



An assessment of recreational impacts on Dawlish Warren SAC



Sophie Lake

Footprint Ecology
Assessment of Recreational Impacts on Dawlish Warren SAC

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Summary

This report was commissioned by Teignbridge District Council to consider the impacts of recreation on Dawlish Warren SAC. The aim of the report is to identify the extent to which access is currently having an impact on the site and the extent to which additional visitor numbers may exacerbate any problems. Key findings are:

- The impact of recreational pressure on Dawlish Warren is closely intertwined with other factors operating on the site, most notable coastal erosion, the presence of sea defences, the naturally dynamic state of the sand dune habitats present and management practices. The role of trampling in particular is ambiguous, as in some places it contributes to maintaining the preferred habitat conditions, whereas in other places it is leading to significant erosion problems.
- Embryonic shifting dunes are particularly vulnerable to trampling, and there is evidence that the current level of visitor use is negatively impacting on this community. Should changes to coastal erosion and coastal management in the future create the potential for the recovery of this habitat, current levels of visitor pressure could have a significant effect in preventing the establishment of functional embryo dunes. Any increase in visitor pressure is expected to increase the damage to this habitat.
- Trampling is causing severe localised erosion in the mobile dunes in several places in the western section of the site. The impact of trampling is exacerbating the effect of coastal erosion on the dune face. Coastal erosion is also changing visitor behaviour, and concentrating visitor pressure on the dune ridge. An increase in visitor pressure is likely to result in an increase in erosion damage in vulnerable areas.
- However, over-stabilisation of the mobile dunes is also a problem in places, leading to loss of diversity and to scrub colonisation. Trampling on the path along the top of the dune ridge, and small subsidiary paths, may be beneficially increasing the mobility of sand in the system. At some point an increase in trampling will cause damage rather than benefit to these areas, but it is not possible to predict the trampling threshold at which this will occur.
- In the absence of significant rabbit grazing, trampling is currently playing a role in creating the short, open sward required by many of the characteristic plants of the fixed dune grassland at Dawlish Warren. However, the diffuse trampling required to do this is difficult to achieve and the level of visitor pressure which is creating a suitable sward in some places is also leading to significant wear and erosion in other places. Beyond a certain threshold, trampling will cause more damage than benefit to this habitat, but it is not possible to quantify at what level of visitor pressure this will happen. Increased visitor pressure will increase wear on already vulnerable swards.
- Trampling plays a similar role in the humid dune slacks, where diffuse trampling is thought to create suitable conditions for petalwort. Petalwort may be declining at one of its two locations at Dawlish Warren. Insufficient data are available to establish whether this is the case, or any possible role of changes in visitor pressure.

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- Sand dune habitats are naturally very nutrient poor, and any increase in nutrients due to dog fouling is undesirable. Nutrient enrichment, presumably from dog faeces, is evident near access points in the fixed dune grassland, where the characteristic dune grassland flora is replaced by coarser vegetation in places. Any increase in visitor pressure is likely to mean an increase in dog-related eutrophication and its negative impacts on the vegetation.
- High visitor numbers mean there is a high risk of fire in the summer months. When wildfire occurs, it can destroy large areas of dune vegetation. Re-colonising vegetation is generally characterised by a higher percentage of unwanted ruderal species. An increase in visitor numbers will increase the risk of wildfire.
- The effect of trampling on Dawlish Warren Golf Course is perhaps partially obscured by the significant impacts of some of the current management practices on the site. These include fertilisation, irrigation, close mowing and some reseeding of tees and greens and drainage. However, wear is noticeable on many of the fairways. Numbers of sand crocus are thought to have declined on the site – more data are needed to ascertain the cause and extent of the decline. However, trampling along paths is creating areas of bare ground in the otherwise fairly closed and uniform acid grassland – lowland heath transitional communities, where it may be beneficial.

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1. Introduction

- 1.1 This report provides an overview of the recreational impacts on the sand dune habitats at Dawlish Warren Special Area of Conservation, Devon (SX984792). A report by David Tyldersely Associates (Tyldesley, 2010) identified a shortfall in previous Appropriate Assessments carried out by Teignbridge District Council regarding information on recreational impacts on the SAC. Specifically, in paragraph 16 the Tyldersley report states that “The AA appears to progress ... on an assumption (that is implied rather than specifically stated) that any increase in recreational impacts over present levels would represent an adverse effect on the integrity of the sites concerned. Whilst such an assumption may be correct, it is not supported by the evidence presented within the report”. This report is therefore intended to clarify what the current impacts are, and what impacts could be in the light of potential future developments in the district.
- 1.2 The report forms part of a larger project looking at recreational disturbance issues in the Exe Estuary, which includes a visitor survey of the area in addition to work looking at the issues relating to disturbance to the wintering waterfowl.
- 1.3 Dawlish Warren SAC is designated for its dune habitats (see Table 1) and a population of petalwort *Petalopyllum ralfsii*, a liverwort. Large populations of petalwort occur in two dune slacks at Dawlish Warren. One of the slacks is on a natural, sandy substrate which is probably affected by the concrete materials used to build the visitor centre foundations. In the other slack, petalwort grows on sand overlying an artificial masonry/stone substrate, which receives run-off from an adjacent limestone gravel track (Holyoak 2003). Both slacks are closely grazed by rabbits *Oryctolagus cuniculus*¹. The qualifying species sand lizard *Lacerta agilis* is also present on the site following reintroduction in 1994 under English Nature’s Species Protection Programme, but is not a reason for designation.
- 1.4 Embryonic dunes is an Annex 1 habitat type (i.e. listed on Annex 1 of the Habitats Directive and therefore a habitat type that could be a qualifying feature of an SAC). Embryonic dunes are listed as being present at Dawlish, being identified in the Natura 2000 standard data form for the site². It should be noted that on the Natura 2000 standard data form its “representivity” is classed as D, which means “non-significant presence” (see explanatory notes on the data form). Embryonic dunes is therefore not listed as a qualifying interest feature for the SAC. In our view this means that it does not, in its own right, need to be considered in an appropriate assessment of impact at the site. However, at Dawlish, the mobile dunes, which do form a qualifying feature, are likely to be affected if the ecological functioning of the embryonic dunes is compromised, i.e. the shifting dunes as a qualifying feature is indirectly affected by impacts on the embryonic dunes. Therefore we have included them in our assessment of recreational impacts on the SAC features at Dawlish, because indirect effects upon shifting dunes could constitute an adverse effect on

¹ <http://www.jncc.gov.uk/ProtectedSites/SACselection/sac.asp?EUCode=UK0030130>

² <http://www.jncc.gov.uk/ProtectedSites/SACselection/n2kforms/UK0030130.pdf>

the integrity of the SAC.

