	SH 39385 63676
38	17.09.2015.	adult	male	SH 41211 62944
39 & 40	17.09.2015.	adult & juvenile	male & unknown	SH 41055 63099
41	18.09.2015.	adult		SH 40632 63336
41 and 42	18.09.2015.	adult & juvenile	female & unknown	SH 41277 63556
43	18.09.2015.	adult	female	SH 41420 63006
44	18.09.2015.	adult	female	SH 42437 62302
45	18.09.2015.	subadult	unknown	SH 42100 62210
46	19.09.2015.	juvenile	unknown	SH 42797 62089

47	19.09.2015.	juvenile	unknown	SH 43337 61894
48	19.09.2015.	adult	male	SH 43530 61807
49	19.09.2015.	juvenile	unknown	SH 42523 61972
50	19.09.2015.	adult	male	SH 41697 62527
51	19.09.2015.	adult	male	SH 42371 62069

10.3. Conclusions from September 2015 surveys

Although comparatively few animals were detected during the survey, we can conclude the following:

- Both sand lizards and common lizards persist at Newborough Warren NNR
- Populations of both species appear to show a good demographic profile, with mixed age classes and reasonable sex ratios observed (this is particularly encouraging given the seasonality of the survey, which could have resulted in low detection for adult males)
- Both species were found across their formerly occupied ranges on site, including some individuals close to the re-mobilisation works.

Given that the surveys were done with limited effort and at a sub-optimal time of year, it is probable that our surveys detected only a small proportion of the animals present. However, this is uncertain, and further surveys are recommended in order to more thoroughly assess abundance. Our abundance results are insufficient to compare with surveys undertaken before the works.

The surveys reveal that habitat is now significantly fragmented compared to the pre-works state. Dispersal routes for sand lizards are disconnected.

11. PART C: Recommendations for short-term habitat enhancement measures

11.1. Potential short-term impacts of re-mobilisation measures on sand lizards

As discussed in more depth in Part A, section 4, re-mobilisation works may result in a number of impacts on sand lizard populations, with consequences in both the short and long term. Whilst some consequences relating to long term persistence of frontal dune systems should be positive, here we focus on the likely negative short-term effects.

Negative impacts may have arisen due to the timing and location of the works: they were undertaken during the hibernation period, and were focussed on areas suitable for hibernation, i.e. the frontal ridges and habitat immediately to the rear of the frontal ridges. The highest densities of recent historical records indicate that the areas of management locations 4 and 5 are likely to have comprised a “focus” (i.e. an area used by high densities of sand lizards) prior to management. This is consistent with available images of suitable habitat at the location prior to the management, and the tendency for sand lizards to occupy frontal ridges of dune systems. It is possible that there was substantial sand lizard mortality in this area.

Our findings show that sand lizard habitat has become more fragmented as a result of the re-mobilisation works. This will mean that individuals are less likely to disperse between patches, which in turn could result in reduced viability. At the individual level, lizards will be more restricted to smaller habitat patches, and might suffer reduced foraging, resting, hibernating and mate-finding opportunities.

Some measures for enhancing habitat in the short term are outlined here with the aim of remedying the above impacts.

11.2. Recommended short-term habitat enhancement measures

Following the September 2015 survey, it is known that animals remain in two areas of habitat:

- The block of habitat that remains largely undisturbed between management location 5 (SH 41008 63056) and location 6 (SH 41132 62960).
- The area of frontal ridge habitat that extends in a southerly direction from management location 9 (SH 41260 62845).

Animals are probably also present between these two areas, although connectivity has been significantly disrupted within the immediate area and animals are likely to be isolated in the short term. It may be possible for any isolated groups of animals to reconnect once the vegetation structure recovers to a stage promoting dispersal through both the frontal ridges and any available corridors of habitat further inland. The vegetation regeneration process will require monitoring and is likely to take three seasons or longer to reach a condition suitable for sand lizards to negotiate.

Allowing the vegetation to recover over time is likely to render the sloped sides of the notches once more negotiable by sand lizards and will help restore dispersal routes. In order for the vegetation to recover to the stage at which sand lizards will use it regularly (e.g. for thermoregulation, foraging and sheltering from predators), rather than just passing through it, a greater time span will be required for dense mature marram clumps to develop. This could be as long as 15 seasons, or even more if conditions are unfavourable. At specific areas where the highest density of sand lizard sightings was recorded during 2013/14 (e.g. management locations 4 and 5) it is worth considering transplanting marram clumps to decrease habitat recovery time (see Map 16).

Map 16: Locations of recommended marram planting. Pink hatched areas show locations where marram clumps could be planted to enhance connectivity.

Only three sightings of juvenile sand lizards were recorded at the block of habitat situated between notches 5 & 6 during the September 2015 survey. However, the timing of the survey means that detection would be relatively low, hence the results should be treated with caution. Should enough animals be present, then the area is sufficiently large to potentially support a population that could remain viable until connectivity increases within a few seasons from now (2016). Further surveys during the spring are recommended in order to produce a better informed understanding of the population density, and would likely provide a more representative account of the true distribution of sand lizards.

Sand lizards in the area south of notch number 9 can currently disperse naturally in a southerly direction (6 were found here in September 2015). Northerly connectivity is currently disrupted at this area along the frontal ridge but is likely to improve over the next few seasons as the vegetation structure regenerates. Inland connectivity will also improve over a similar time period, after which animals south of notch number 9 are likely to be able to re-integrate with animals from the area around notch number 5, where the majority of animals have previously been recorded.

Following consideration of all of the available information, recommendations for short-term habitat connectivity enhancement measures within areas of the dunes subject to recent mobilization works comprise:

- Allowing vegetation structure to regenerate, particularly at the sides of all of the notches in the frontal ridges and at areas further inland directly behind the notches.
- Transplanting marram clumps to specific areas at which high densities of sand lizards were previously recorded, i.e. management locations 4 and 5, and possibly 8 and 9.
- Removing shading conifer trees from the interface between dune and forest at areas 1 until 5 to a depth of 5 to 10 m to provide an unshaded strip of habitat that could serve as an inland corridor in the short term.
- Removing shading conifer trees from the interface between dune and forest at areas 1 until 5 to a greater depth of 40 m would increase natural aeolian sand transport processes longer term and reduce the need for the use of heavy machinery in the future.