- 1.5 Dawlish Warren is an unusual double sandspit. Throughout much of its history the Warren has been a very dynamic feature, with numerous periods of deposition and erosion. However sea defence works in the late 1960s or early 1970s have prevented full mobility from occurring (TDC 2010). Storm events in recent years have resulted in the substantial erosion of significant amount of the beach and embryonic dunes (P. Chambers pers. comm.). The fixed sea defences mean that there is no possibility for the mobile element of the dune system to migrate inland.
- 1.6 Dawlish Warren SAC includes Dawlish Warren NNR, managed by Teignbridge District Council, and Dawlish Warren Golf Course, which is managed as a private golf club on land leased from the Devon Wildlife Trust.
- 1.7 Dawlish Warren is an extremely popular seaside resort and human visitor pressure is considerable. The rise of tourism has been charted through the availability of “bed spaces” in Dawlish Warren village, which rose from 800 in 1950 to 11,700 in 1977 to 12,000 in 2007 (TDC 2010). The tourist resort on the Warren attracts 480,000 visitors per annum (SWT cited in TDC 2010), the majority of which are summer visitors, although year round tourism is thought to be increasing. The site also forms a valuable resource for the local community. Most visitors arrive at the western end of the site where there is a large carpark just outside the SAC. However in the summer visitors also arrive via water craft at the eastern end. There are two car parks with a combined capacity of 2080 spaces, a railway station and regular bus service to Exeter and Dawlish. There is a surfaced “easy access” route from the car park to the visitor centre. Although there are no public rights of way through the SAC there are numerous footpaths, the largest of which continues north east from the visitor centre. There is also a board walk between the visitor centre and the promenade. Many small paths lead from the dunes onto the beach, particularly near the amenity beach and near where a branch of the main track approaches the dunes. The site has largely unrestricted open access at all times.
- 1.8 Dawlish Warren Golf Course was established in 1892, and is a links course with 18 holes. It is a private membership club, although visitors are welcomed. Membership is currently about 540, although not all of these are regular players.

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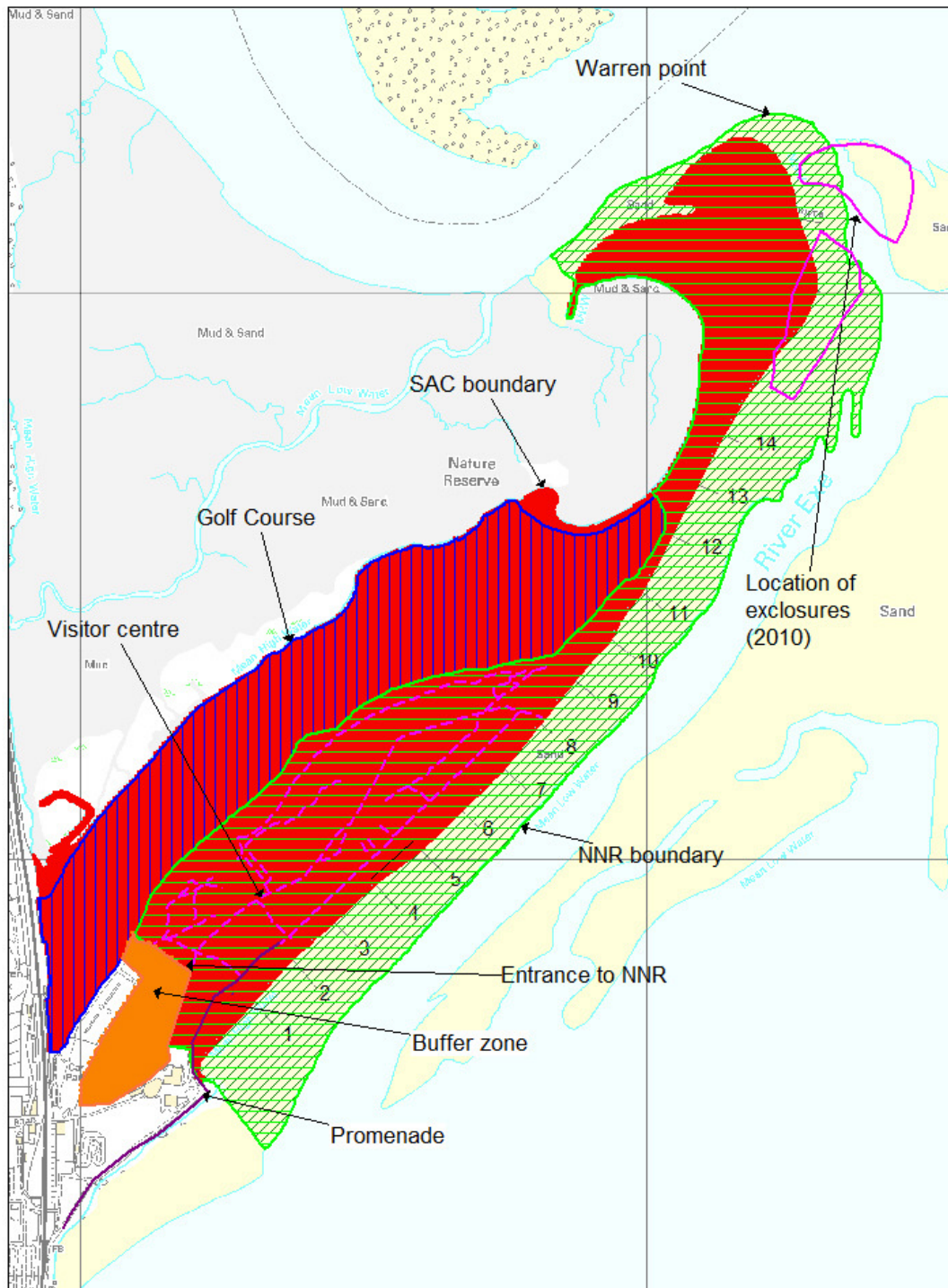


Figure 1 Key boundary features at Dawlish Warren (only the terrestrial part of the NNR is shown). Main paths on the NNR are shown in pink. The position of the exclosures is correct, and reflects recent changes in the shape of Dawlish Warren.