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Plate 28: Areas for short-term habitat enhancement. 1) Looking south from the rear of management location 1. Inland connectivity would be created and aeolian sand transport would be increased if conifers were felled along the interface. 2) Extensive area of bare sand to the rear of management locations 4 and 5 showing early stage bank vegetation regeneration. 3) Detail of the vegetation at the forest edge interface.

12. PART D: Suggested Annex for the Reptile Habitat Management Handbook; guidance for dune renovation management on sand lizard sites

12.1. General guidance to inform sand dune re-mobilisation works when sand lizards are present

12.1.1. General points

Sand lizards have relatively limited dispersal abilities and occur at low population densities, which make them particularly susceptible to the effects of habitat fragmentation. They cannot cross large expanses of unsuitable areas between habitat patches. Prior to landscape modification by humans, habitats would change in suitability over time, and sand lizard populations themselves could shift and fluctuate considerably in both space and over time. Such dynamics are rarely possible in the modern British landscape. Many sites are now isolated so that reptile populations cannot function in this more ‘natural’ way, but rather must be managed in situ. Sand lizards have no means of “sitting out” long-term adverse conditions (as do plants, in a seed bank, for example), or of rapidly moving long distances to avoid poor conditions. Sand lizards are therefore particularly vulnerable to declining habitat quality and inappropriate habitat management.

Fortunately, with some understanding of sand lizard ecology, the habitat requirements of these animals are relatively easy to meet. Sand lizards require warm, relatively open habitats, which are also favoured by a range of other species, especially invertebrates. A common approach, important to both groups, is attention to the fine structure of habitat. Habitat suitable for invertebrates and sand lizards contains a high degree of structural diversity, providing a range of microhabitats within a site. Hence, managing habitat to achieve such diversity greatly increases its ecological value.

Management should consider sand lizard ‘hot-spots’ or ‘foci’ - key features that provide ideal conditions, for example south-facing dune slopes. Provided that these areas do not become isolated in large expanses of unsuitable habitat, the management of these 'hot-spots' can be the most cost effective and reliable way of ensuring continued existence of sand lizards on a site. At dune habitats with sand lizard present, foci occur most often in the frontal dunes.

Sand dune habitats are increasingly classed as being in unfavourable condition due to over-stabilisation. Re-mobilisation of the sand supply is considered essential for the restoration of sand dune habitats in the UK. There are clear long-term benefits for dune habitats and the unique flora and fauna that are associated with it. However, such management requires careful consideration at sites supporting herpetofauna, and sand lizard in particular. Survey and appropriate risk reduction measures can help to minimise harm to individual lizards and to populations during dune rejuvenation works.

All native reptile species are legally protected. Inappropriately planned and implemented habitat management has the potential for adverse consequences for reptiles, as well as breaches of the legislation, particularly when heavy machinery is used.

Carefully planned and implemented measures can reduce and compensate for potential negative impacts and can also minimise the risks of committing an offence. The objectives of these measures should be:

- To protect sand lizards from direct harm that might arise during habitat management works;
- To ensure that there is no net loss of local sand lizard conservation status, by ensuring that sufficient quality, quantity and connectivity of habitat remains to accommodate the population in the long term;
- To contribute toward the long-term targets for the species at the site in question.

Survey, habitat assessment and careful planning are critical to inform this strategy.

12.1.2. Survey

Thorough and appropriately timed survey is required to properly identify the potential impacts of any proposed habitat works on sand lizards and to plan the avoidance measure strategy. The level of survey required will depend on a range of factors, primarily the scale and type of the intended work, and therefore the likely impact on sand lizard populations.

Effective reptile survey of dune habitat comprises two main field methods which can be supported by additional supplementary methodologies where appropriate:

1) *Visual search* involves searching for reptiles whilst they are basking in the open or partial cover. The search should focus on areas that provide insolation yet are close to cover. It is paramount that the survey is undertaken by a field worker experienced in reptile surveys. Experience plays a major role in determining the results of a reptile survey, since there is a high degree of field craft involved. The field worker should have previously undertaken surveys in a range of habitats and for all the species potentially present, using all appropriate methods. An appropriate survey licence will normally be required where sand lizards occur. This will depend on whether an offence would be committed if no licence were obtained. Survey visits must be carefully timed to favourable times of day, weather and seasonal conditions. Although visual search can result in very low detection rates for some species (notably the slow-worm) and is also highly weather dependent, it is the survey methodology that is most suited to detecting sand lizards.
2) The use of *artificial cover objects* (ACOs) involves checking underneath and on top of artificial refuges (for example, corrugated iron, roofing felt or similar materials), which are placed in suitable locations before the survey starts. ACOs must be placed in locations likely to be used by reptiles. ACOs must be placed at least 2 weeks in advance in good conditions before survey starts. If

ACOs are placed for long periods so that vegetation dies off underneath or they are colonised by ants, then ACOs should be moved to a new location nearby. The use of ACOs can provide a slightly wider weather window in addition to allowing easier capture (if required) and substantially improving the detection rate for some species. However, the methodology produces low detection rates for some species, notably the sand lizard. Effort is required in preparing and distributing ACOs. There can be a safety risk for people, pets and livestock (though negligible with some ACO materials) and ACO use can also put reptiles at higher risk of harm as they can potentially be disturbed by people and land management operations.

NB: when surveying specifically for sand lizards, it is critical to select appropriate habitat features for survey. ACO surveys are generally inappropriate for sand lizards, unless the species is present at high density and the ACOs are also placed at high density.

Supplementary survey methods for sand lizards are of very limited use in dune habitats, but include techniques such as surveying pre-existing refugia, and searching for test egg-burrows and tracks. Searching refuges already present on site including natural objects such as logs, as well as artificial debris such as discarded fence panels, tyres and bags can on occasion produce results but the methodology is of limited use where existing refuges are scarce or hard to lift.

Female sand lizards create egg burrows (and test burrows) in late May-June with distinctively shaped entrances. Test egg burrow searches are substantially more effective on heathland than on dune systems, and so this method is discouraged on dunes.

In very soft sand, such as on dunes, sand lizards may leave tracks. Care and experience is needed in interpreting these, not least because they can be confused with marks left by common lizards or other non-reptile species, or even objects blown by the wind, but finding them will be a good indicator to intensify other survey efforts.

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Plate 29: Sand lizard signs. 1) Confirmed test hole, Dorset. A female sand lizard was observed from a distance undertaking the excavation. 2) Unconfirmed, possible test hole, Braunton Burrows, Devon. 3) Tracks left by a male sand lizard observed moving between marram stands, Ynyslas NNR, Ceredigion.

The time of year at which the survey is undertaken is critical. Late April and May are the most productive survey periods during which to detect sand lizards on dune systems. Survey results are affected by a wide range of factors, such as weather conditions, physiological state, time of day, seasonality and habitat condition. An effective survey requires multiple visits in suitable conditions to reduce the chance of false negatives (i.e. incorrectly declaring absence, when reptiles are in fact present).

12.2. Harm avoidance measures

Dune rejuvenation works are generally focussed on management of the frontal dunes in order to increase sand mobility. Frontal dunes are disproportionately important to sand lizards. Appropriate avoidance measures are therefore normally recommended. Given that specialist experience is required to interpret survey results, suitably experienced advisors should be consulted when planning potentially harmful management.

There are several options for avoiding harm during management works:

a) Modify the operation to substantially reduce the chance of harm, by altering the timing, location, intensity and/or methods;
b) Undertake the operation along with specific passive displacement, capture or exclusion operations to reduce the risk of harm (typically under licence; methods similar to mitigation for construction projects);
c) Undertake the operation with on site enhancement to offset the effects of harm (harm would typically require a licence)

d) Abandon the management operation altogether (rarely appropriate unless a review of the management objective is indicated);
e) Undertake the operation knowing that there will be direct harm, along with "compensation" in another area to offset that harm (a legally complex area when European Protected Species are involved).

The precise circumstances at a given site will guide the selection of the appropriate option(s). In relation to re-mobilisation works on sand dunes, the typical option would be to modify methods (a). In some cases, it may be appropriate to undertake specific operations (b) in particular high risk locations where the management objective has a high level of support, yet there is little prospect of reducing the risk of direct harm from methods.

These latter methods adopt conventional mitigation techniques, as might be used on a construction site. Whether such a conventional mitigation approach is appropriate requires further consideration, as there are both advantages and disadvantages.

This approach would typically entail a programme of capture, removal and exclusion of reptiles from the works area. To be effective, capture projects will need a perimeter fence to prevent re-entry to the works area. Exclusion fencing should be erected in advance of the capture effort to exclude lizards from the working areas and relocate any lizards in the working areas to safe areas. However, erecting the fencing too far in advance in a dune situation can be counterproductive as the fence is likely to either be exposed further by the wind or buried by the movement of sand. If the management works area is used for hibernation, exclusion fencing for sand lizards should ideally be erected in late March/early April to a height of 30cm and a depth of 30cm. Although installing fencing in this way has the potential to harm individual hibernating lizards, such measures can significantly reduce the impact upon the population as a whole.

The sand lizards and other reptile species present should be caught from the area during April to September and released at suitable habitat elsewhere at the site. Intensive capture effort would be required. Immediately after capture lizards should be placed in buckets with lids or similar containers, lined with vegetation to provide a soft base.

Passive displacement is one experimental option to consider. This involves mowing an area several months in advance of the works, and then keeping it bare to reduce occupancy leading up to the management operation. This might reduce the chance of lizards occupying the area to be affected. However, sand lizards have a strong homing instinct and so to be effective, the target area must be retained in a highly unsuitable state. Enhancement of nearby areas must be undertaken to offset the local impacts. Passive displacement should not be relied upon in sensitive situations, since there is evidence that individual sand lizards may cross apparently unsuitable habitat. The operation may require a licence.

Only after other methods of removing lizards have been attempted, the task of cutting notches through frontal dune ridges could be implemented using a destructive search approach, i.e. using machinery to gradually dismantle structures or excavate substrates to reveal any remaining sheltering lizards. They can then be captured by

hand. The degree to which this is possible will vary significantly from site to site and there may be overriding (human) health and safety considerations which constrain such activities. In some situations, a destructive search can be helpful in removing the last few individual reptiles without compromising their welfare. Generally the best approach to adopt is to begin the search in a very careful and precautionary manner, and gradually increase the speed of the operation if no lizards are found.

It is very difficult to find lizards sheltering underground or inside large above ground structures. Moreover, even with the most careful operation, injuries and mortalities may occur if a substantial number of animals remain. Hence destructive searching is normally only advised after a thorough capture programme using standard methods described above.

12.3. Timing of management works

General habitat management tasks on coastal dune systems for reptiles, such as scrub and tree removal, should be undertaken during winter when lizards are hibernating and birds are not nesting. Larger scale dune rejuvenation works in areas where sand lizards are present will often require different timing, in order to avoid disturbing and killing hibernating lizards. Both frontal and inner ridges of dune systems can be used for hibernation. Heavy machinery has the potential to impact significantly upon reptile populations if undertaken during the hibernation period, but where lizards have been captured and excluded, winter works could be appropriate if carefully planned.

1) 2)

Plate 30: 1) Remobilizing sand with heavy machinery at Kenfig, South Wales. Photo David Carrington. 2) ARG volunteers hand dig sand patches on a south-facing bank at an inland site, Hillside Golf Club, Birkdale on the Sefton coast. This task, although essential, is undertaken with precision timing so as to avoid either killing or disturbing hibernating sand lizards or common lizards, or disturbing early clutches of sand lizard eggs.

The protracted emergence period is an important consideration, particularly when planning habitat management aimed at increasing the movement of sand undertaken with heavy machinery. The first half of May is recommended for undertaking dune rejuvenation works, so long as there is confidence that the population has entirely emerged from hibernation. Adult females are of particular importance to population viability in small populations, and their relatively late emergence should be taken into account.

Aside from emergence from hibernation, egg-laying is a further consideration. The period during which female sand lizards deposit their eggs can also be protracted. Considering this whilst also being mindful of the more southerly aspect of the North Wales dune systems when compared with the Sefton coast, dune rejuvenation works should be undertaken during the first half of May. Recognising this relatively narrow but appropriate time window will significantly reduce the impact upon hibernating lizards and in particular mature breeding females, which are often the last to emerge. Avoiding later works also reduces the likelihood of destroying early clutches of sand lizard eggs.

12.4. Recommendations for dune rejuvenation work methods to reduce impacts on sand lizards

Sand lizards require sufficiently large areas of habitat to support viable populations in the long term. Population modelling predicts that extinction risk is high with a patch size below 5ha.The relatively short distances over which sand lizards can disperse mean that they are dependent either on large areas of continuous habitat, or closely spaced patches, ideally linked by favourable intervening terrain. The periodic movement of individual animals between local populations effectively combines them into a larger metapopulation, increasing effective population size and viability. This is essential to promote genetic diversity in the long term, avoiding the impacts of inbreeding. It also reduces the risk of populations becoming extinct due to locally catastrophic events, such as fire. Habitat connectivity is important for sand lizards not only at a landscape level but also within a site. Reptile distribution within most habitats is generally not uniform. Sites should, therefore, be managed so as to enhance the connectivity of habitat patches favoured by reptiles.