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Table 1: Annex 1 habitats for which Dawlish Warren is designated a SAC

Annex 1 habitat type	Description	Approx. area of SAC
Embryonic shifting dunes (present but not a qualifying feature, see para 1.4)	Embryonic shifting dune vegetation exists in a highly dynamic state and is dependent on the continued operation of physical processes at the dune/beach interface. It is the first type of vegetation to colonise areas of incipient dune formation at the top of a beach. In most cases Embryonic shifting dunes are transient and will either be displaced by marram-dominated vegetation as the dunes develop or will be washed away by storms. The continued supply of new sand from the beach plain into the dune system is therefore vital to the continued existence of this community, even if this sand is derived from within the same system. The habitat type is of exceptional importance as an indicator of the general structural and functional 'health' of a dune system. Creation of new dune habitat, and indeed the long-term survival of the dune system at which it occurs, is often dependent upon the survival of this habitat type. The predominant plants are strandline species such as sea rocket <i>Cakile maritima</i> and the salt-tolerant, sand-binding grasses such as sand couch <i>Elytrigia juncea</i> .	1% of 58.84 (at notification)
Shifting dunes along the shoreline with <i>Ammophila arenaria</i> ("white dunes")	Shifting dunes encompasses most of the vegetation of unstable dunes where there is active sand movement. Under these conditions sand-binding marram is a prominent feature of the vegetation and is usually dominant. This is a dynamic vegetation type maintained only by change. It can occur on both accreting and eroding dunes, but will rapidly change and disappear if stability is imposed. It rarely occurs in isolation because of its dynamic nature and because it is successional related to other dune habitats. The habitat type excludes the low, embryonic dunes where occasional exposure to saltwater flooding constrains the growth of marram and where plants of the strandline mingle with salt-tolerant, sand-binding grasses. Dawlish Warren is considered to support a significant presence of this habitat type.	23.6%
Fixed dunes with herbaceous vegetation ("grey dunes")	Fixed dune vegetation occurs mainly on the largest dune systems, where there is sufficient width. It typically occurs inland of the zone dominated by marram, and represents the vegetation that replaces marram as the dune stabilises and the organic content of the sand increases. At Dawlish this includes both calcareous dune grassland (on the area under TDC ownership) and acid dune grassland with transitions to dune heath and acid grassland on Dawlish Warren golf course. Dawlish Warren is considered to support a significant presence of this habitat type.	22.6%
Humid dune slacks	Dune slacks are low-lying areas within dune systems that are seasonally flooded and where nutrient levels are low. The range of communities found is considerable and depends on the structure of the dune system, the successional stage of the dune slack, the chemical composition of the dune sand, and the prevailing climatic conditions. While Humid dune slacks include creeping willow, the Annex I type excludes those sites where the species is dominant. Dune slacks are characterised by a pattern of pronounced annual fluctuation of the water table, related to the landform of the dune system as well as climate and the nature of the underlying sediment – whether porous shingle or impervious clay. Variations in the extent and duration of flooding of the dune surface are very important in determining the vegetation. Dune slacks are often rich in plant species, particularly rare and local species. The Annex II Petalwort <i>Petalophyllum ralfsii</i> is present at Dawlish Warren. Dawlish Warren is considered to be one of the best areas in the UK for this habitat type, which is a primary reason for its designation.	1.9%

- 1.9 Here we present a literature review of the effects of recreational pressure on sand dune habitats. This is then interpreted in the light of the current characteristics, condition and management of Dawlish Warren. Field work was limited due to time constraints and season, therefore information on species diversity and distribution was largely obtained from site managers. Work predominately addresses the NNR, but information is included on the golf course wherever this was available. The possible effects of a potential increase in visitor pressure is then explored, and suggestions for future monitoring to assess any changes outlined.

2. Vulnerability of the special interest features to recreation impacts

2.1 Habitats

- 2.1.1 Visitor access can be both beneficial and detrimental to sand dune vegetation, depending on the extent, intensity and existing conditions. Trampling is the main factor causing change, but dog fouling and wildfire are also implicated.
- 2.1.2 Sand dunes are dynamic systems, changing in response to various factors. The shape and size of dunes depends on the supply of sand and the strength and direction of the prevailing wind. However, fewer than 20% of coastal sand dunes in England are currently prograding (building outwards towards the sea), and coastal erosion is the dominant process affecting most contemporary dune systems (Crooks 2004, (Mark Lee 2001), Ritchie 2001) . Access is one of a variety of factors (such as wind and grazing levels) that influences bare ground creation and erosion within a dune system (Ritchie, 2001) which may result in surface sand movement, increasing the dynamism of a dune system.
- 2.1.3 Access can effect the composition of vegetation in addition to causing the replacement of vegetation with bare ground. Natural England's Access and Nature Conservation Reconciliation guidance (Lowen et al., 2008) highlights the impacts of trampling, citing a range of studies. The guidance notes that experimental work has demonstrated that light levels of trampling can increase plant diversity, but moderate to high trampling can lead to increased bare ground, soil compaction, loss of plant species diversity and changes in vegetation height.
- 2.1.4 However, differences exist between dune habitats. For example, Coombes (2007) explores the relationship between the amount of passes (footfalls) and reduction in vegetation cover in different habitats. For yellow dunes (i.e. mobile dunes) and grey dunes (i.e. fixed dunes) the relationship appears to be linear, suggesting that the impact is proportional to the amount of access. The slope is steepest for yellow dunes, suggesting that yellow dunes are the more sensitive. The relationship for foredunes (i.e. embryonic dunes) appears to be curvi-linear, with a small amount of trampling resulting in a disproportionately high impact (Coombes, 2007). Another experimental study compared the resistance and resilience of three typical plant communities belonging to mobile dunes, semi-fixed dunes, and fixed dunes. Only the vegetation cover of the semi-fixed dune benefitted from long-term trampling

and had a very high resilience. This response was explained largely by soil compaction increasing soil stability and moisture content (Lemauiel and ROZÉ 2003).