Habitat management at too large a scale can be highly damaging to sand lizard populations. There are three main negative impacts on sand lizards:

- Immediate (direct killing or injury).
- Short-term (killing by the removal of cover and hence effecting increased exposure to predation).
- Long-term (removal of key elements of habitat, such as marram tussocks or a diverse vegetation age structure).

Where sand lizards are present, a single large-scale intervention is more likely to impact significantly on sand lizards than mixed methods used at smaller spatial scales. Creation of artificial blowouts in the frontal dunes, particularly when linked to rejuvenation works undertaken on the inland dunes, is a method trialled recently at Kenfig NNR and is showing promising early stage results. Whilst such simultaneous large-scale intervention is likely to cause considerable impact on a sand lizard population if undertaken during the hibernation period, if appropriate avoidance measures are first implemented, then appropriately timed intervention could be undertaken at dune systems supporting sand lizards without serious adverse impact. In addition to allowing sufficient connectivity to remain to sustain a viable population of animals, care should be taken to ensure that a minimal extent of frontal dune ridges is disturbed at any one time, as the frontal dune habitat almost certainly supports the highest population densities.

It is more favourable to sand lizards if notches cut into the frontal dunes are of a modest size and of comparatively regular occurrence, rather than fewer larger areas of open sand which can disrupt the manoeuvrability of sand lizards on dune systems and further increase the fragmentation of fragile populations. Notches 5 - 6 m wide cut at intervals of 50 - 100m would achieve increased aeolian sand transport. If appropriate, these could also be combined with path realignment and the creation of new beach access points to simultaneously increase human foot traffic or vehicular access, as well as enhance wind flow. Wherever possible and appropriate, beach sand nourishment on a 5 – 10 year cycle could also support a multi-pronged approach to dune rejuvenation at sites occupied by sand lizards.

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Plate 31: Kenfig NNR dune works. 1) Detail of the gradual sloping sides of a recently re-profiled frontal dune at Kenfig NNR. 2) Sand moving behind recently re-profiled frontal dunes at Kenfig NNR.

The re-profiled dunes at Kenfig NNR (5m wide frontal notches to enable sand transportation with gradual sloping sides that would be traversable by sand lizards) are an example of the proportions and slope angles that could be applied to future mechanical intervention implemented during management at dune systems occupied by sand lizards. However, site specific design is required due to the varying geomorphological and topographical situations that occur around the coast.

When developing a management plan, the potential impacts of proposed methods on sand lizards (and other species) should be considered. For example, removing large expanses of grassland vegetation in a single operation risks directly harming resident lizards, removing their shelter from adverse weather and exposing survivors to predation. Such an operation could lead to the eradication of sand lizards from the site; this could mean permanent local extinction if there are no sources of colonisation nearby.

Single operation large-scale turf stripping (areas measuring more than say 50m across) is not recommended on areas supporting sand lizards. Stripping large areas of grassland vegetation removes the structural diversity that provides the microclimates required to enable ectothermic animals such as reptiles to function. The resulting large expanses of bare sand that are produced from turf stripping on a large scale are both difficult and dangerous for sand lizards to move across. In the short term, turf stripping across a large area also significantly reduces the available source of invertebrates. A suitable compromise would be to undertake the removal of fixed areas of grassland vegetation in sinusoidal strips, no greater than 5 to 10 m wide and alternated with intact strips of vegetation of a similar width. This would

produce interspersed areas of bare sand which could potentially increase aeolian sand movement as well as creating habitat interfaces with potential foraging and egg-laying opportunities for sand lizards. Site specific management should be designed to maximise the benefits, and minimise the adverse impacts, for the habitats and species of importance at each site. Note that whilst the sand lizard is especially sensitive due to its low population density and particular habitat preferences, other reptiles and amphibians may be adversely impacted by large-scale turf stripping. It may be appropriate to reduce the scale of works, divide the area into smaller components, split the activity over several years, or employ other mitigation actions if the short-term impacts were deemed unacceptable. The short-term and long-term advantages and disadvantages of this activity should be carefully considered on any site supporting reptiles and amphibians, before deciding whether and how to implement it.

Only the edges of a large sand patch, where lizards can remain near cover, are used for egg-laying. Hence, a long, narrow patch (ideally sinusoidal) is preferable to a large expanse of bare sand. For the same reason, several smaller patches are typically better than one large one. Precisely how this is implemented may vary depending on the site topography, as well as the site's other interest features and their management requirements.

13. Part E: Suggested Annex for Reptile Habitat Management Handbook; sand dune habitat management for reptiles.

13.1. Sand Dune Habitat Management Guidance for Reptiles

13.1.1. Introduction

Great Britain has six species of native reptile: sand lizard (*Lacerta agilis)*, smooth snake (*Coronella austriaca)*, adder (*Vipera berus)*, grass snake (*Natrix natrix)*, common lizard (*Zootoca vivipara)* and slow-worm (*Anguis fragilis*).

These species are protected in Great Britain and it is illegal to kill, injure or sell or trade these animals. Due to their rarity the sand lizard and smooth snake are additionally protected under both British and European law and it is illegal to kill, injure, disturb or capture them; to damage or destroy certain elements of their habitats; or to possess or trade them. A licence is required for some activities involving these two species. In addition, public bodies must consider these species under the “biodiversity duty”. Note that this paragraph is a highly summarised account of the legislation and readers are referred to the original laws for more detail.

These species can be naturally present, absent, nearby, or re-introduced to sites. Habitat use within sites depends upon niche requirements, land-use, management and connectivity of habitats. In general reptiles have low dispersal powers. For their conservation status to remain favourable, primary effort is geared to retention and enhancement of particular niches (both extent and quality are important here) and also to enhance habitat connectivity, to promote interchange and colonisation.

On many dune sites both microhabitats and population sizes can be naturally dynamic, limited in extent and may be fragmented. This can make them inherently vulnerable to natural change and also changes in habitat management. Key activities for their conservation include monitoring and mapping of habitat condition and populations, and dissemination of quality information to relevant stakeholders. Of particular note are government agency and land-managers, to assist in management plan determination and delivery.

13.1.2. Reptile habitat requirements on sand dunes

In general reptiles prefer open habitats with access to direct sunlight. They generally prefer a mosaic of dense vegetation, which provides cover from predators and temperature extremes, and open areas to allow access to sunlight, for basking.

This requirement for a combination of dense vegetation cover with open areas is mostly associated with mobile dunes with dense, tangled stands of marram grass (*Ammophila arenaria*). These areas are considered highly important for reptiles, notably sand lizards and common lizards.

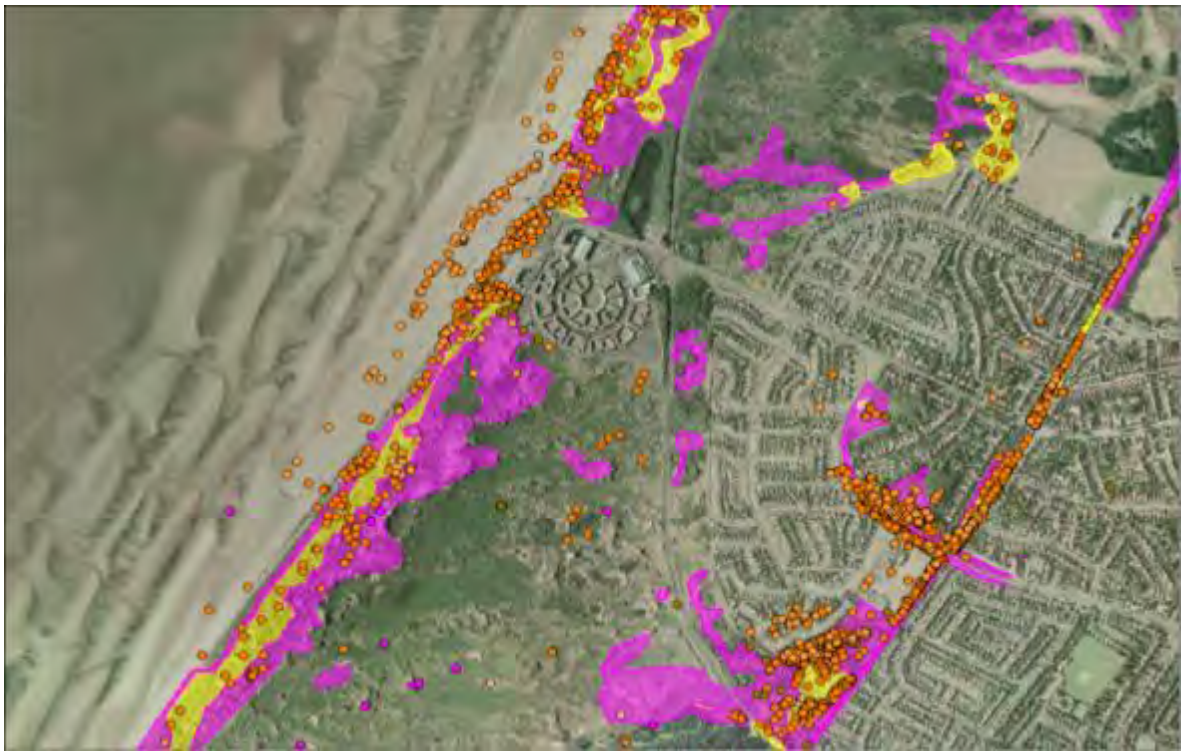
Fixed dunes can naturally have more uniform dense vegetation. Many dune systems require active management intervention, e.g. scrub removal and grazing, to prevent scrub or invasive species encroachment, though a balance is required for reptiles.

Inland scrub and rank grass stands can be highly important habitats for the adder, grass snake, common lizard and slow-worm.

On sand dunes, reptiles are typically active and above ground on warm sunny days from March/April to October and hibernate from October to March/April (exact timings depend primarily on local weather conditions and vary between species). Many animals hibernate singularly though communal hibernacula are also used, especially in sites more exposed to extreme cold. Both communal and individual hibernacula are highly important, since they may represent locally limiting habitat. Management that directly impacts such features, via above ground and especially below ground changes, can have a disproportionate effect on populations.

Plate 32: High quality dune reptile habitat at Morfa Harlech NNR.

Plate 33: High quality dune and heath habitat at Studland dunes.



Map 17: Species and habitat niche mapping. Orange circles = sand lizard record, yellow shading = prime habitat, and pink shading = potential and low occupancy habitat niche extent.

13.1.3. Reptile Monitoring and Population Status

Reptile population status can vary substantially between sites. Reptile monitoring consists of both a habitat and species measure, to help assess status and trends. Measures of habitat status include: site characteristics i.e. site size, habitat connectivity and habitat extent. They also include condition of habitat for reptile species e.g. tree, scrub, bracken cover and other site factors e.g. site protection, management regime, disturbance, etc. Combined these attributes can guide a quick assessment of reptile conservation status and carrying capacity on any given site.

A species measure is also required indicating range i.e. widespread, localised, rare, etc. Species with localised range, either natural or via recent re-introduction, carry an inherently higher chance of negative impacts by management. Reptiles are secretive, and numerous variables affect their detection rate in surveys. Population monitoring typically requires 6-10 annual timed visits. This increases the chance of encountering reptiles and allows mean encounter rates to be derived. Detailed guidance on survey methods and analyses are currently (2016) being developed by ARC, as part of the fixed site, repeat visit element of the National Amphibian and Reptile Monitoring Scheme (sometimes termed “NARRS2”.

From annual species and habitat monitoring, combined with habitat niche mapping and accessible data systems to government agency and land-managers, sensitive reptile areas can be located to assess the impacts of proposed management. Map 3 shows an example of sand lizard species and habitat niche mapping at the Sefton Coast, highlighting current and potential occupancy.

13.1.4. Assessing impacts on reptile populations and dune habitats

Various types and scale of impact can occur on reptile populations and their habitat niche either via natural process or influenced by humans (see Table 3 below). Impacts must be considered in relation to the site and population status. A large, well connected sand dune system with extensive reptile microhabitat features and a robust population is more resilient to negative impacts than a small isolated dune with fragmented microhabitats and a small reptile population.