- 2.1.5 It is therefore important to consider access impacts on dune systems within the context of the site, the levels of pressure and the nature conservation interest. Light trampling or disturbance may be beneficial, but it is generally accepted that recreational pressure can result in a decrease in species diversity within dunes (Bonte and Hoffman 2005), and that a threshold can be reached where irreversible damage can occur (Covey and Laffoley 2002) (Curr et al. 2000), Ritchie, 2001). However, it is often difficult to identify at what point this may threshold may occur. A survey of Scottish sand dune systems led to a proposal that an acceptable proportion of bare sand within a site might be 2.5% (Ritchie, 2001). Much higher percentages of bare ground may be acceptable in some circumstances, especially where specialised dune invertebrates occur (Lowen et al. 2008). The condition monitoring guidance³ for sand dune SACs suggest bare ground should be no more than 15% cover and notes that an element of instability is a positive attribute as bare surfaces are essential for invertebrates and a cycle of small-scale erosion and recolonisation imparts greater diversity to the system. There are examples of sites where human erosion within a dune system is seen as positive (Reimers 2001). A key issue is therefore how to achieve appropriate levels of visitor pressure within a mosaic of habitats that changes in distribution over time.
- 2.1.6 An Increase in visitor pressure is likely to mean an increase in the number of interlinked paths, path widening and extension, and in the enlargement of path nodes (Curr et al., 2000).
- 2.1.7 Dune systems are often of importance for their invertebrate assemblages. Negative impacts of public access have been identified for a large number of aculeate Hymenoptera and a number of flies and spiders associated with sand dunes (Falk 1991, (Alexander et al. 2005). In contrast, there are some species for which recreation pressure may be a benefit, in that it maintains open habitats. While trampling and disturbance from public access is a direct threat to nesting aggregations (Plant 1998), it also is important in maintaining suitable habitat. A number of species of aculeate Hymenoptera are associated with sandy paths or areas of moderate disturbance (Falk, 1991b; Alexander et al., 2005b). A number of ground beetles (Carabids) may benefit from controlled public access on sand dune systems, and species of tiger beetle are often associated with sandy pathways (Luff 1998, (Telfer and Eversham 2000): it is possible that the correct level of trampling can create suitable conditions (ground which is neither too heavily compacted nor too loose and churned up) for larval burrows (Alexander et al., 2005). However, access has been shown to impact on behaviour for tiger beetles (Arndt, N. Aydin, and G. Aydin 2005).

³ http://www.jncc.gov.uk/pdf/CSM_coastal_sand_dune.pdf

- 2.1.8 It is difficult to generalise between invertebrate species, groups and sand dune sites (Lowen et al. 2008). Moreover, for many sand dune invertebrate species it is difficult to untangle the importance of access levels in modifying habitats from the direct impacts of trampling and disturbance for which clear impacts have been identified (Bonte 2005).
- 2.1.9 Dune systems are also vulnerable to nutrient enrichment from dog fouling. Dogs typically defecate within 10 minutes of a walk starting, and as a consequence most deposition tends to occur within 400m of a site entrance ((K. Taylor et al. 2005). Similarly, dogs will typically urinate at the start of a walk, but they will also urinate at regular intervals during the walk too. The total volume deposited on sites may be surprisingly large. For example, at Burnham Beeches NNR over one year, Barnard (2003) estimated the total amounts of urine as 30,000 litres and 60 tonnes of faeces from dogs. Limited information on the chemical composition of dog faeces indicates that they are particularly rich in nitrogen (see work cited in Taylor et al., 2006).
- 2.1.10 Nutrient levels in soil are important factors determining plant species composition and on sand dune sites the typical effect will be equivalent to applying a high level of fertilizer, resulting in a reduction in species richness and the presence of species typically associated with more improved habitats. A lush green strip is often evident alongside paths, as nutrient enrichment can also lead to more vigorous growth and flowering (Taylor et al., 2006).
- 2.1.11 Wildfire can be a further impact of visitor access. For example, increased fire incidence is a feature of heaths with high levels of visitor access ((J. C. Underhill-Day 2005). The effects of fires on wildlife depend on their extent and frequency. The effect of individual fires depends on date, fire temperature and duration. No studies of burning on sand dune communities could be found, although English Nature (2003) note that fires may damage seed banks and seedling recruitment. A study on the effects of wildfire on calcareous grassland found that annual and biennial grass species increased after burning and that invading woody species were severely checked but seldom killed outright (Lloyd 1968). On acid grassland, large scale burning, under low intensity grazing can lead to purple moor-grass dominance and substantial areas of uniform, even-aged and species-poor habitat (Tucker 2003).
- 2.1.12 Human access to dunes has been associated with the spread of alien plants (Houston 2008). This may be where housing development is adjacent to the dunes, although plants are also sometimes planted out as memorials etc.
- 2.1.13 In summary, there are clear impacts of trampling in dune systems. Trampling can lead to increases in bare ground, surface movement of sediment, loss of vegetation species diversity and cover. For most dune habitats the impact will be in proportion to the amounts of access. The exception is embryo dunes, where small amounts of trampling have a disproportionate affect. There is however a need to address over-stabilisation of sand dune surfaces and subsequent reduction in diversity of habitats. This is a complex area as it is potentially affected by a range of factors interacting, including artificial stabilisation, nutrient deposition, lack of grazing and soil development. There is potential for trampling to be used as a means of re-invigorating surface movement of sand to restore some of the necessary dynamism of this habitat for some of the more diverse vegetation types.