Table 3

Activity	Impact (positive, negative and comments)
Climate change - succession	Impact varies. Modification of management plan may be required. Options include increasing dune rejuvenation, grazing, scrub management regimes.
Climate change – sediment supply	Impact varies. Reduction of supply reducing extent and quality of habitats. Accretion can increase habitat extent and condition.
Sea defences	Impact varies. Often negative effects on dune system dynamics affecting habitat extent, condition and management. Can also increase sediment supply increasing system viability.
Change of land-use - development	Negative and permanent impact. Most notably affects grey-dune scrub belt, nullifying successional stages notably for extent and condition.
Change of land-use - agriculture	Negative and often permanent impact. Most notably affects grey-dune scrub belt, nullifying successional stages notably for extent and condition.
Change of land-use – mineral winning	Impact dependent on locality and extent. Offshore winning can reduce sediment supply and combine to cause erosion and negatively affect both habitat extent and condition. Inland winning can cause direct loss and fragmentation of habitat extent and condition.
Change of land-use – forestry	Impact dependant on locality and extent. Direct reduction in habitat extent and condition (via interruption of natural processes), habitat fragmentation and increased pressure on management resources to retain favourable condition for dune habitats.
Mechanical beach cleaning	Impact varies. In general can negatively affect foreshore and embryo dune development, affecting system.
Leisure and tourism	Impact varies, dependant on scale, location and timing.
Site management	All management activities can have variable impacts and, for reptiles, mainly dependent upon scale, location, timing and methods.

13.1.5. Management Operations

Many habitat types, e.g. dune and lowland heath, require active management intervention to retain the sites habitats and species in favourable condition.

Most management operations have impacts at either habitat or species levels depending on location, scale and timing. Impacts can vary and be positive, neutral or negative. Some impacts may be initially negative though through time can improve habitat and or species status. As habitats and species often require inherently different and often conflicting components, it is often difficult to achieve a balance of requirements for all habitat and species and retain all in favourable status through time.

Many common and historic management techniques have been tried and tested and a balance of requirements can be set to provide benefit to most habitat and species. For example, sensitive hand-tool management during winter and disposal of scrub at pre-identified key locations, can directly benefit habitat condition, and is undertaken at the best period to minimise harm to reptiles. The same management operation conducted in spring or summer, however, whilst improving habitat condition in the long-term might result in serious harm to species such as birds and reptiles.

13.1.6. High level impacts on sand dunes

Change of land-use:

Change of land-use on dunes would cause high level impact on sand dune habitats and supporting species. Common forms of change of land-use on dune habitats include: housing, caravan sites, infrastructure, farming, woodland creation, minerals use, etc.

Dependent upon scale of conversion, impacts can be severe and permanent with complete loss of habitat and population. Even limited scale of conversion can alter dune system viability increasing fragmentation, nutrient enrichment, successional affects, etc.

These types of land-use change are most noticeable within fixed grey dune areas and directly reduce functionality and natural dynamics of dune ecosystems, cause direct loss of habitats and species and, greatly increase the potential for secondary negative affects including succession, fragmentation, enrichment and invasion by scrub, trees and alien species.

For example, afforestation at Newborough Warren has covered around half of the former open dune area. This will have also affected system dynamics, both reducing and trapping sand required for the remaining open dunes to stay in favourable condition. Through time this has negatively affected the status of the open dunes for habitats and species, and large-scale management is therefore required to improve the condition of the remaining dune area.

Climate change:

Changes with climate can affect the conservation status of dune habitats and species. Changes to prevailing wind, waves and strength can alter sediment

availability and flow e.g. changing an accreting system to an eroding system, which can directly reduce dune habitat extent and quality.

The current warmer and wetter climate can also increase succession within dune systems, reducing natural dynamics required for a dune ecosystem.

As many dune systems are now remnants of formerly larger systems negative climatic affects at habitat and species level can be compounded, requiring a higher level of management intervention.

Large-scale Mechanical Vegetation Clearance:

Dune restoration works are increasingly indicated in order to retain the frontal/pioneer habitat used by many sand dune specialist species in the face of a combination of habitat loss, coastal squeeze, climate change and nitrogen-induced fixation. There is a potential tension here because large-scale mechanical vegetation clearance required for dune mobilisation can have an adverse local impact on sand lizards, as it is required on the frontal systems which typically support highest densities of this species.

When highlighting potential areas for this type of management, first check if the area is known for reptile species, or if survey effort is limited assess the areas habitat suitability for reptiles. Avoid any identified suitable reptile areas if possible.

The location and scale of management can affect the scale of impact on reptile populations. Large-scale management, over say 1 ha, may result in a very high level of impact if it coincides with key habitat features.

Plate 34: Photo of highly suitable reptile habitat at Newborough Warren NNR.

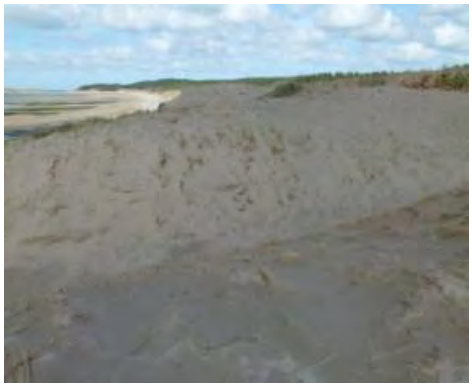


Plate 35: Photo of the same area at Newborough Warren NNR after management.

Timing of management is often crucial. If management is undertaken during winter in an area used for hibernation, there is potential for a direct, large-scale mortality as animals are torpid and hibernating below ground. For large-scale operations even management undertaken during active periods could still result in direct mortality as animals would likely hide in deep vegetation when disturbed. There is no universally ideal time of year for management because of the various considerations: multiple protected species issues, machinery access, weather conditions, etc. Planning to determine the most beneficial and least harmful timing is therefore crucial, taking into account the various options and constraints.

Where this management is necessary, firstly assess if management can be undertaken in less sensitive areas. Reduce the scale of operations to ensure that populations will be maintained. Assess if sensitive vegetation mowing can be undertaken at least one season in advance of mechanical operations, as a method of passive displacement. This could make the target area less suitable for reptiles and allow them time to move to suitable habitats away from the target area, reducing the chance of direct mortality. A combination of advance mowing, hand-capture of animals *in situ* and relocation away from the management area could be feasible, as long as the target area is kept bare, or exclusion fencing isolates the management area from re-colonisation. Note that this method is experimental and may require a licence. Given that there is recent evidence for individual sand lizards crossing apparently unsuitable habitat (ARC, unpublished), passive displacement should not be used as the sole risk reduction measure in sensitive situations.

For large-scale operations, say works of 50m width and above, phased management through time could also reduce impacts. Although habitat recovery may be relatively quick on sand dunes, reptile populations can be slow to recover if the original population was small or fragmented. Large-scale operations are generally more appropriate to phase through multiple years (possibly as much as 10 years for extensive works), thus balancing requirements for both the dune system and reptile population status.

Sea Defences:
Sea defences at or close to a dune site can reduce and interrupt sand supply and flow which can degrade dune habitats, either via loss of habitat or loss of habitat quality. Mechanical beach cleaning can also reduce embryo dune formation and sand supply required at ecosystem level again causing loss of habitat extent or quality.

13.1.7. Medium level impacts on sand dunes:

De-stabilisation “Notches”:
De-stabilisation “notches” are advocated on dunes that are over-stabilised, reducing the natural dynamics required for a sustainable dune system. This stabilisation can lead to habitat succession and encourage dense non-dune vegetation and scrub. In turn this can favour reptile occupancy but reduce its suitability for other notable dune specialists.

Notches are undertaken by mechanical excavation of the first dune ridges and each notch can vary in length c. 10-30m and width c. 5-20m. Multiple notches are often required to breach the dune ridge and promote active sand flow to inland habitats.

Location of notches should first be checked for known reptile populations and presumed reptile habitats. Avoidance of key reptile features is the first level to reduce impact.

Plate 36: Multiple dune “notch” management at Kenfig dunes

Although small single notches in sensitive areas would have a limited impact on reptiles, multiple larger notches in combination with large-scale vegetation clearance are often required to benefit dune systems. This combination would inherently have higher impacts, reducing the extent of reptile habitat and increasing fragmentation of populations. Sensitivity of location and assessment of fragmentation could reduce impacts for reptiles.

Timing of works is important. Winter management using heavy machinery would cause direct mortality of hibernating and torpid reptiles if undertaken at hibernation sites. As each notch is limited in area, sensitive advance mowing, one year before notch creation, could reduce the areas that reptiles use by passive displacement, and reduce re-colonisation before mechanical management. If notches have to be undertaken in known or presumed hotspots (“foci”), it may be advisable to use advance mowing and survey, capture, relocation and exclusion.

13.1.8. Low-Medium level impacts on dunes

Scrub Management:

On many dune sites scrub management is required for native and invasive species. Scrub succession can be most notable on sites with low levels of natural dynamic processes e.g. sites where natural processes are compromised by sea defences, sand winning, development infrastructure, woodland planting, etc. Sites with low levels of natural dynamics can also be more susceptible to successional effects by climate; warmer and wetter years can increase succession.

The impacts of scrub management on reptile populations vary depending on the local circumstances, and in particular on the scale, timing, location, and activity of

operations. General advice on protected sites suggests that dunes should be actively managed to have <5% scrub and trees (JNCC, 2004); this can favour reptile species that require mainly open habitats but may have negative impacts on those species favouring higher scrub levels.

Some sites may initially require large areas to be managed for scrub, to enhance habitat status, and then retain a lower annual level of scrub maintenance management. These areas have to be assessed for consents e.g. felling licence, use of chemicals, Tree Preservation Orders, Scheduled Ancient Monuments, etc. On sites with high levels of scrub and woodland, mechanised management is often most effective (Plate 36). Sites with moderate scrub and other practicalities e.g. steep slopes (Plate 37) prevent the use of machinery and are more suitable to manual management.

High density scrub and woodland areas have limited value to most reptiles, and so mechanised management typically has limited impact, and can be useful for restoring habitats for reptiles. Consideration of management impact using heavy plant should assess vehicle access and disposal of cut material. Access routes should be assessed in advance, and restricted to minimise impacts to sensitive areas, especially if material is to be disposed of off-site and where multiple visits are required. If cut material is to be managed in situ, safe controlled burning, using bonfires, is an option. Here conditions must be suitable for safe burning i.e. undertake in a sterile area to prevent uncontrolled fires, disturbance via excessive smoke, etc. Nutrient enrichment can be reduced by the burial (1m deep and only on dry areas) of any remaining ash.

Plate 37: Dense scrub at Queens Jubilee Nature Reserve, Sefton.

Plate 38: Dense sea buckthorn at Ainsdale Sandhills, Sefton.

To prevent regrowth, cut deciduous stumps should be chemically treated with an appropriate herbicide. This can be most effective by immediate direct application using a paintbrush. This ensures a good suppression rate and minimises herbicide use. On some sites and for some scrub species, spring-summer herbicide regrowth spraying is necessary. This carries inherently higher risks including spray-drift and uptake within the food-chain of native species. Here suitable weather conditions, proximity to open water and choice of herbicide should be selected with care to ensure that negative impacts are minimised.

Management on any sensitive area requires assessment of impacts and to check for whether modification of standard practices may be required e.g. location, timing, scale and methods. For example on a location with moderate scrub and adder hibernacula, standard winter management would be recommended, though also sensitivity via manual management (reducing damage to hibernacula), combined with a retention of some scrub levels to prevent excessive disturbance and exposure.

Substantial scrub and tree management should be only undertaken during September-March, when reptiles are hibernating. Care should be taken to assess if communal hibernacula could be affected by heavy plant. Winter scrub and tree management has the benefit of reducing impacts to many species e.g. reptiles and nesting periods for birds. Where possible, all cut material should be disposed of during the management phase, to reduce future use as refuges if that could cause a conflict e.g. burning of brash piles used for hibernation. However, actively retaining a proportion of brash and log piles can be highly beneficial to reptiles if left as permanent features.

Conservation Grazing:

Conservation grazing mimics natural processes or replicates traditional agricultural regimes and is used with the aim of benefit plant and animal communities. Timing, intensity and both species and breeds of livestock all influence the outcomes of grazing regimes.

Like most management methods, grazing has the potential to either benefit or harm reptile species populations and their habitats. Grazing can be positive for reptiles on dunes, by limiting excessive scrub development, increasing the diversity of vegetation structure, and creating open basking areas between dense areas of uniform habitats. Grazing can also be detrimental, by creating a very low sward, uniform vegetation structure, reducing prey abundance, enrichment via dunging, simplifying habitat structure via trampling, and potentially causing disturbance.

A risk assessment for grazing heathland (Offer *et al*., 2003) assists on predicting possible negative consequences and precautions and recommendations, many of which are equally applicable to dunes. These include defining objectives and a baseline for trend monitoring, for reptiles this is best via mapping vegetation structure and type. If negative impact occurs consider reduction of grazing pressure (stock density and/or time on site), modify grazing location if units of the site show initial signs of over-grazing. Monitoring of both vegetation structure (extent and condition) combined with reptile species use should be ongoing to assess trends and options for modification.