2.2 Petalwort

- 2.2.1 Petalwort is a small, pale green thallose liverwort with erect lamellae (tiny flaps of tissue one cell thick) on its upper surface giving the appearance of small petals. Underground, there is a storage organ, similar to a tuber or rhizome. The thallus tends to shrivel in summer as it requires continual moisture. It occurs throughout western Europe and is infrequent and declining throughout its range. It is rather closely confined to dune slacks of a certain kind, which are under threat in many areas, and the species is classed as Vulnerable on the European Red list (although there is suggestion that it should now be classified as Endangered (see Plantlife n.d.). The UK and Ireland may now be its stronghold. It is widely but sparsely distributed in the UK and is classified as National Scarce, and is protected under the Wildlife and Countryside Act 1981. Many, but not all, of the sites support large populations. All the sites are large dune systems with extensive dune slack habitat. It currently has about 25 sites in the UK.
- 2.2.2 Petalwort mainly grows in open, damp, calcareous dune slacks, often on low hummocks rather than on the very wet ground, on compacted sandy/muddy bryophyte-rich turf. It usually grows on sites which are often wet or flooded in winter but dry out over summer (Hill, Preston, and Smith 1991). It does not grow in water-filled slacks or in slacks where willow *Salix* spp. scrub predominates. It prefers sites which remain stable for several years, in accordance with its slow growing habit. In Britain it tolerates only light shading and there are several records of it being lost when bushes spread to shade dune-slacks (Plantlife n.d.). Most petalwort sites have some bare substrate exposed (typically 10-15%), but it can also grow throughout large areas with very thin, low cover of grasses and herbs.
- 2.2.3 Because of the fragility of its habitat and its specialised ecology, petalwort is potentially threatened by a large number of factors, including holiday developments, recreational activities, under-grazing, over-grazing, erosion and desiccation due to water abstraction (Anon. 2007).
- 2.2.4 Factors maintaining the low vegetation are usually poverty of nutrients and intense grazing by rabbits, but light trampling pressure also plays a part in some places. At Upton Towans in Cornwall, petalwort is found on the edges of tracks (Plantlife n.d) and it can be found on the sides of paths⁴. On the Sefton Coast petalwort is often found in association with footpaths, where light trampling keeps the ground vegetation sparse; infrequently-used paths or less-trampled edges of pathways seem to be favoured. Although the preferred habitat is short damp turf with plenty of bare patches, populations have been found growing amongst dense marram with few other associated species.
- 2.2.5 Disturbance through trampling is not necessarily required, although the habitat must be open. At Carmarthen Bay Dunes/ Twyni Bae Caerfyrddin in Carmarthenshire the species is known from large and undisturbed dune slacks which are very open in

⁴ <http://www.jncc.gov.uk/ProtectedSites/SACselection/species.asp?FeatureIntCode=S1395>

character, and at Achnahaird in the Highlands the species is found along the banks of small burns and drainage lines, and on areas of stable, bare sand.

- 2.2.6 Threats to petalwort include: too extensive or regular disturbance which could lead to loss of stability of the substrate or increased mobility of sand causing over-rapid accretion of sand, smothering petalwort; the development of taller vegetation in slacks due to reductions in grazing (including rabbit grazing) and trampling (including human) or eutrophication; changes in drainage or climate leading to dessication.

3. Current site condition and management

3.1 Site condition

- 3.1.1 The SSSI condition assessment provides useful information and a broad indication of the current status of the site and issues affecting it.
- 3.1.2 Condition status and comments on the assessment for relevant SSSI units are given in Table 2. This means that about 26 ha (30% of the area) of the SSSI units within the SAC have been assessed as unfavourable declining, largely due to inappropriate coastal management leading to erosion. 60 ha (70%) has been assessed as unfavourable recovering due to the instigation of grazing and mechanical methods to address the extent and frequency of scrub and non-native species.

- 3.1.3 Table 2 Seven SSSI units fall within the Dawlish Warren SAC. Of these, two are listed as unfavourable declining and five as unfavourable recovering⁵. This means that about 26 ha (30% of the area) of the SSSI units within the SAC have been assessed as unfavourable declining, largely due to inappropriate coastal management leading to erosion. 60 ha (70%) has been assessed as unfavourable recovering due to the instigation of grazing and mechanical methods to address the extent and frequency of scrub and non-native species.

⁵<http://www.sssi.naturalengland.org.uk/Special/sssi/reportAction.cfm?report=sdrt13&category=S&reference=1003137>

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Table 2: Status of SSSI units within Dawlish Warren SAC, and the condition of SAC features

<i>Unit</i>	<i>Condition assessment comment</i>	<i>Condition (date of last assessment)</i>
3	Coastal defences mean that the dune system does not show the full zonation of sand dune communities - no strandline or embryonic communities were identified at the last assessment (2005). The non-native species tree lupin was occasional (should be no more than rare ⁶) and scrub cover was at least 20% (should be no more than 5%).	Unfavourable declining due to inappropriate coastal management (2005)
4	Strandline and extensive new dunes forming, shifting dune stabilising; non-native species actively managed.	Unfavourable recovering (2010)
5	Coastal defences are preventing the natural sediment supply dynamics on Dawlish Warren. Remaining sand dune communities eroded since last survey, beach height considerably lowered.	Unfavourable declining due to inappropriate coastal management (2004)
8	Scrub frequency and cover and presence of non-natives being addressed through grazing and mechanical removal.	Unfavourable recovering (2009)
9	Management to address scrub cover and frequency now implemented	Unfavourable recovering (2009)
10	Management to address invasive non-natives and scrub frequency & cover now being implemented across unit through mechanical removal and grazing	Unfavourable recovering (2009)
11	Unit does not included SAC qualifying features	Unfavourable recovering (2009)

⁶ http://www.jncc.gov.uk/pdf/CSM_coastal_sand_dune.pdf

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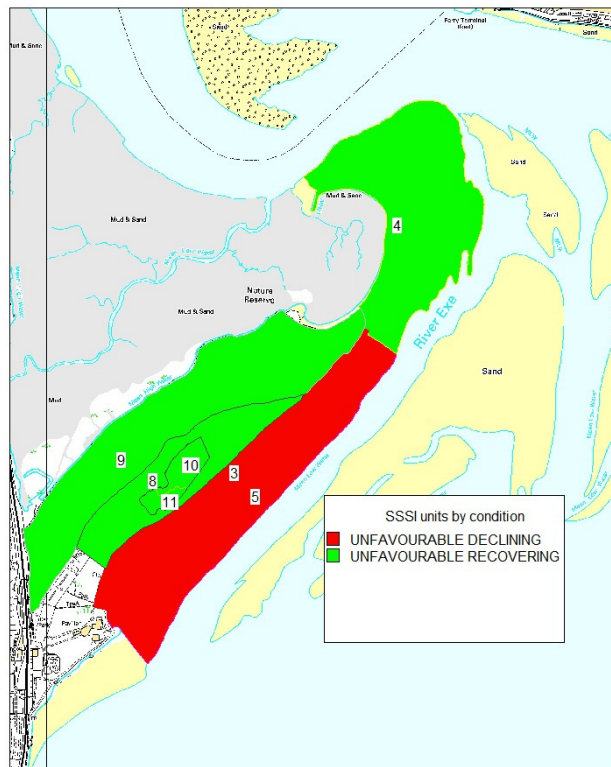


Figure 2: Condition status of SSSI units at Dawlish Warren.