In general, grazing of small sites carries a higher risk of adverse impacts and fewer options for modification. On large dune systems, any adverse impacts are more manageable. There is some evidence to demonstrate the value of grazing to sand lizards on dune systems in the Netherlands (Wouters et al, 2012).

Grazing pressure is expected to be more associated with fixed dunes and dune scrub. Here vegetation is more palatable, more prone to succession and loss of important plant species without management intervention. As we have few remaining intact dune systems that have natural succession to dune scrub (most have been

modified to farmland, housing, etc.) management of this transition zone is often understandably biased to benefit open dunes and the rarer dune species. Although rank grass swards and open scrub are perceived as poor for dune habitat and species, they can provide optimum habitat for widespread reptile and amphibian species. Ideally a higher level of dune scrub should be retained as a natural succession and important habitat for reptiles and amphibians, that can also assist as a buffer between nature reserves and other land-uses. In reality, though, options may be limited by protected site status and the extent of management units.

Mowing:

Repeat cutting of herbaceous vegetation can assist to control succession to scrub and diversify habitat age structure. It is often combined with grazing regimes and, on dunes, targeted to fixed dune habitats. As with other forms of management it can have a positive or negative affect for reptiles depending on management location, scale and timing. Negative effects include; direct mortality, loss of cover and exposure to predation, loss of key habitat structure e.g. tussocks. Positive effects include the creation of varied vegetation structure (when used appropriately) and the reduction in succession to dominant scrub.

When considering management prior assess habitats, consider modifying management plan to retain favourable reptile habitats or reduce scale of operation within sensitive locations.

The scale of mowing regimes should be initially limited and monitored to assess impacts. Monitoring should be used to calibrate a balanced management plan. Management should be phased through time. Many small management plots, implemented through consecutive or alternate years would have less impact than large management plots delivered all in one year.

Cutting should be undertaken only during November-February. Retention of habitat round key reptile localities e.g. adder hibernacula should be planned. On sites where botanical interest requires cutting in spring and summer, firstly identify key reptile areas (or likely areas) and exclude these where possible. Modify intensive cutting management where appropriate, for instance by reducing the extent of management at any one time on areas that are likely to support important reptile features.

Mowing is often done via the use of tractor-mounted forage harvesters that allow efficient management over larger areas. On sensitive areas, small-scale management can be undertaken more sensitively via smaller reciprocating cutters, brush-cutters and strimmers. For any operations during spring and summer “high” cuts (c. retaining 15cm vegetation height), can reduce direct mortality and retain some cover.

Vegetation cuttings can provide ideal cover for reptiles. When retained as heaps in sunny locations these can also provide egg-laying sites for grass snake.

Public Access Management:

Management of public access is often required on dunes. In general, small sites with high levels of public use can have higher impacts, e.g. via disturbance to species or trampling of vegetation. The scale, location and timing of such disturbance impacts

are key and for managers to assess impact (positive or negative) and assess if modification of management plans is required to retain a balance.

Due to previous concerns of adverse impacts on dune habitats, Sefton Council have significantly reduced vehicle use on the foreshore between Ainsdale and Birkdale dunes. Public vehicle use, combined with mechanical beach cleaning, was having a negative impact on foreshore and embryo dune development along a significant extent of dune habitats. This modification of site use was successfully achieved via a combination of public engagement and awareness, modification and integration of management plans and part-area fencing, and restricting vehicle use to certain localities. This has allowed a good compromise between continued public use of the area and also retaining achieving favourable condition for rare habitats.

At Studland dunes in Dorset a combination of high public use combined with natural erosion is having a negative effect on dune condition in certain high use areas. Again, public consultation combined with “token” fencing has been adopted to reduce impacts at key localities.

For most sites public disturbance is often highest around major access routes, especially car-parks, main paths and viewpoints. Where this causes a negative effect, options include token fencing, boardwalks, and alternative provision.

Plate 39: High public impact, showing loss of habitat height and structure, at Studland NNR.

Plate 40: Token fencing at Studland NNR has been used to reduce public use and promote habitat recovery.

13.2. Management Summary

Many habitats require active management intervention to retain or increase the status of habitats and notable species. For most management activities there are positive, neutral or negative effects for all habitats and species, so it can be a daunting task for land-managers to try and deliver effective management for all habitats and species.

For reptiles a key consideration is monitoring, both for habitat suitability and species status (size, range and trends). Likely reptile habitats should be mapped at site and unit level within management plans to indicate sensitivity.

Most management options that benefit habitats are also beneficial to reptiles in the long term, though often the scale, location, timing or management methods need to be modified to achieve positive results for both.

In some cases management is indicated that would initially impact negatively on reptiles via direct harm or reduction in habitat quality or extent. Early consideration of management objectives and methods should be undertaken. Many management impacts can be reduced via modification of scale, timing and methods.

In some instances there may be limited practical options to reduce impacts, so assessment of “mitigation” options can also be undertaken.

13.3. Mitigating adverse impacts of habitat management

Key principles of management mitigation for reptiles and their habitats are to protect reptiles from any harm that may occur during management operations and, to ensure there is no net loss of local reptile conservation status by retaining sufficient quantity, quality and connectivity of habitats to accommodate the population in the long-term, and to ensure management is consistent with long term objectives for reptiles.

Important direct negative impacts for reptiles include: habitat loss, population isolation via habitat fragmentation, reduction in habitat quality, and direct mortality. Indirect impacts include reduction in survival and reproduction opportunities in the years following management due to modified habitat.

Where management activities are liable to have a high impact for reptiles, options include modification of management regime in terms of scale, location, timing and method of management.

When an impact assessment for reptiles has been completed assess:

- Changing the management plan to avoid impacts and enhance benefits
- Mitigate impacts that cannot be avoided, i.e. reduce the scale of impacts by changing i.e. location, scale, timing, and/or management methods
- Direct intervention by passive displacement, capture and/or exclusion of reptiles from high impact areas
- Compensate for any residual impact by taking positive measures, such as creating or improving habitats elsewhere, ideally on the same site.

Mitigation should be proportionate and pragmatic and must be considered when developing management plans.

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15. Data Archive Appendix

No data outputs were produced as part of this project.

The data archive contains: The final report in Microsoft Word and Adobe PDF formats.

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