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3.2 Management

- 3.2.1 The *Dawlish Warren NNR Management Plan 2010-2020* (TDC, 2010) sets out a 50 year vision for the NNR, followed by detailed management objectives to reach the vision (see also the *Conservation Objectives and definition of favourable condition for designated features of interest* for Dawlish Warren⁷). Management practices are summarised here according to SAC interest features. Specific measures for visitor management are also included.
- 3.2.2 **Embryo dunes:** Embryo dunes currently occur only on Warren Point, where they have developed in the last five years or so, although a small amount of erosion has occurred recently. Elsewhere, substantial erosion has meant the loss of this habit. Much of the area is now transitional to mobile dunes with extensive areas dominated by marram, although species such as sea sandwort *Honkenya peploides* and sea rocket *Cakile maritima* are present. A current enclosure between groynes 13 and 18 (established to protect breeding ringed plover from disturbance) currently provides protection from human footfall. Limited removal of drift wood is carried out to help deter barbeques in specific areas where they are likely. Future

⁷ 2008 draft version prepared by James Diamond, NE Exeter

management will include the erection of more exclosures to aid in the establishment of this community.

- 3.2.3 **Mobile dunes:** Most of the mobile dune habitat at Dawlish Warren is at the stable end of the spectrum. Mechanical and chemical control of invasive species including bramble *Rubus fruticosus*, ragwort *Senecio jacobea*, and non-natives such as tree lupin *Lupinus arboreus* and buddleia *Buddleja davidii* is carried out to prevent further stabilisation and nutrient enrichment on the dunes. Future management may include the erection of temporary exclosures in areas of high visitor pressure to aid recovery of marram dominated vegetation where it has eroded.
- 3.2.4 **Fixed dune grassland:** Following the significant decline in rabbit populations due to Rabbit Viral Haemorrhagic Disease in about 1994, mowing has been used to help maintain the fixed dune grassland. This is notable for a number of small winter-annual species such as early meadow-grass *Poa infirma*, bulbous meadow-grass *Poa bulbosa*, dune fescue *Vulpia fasciculata* and bearded fescue *V. ciliata*, and perennials such as suffocated clover *Trifolium suffocatum*, clustered clover *T. glomeratum*, and sand crocus *Romulea columnae*, which require a very short sward before the growing season starts. Winter pony grazing has subsequently been introduced within enclosures. A diversity of vegetation structure is aimed at to provide conditions favourable to a diverse invertebrate fauna. Scrub control is carried out together with after-treatment to reduce the establishment of unwanted species. Rotational scrub management is carried out on areas of scrub to be retained. Arisings are removed to avoid nutrient enrichment. Future management will include summer cattle grazing (scheduled for 2011) to help control longer vegetation and specific non-natives.
- 3.2.5 **Humid dune slacks:** Areas described as humid slack at Dawlish Warren support vegetation transitional to wet meadow. Management of dune slacks is aimed at addressing the development of unwanted species while creating and maintaining structure and native species diversity through autumn/winter mowing and grazing and hand-pulling. Dune slack creation has been carried out to increase the potential for early stage slacks (absent due to the particular history of slack development on an area that was previously a tidal inlet and the over-stability of the dune system).
- 3.2.6 **Petalwort:** Current management is aimed at promoting a suitable level of diffuse trampling considered important for this species (e.g. through positioning of access points and pathways).
- 3.2.7 **Visitor management:** Paling fence restricts access to the dunes behind groynes 1-4 (this area is often called the tourist or amenity beach). Groyne 9 marks the start of a zone from which dogs are banned year round from the dunes, beach and mudflats in the Warren Point area. Dogs are also banned from the tourist beach (groynes 1-3) between 1st April and 30th September. Since 2002, byelaws also require dogs to be kept on a lead across the majority of the vegetated areas of the reserve. Dog bins are present on the buffer zone, plus one on the NNR. The dog policies are enforced by the site's rangers who provide seven-day a week site presence. Future management may include the provision of more exclosures (see 3.2.2 and 3.2.3)
- 3.2.8 **Golf course:** Here management is largely aimed at providing a suitable environment for a links golf course. Greens and tees are fertilised, irrigated and closely mown, and

some re-seeding is carried out. Paths and fairways are also closely mown and appear improved in places. Scrub is controlled as part of a management agreement with Natural England and the Devon Wildlife Trust. Areas of the site prone to flooding are drained and water pumped into the estuary.

4. Current visitor levels and impacts

4.1 Current visitor levels

- 4.1.1 Dawlish Warren SAC is situated immediately adjacent to the Dawlish Warren resort, separated by a car park and an area of dune grassland known as the “buffer zone”. A 2006 report by South West Tourism (cited in TDC 2010) estimated that there are 480,000 visitors per annum. A previous study by University of Exeter (Tourism Research Group, University of Exeter 1996) gives an estimate of 870,000 visitors, but the lower number is considered likely to be more accurate by the site managers (Phil Chambers pers. comm.). The University of Exeter survey also showed that summer visitors tended to be more static, using a smaller proportion of the site than those visiting outside of the high season.
- 4.1.2 Concentrated access points result in intense pressure in some locations within the NNR. The relatively small size of the site limits the potential to dissipate damaging visitor pressure. However, the University of Exeter study suggests that only 15% of visitors entered Dawlish Warren National Nature Reserve, and only 4% reached Warren Point, the farthest point from the car park.
- 4.1.3 Recent work carried out on visitors to the Exe Estuary (D Liley and Cruickshanks 2010), which included Dawlish Warren, suggested that out of season visitors were most likely to be local dog walkers (55%, n=51) although a large minority (31%, n=29) were walkers without dogs. It is thought that the number of regular dog walkers may have dropped slightly since the implementation of a dogs-on-leads policy within the grazing enclosures on the fixed dune grassland (Phil Chambers, pers comm). Dog walkers were most likely to visit on a daily basis, while walkers were more likely to visit weekly. Dog walkers covered an average of 1.9km, while walkers covered 2.3km.
- 4.1.4 Figure 3 gives an impression of visitor pressure at Dawlish Warren NNR. This is based on winter visitor surveys carried out as part of work to assess extent and impacts of recreational disturbance on the Exe Estuary (Liley and Cruickshanks, 2010). This suggests that most out of season visitors (who are most likely to use a greater areas of the site) walk along the beach, rarely further than Groyne 9, and back along the dunes and promenade, or vice versa while a few walk back along the paths through the dune grassland and dune slacks (see Figure 4: Routes taken by a sample of visitors to Dawlish Warren, winter 2010 (one route per group of visitors, mapped by the visitors themselves on the completion of their walk). See Liley and Cruickshanks 2010)). It is possible that dog walkers who would previously have walked back along the grassland are now using the dunes to avoid the dogs-on-leads area.
- 4.1.5 In the summer season the pattern of site usage is somewhat different. There is likely

to be a far greater concentration of visitors on the amenity beach near the resort who remain fairly static. In addition, however, boats land at Warren Point (including water taxis) and their occupants often then walk around the point. This means there is also greater visitor pressure here than is experienced in the winter despite its distance from the car parks.

- 4.1.6 The golf course is only open to members and there are no public rights of way across it. Golf course membership is currently in the region of 540 (John Welsford pers. comm.) However the figures do not give particularly good representation of site use, as some members visit only rarely, whereas others may be regular, and yet others only use the clubhouse. No further information on actual use was available. The agreement with the landowners (Devon Wildlife Trust) and Natural England mean there is a cap at 600 members.

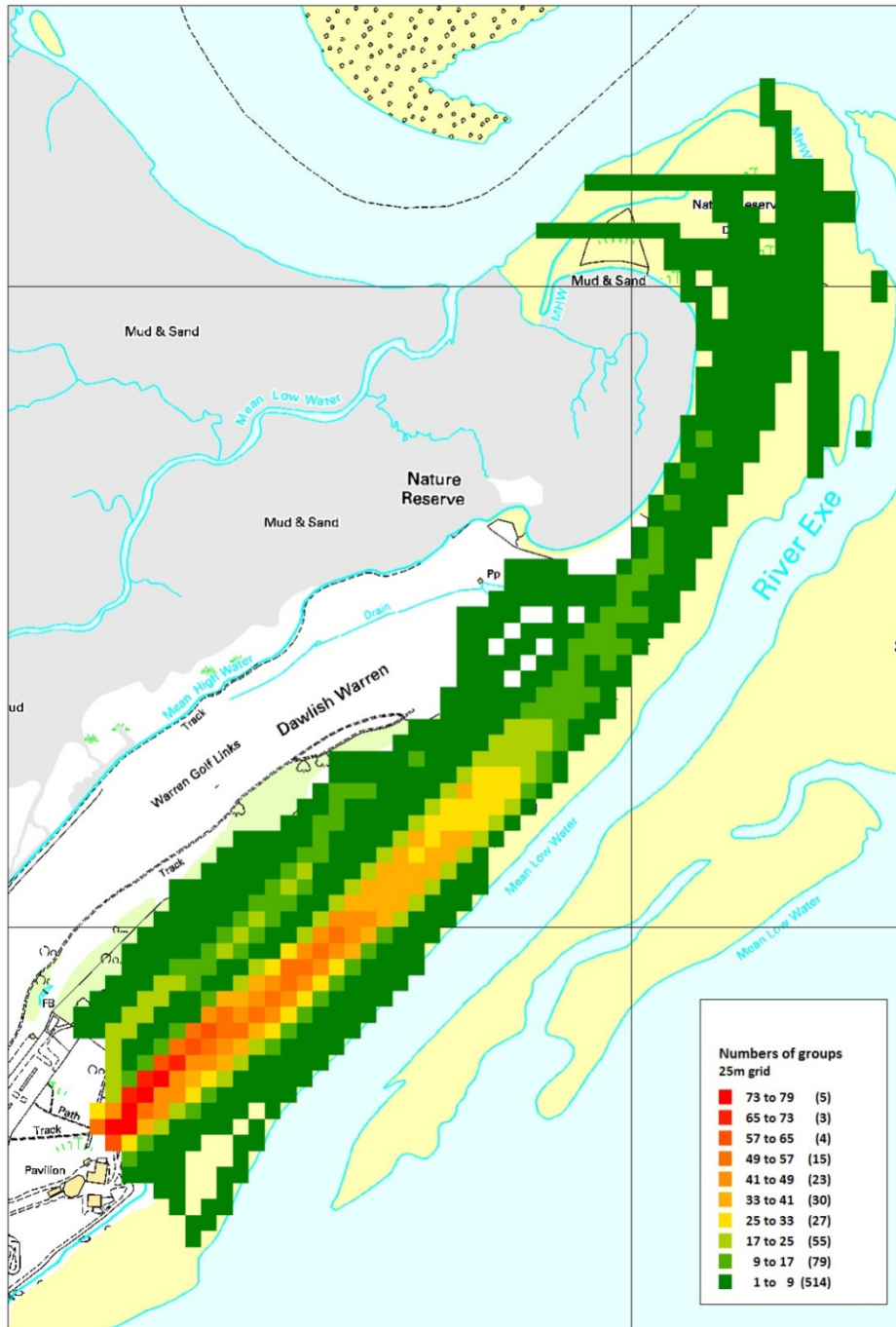


Figure 3: Visitor density within Dawlish Warren SSSI. A 25m grid was drawn over the site, and grid cells coloured according to the number of visitor routes intersecting each cell (from Liley and Cruickshanks 2010). © Crown Copyright and database (2010). All rights reserved. Ordnance Survey licence number 100026380.

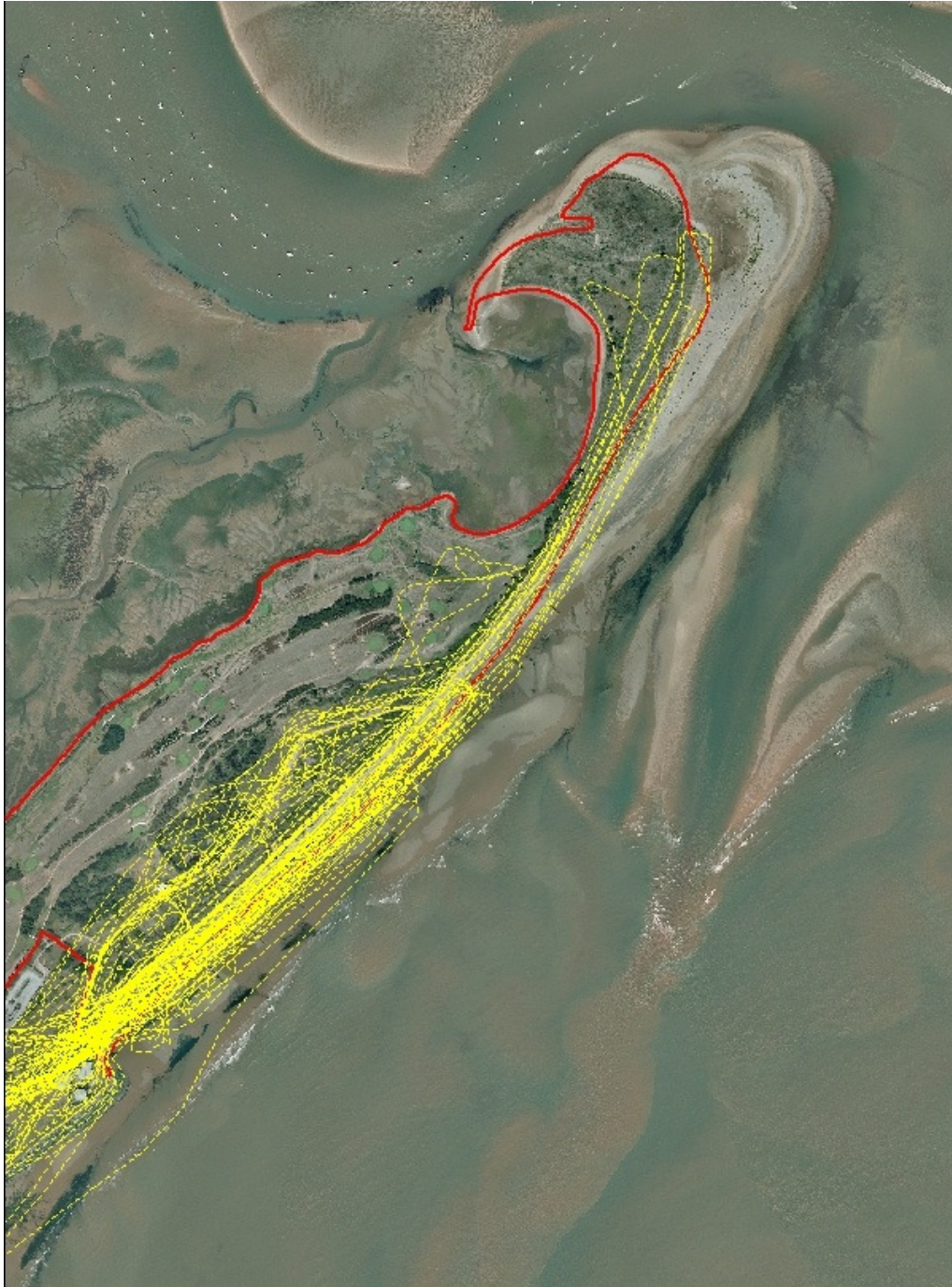


Figure 4: Routes taken by a sample of visitors to Dawlish Warren, winter 2010 (one route per group of visitors, mapped by the visitors themselves on the completion of their walk). See Liley and Cruickshanks 2010)

4.2 Impacts

- 4.2.1 The condition assessment for Dawlish Warren does not identify any areas as being in unfavourable condition due to impacts that are likely to be caused directly by recreational pressure. However, the assessment may not be sensitive enough to pick up such affects (James Diamond, pers. comm.) which may occur gradually over time, and effect only localised areas of the site. Therefore the condition objectives⁸ have been used to further inform our judgement of whether recreational pressure is currently causing damaging impacts to any of the SAC features.
- 4.2.2 There can be no doubt that the high number of visitors to Dawlish Warren definitely has an impact on the habitats present. For example, under “vulnerabilities” the SAC Natura 2000 data form⁹ states that *“erosion problems affect the shifting dunes along the shoreline and consequently fencing is required to direct visitors”* and *“much of the fixed dune grassland is a golf course and is subjected to wear”*. The management plan (TDC 2010) lists as a weakness that *“high visitor numbers results in erosion”* and suggests that future management will include measures to exclude visitors from areas to allow vegetation damaged by trampling to recover. Figure 6 and Figure 7 show aerial images of two parts of the site – the effects of trampling can clearly be seen.
- 4.2.3 However, a light level of disturbance caused by trampling is also recognised to play a role in maintaining species diversity, sand mobility and suitable conditions for specific species such as petalwort (see Section 2). The question therefore is to what extent are the current recreation impacts beneficial, and to what extent may they be considered damaging? This is discussed below for each feature of the SAC considered for this report, and summarised in Figure 5.
- 4.2.4 **Embryo dunes:** This is the dune habitat type most vulnerable to trampling. However, at Dawlish Warren, coastal erosion now the major limiting factor. At the time of writing, the only representation of this community was at Warren Point, where erosion processes have to date been less and trampling is less, particularly within the ringed plover enclosure, where visitor pressure is likely to be least (see figure 3). Along the seaward beach, substantial erosion caused by storm events, combined with the sea defences preventing the inward migration of sand dune communities, means embryonic dunes are absent. Given the increasing recreational pressure westwards, it seems highly likely that the chance of any embryo dunes recolonising is seriously jeopardised by the likelihood of erosion from trampling.
- 4.2.5 It is difficult to establish the relationship between trampling and vulnerability to coastal erosion at Dawlish Warren. The current, high levels of beach erosion by storms is a relatively recent development, occurring since 2004. Before this, there was however very limited formation of embryo dunes. In 1992, the Flora of Dawlish

⁸ Conservation objectives and definitions of favourable condition for designated feature of interest. Dawlish Warren. (Draft) 2008. Natural England, Exeter

⁹ <http://www.jncc.gov.uk/ProtectedSites/SACselection/n2kforms/UK0030130.pdf>

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Warren (de Lemos 1992a) noted “[Embryo dune] plants seem to be excluded from the Western end of the beach by heavy trampling.” The first ring plover enclosure was erected in 1994, and appears to have facilitated the formation of a large area of embryo dunes within two to three years (Mary Rush, pers. comm). This suggests that trampling was inhibiting the development of embryo dunes before the more recent storm events. It is not clear to what extent any seaward migration of the dunes which may have been inhibited by trampling could have made the dune system more resilient to storm damage.

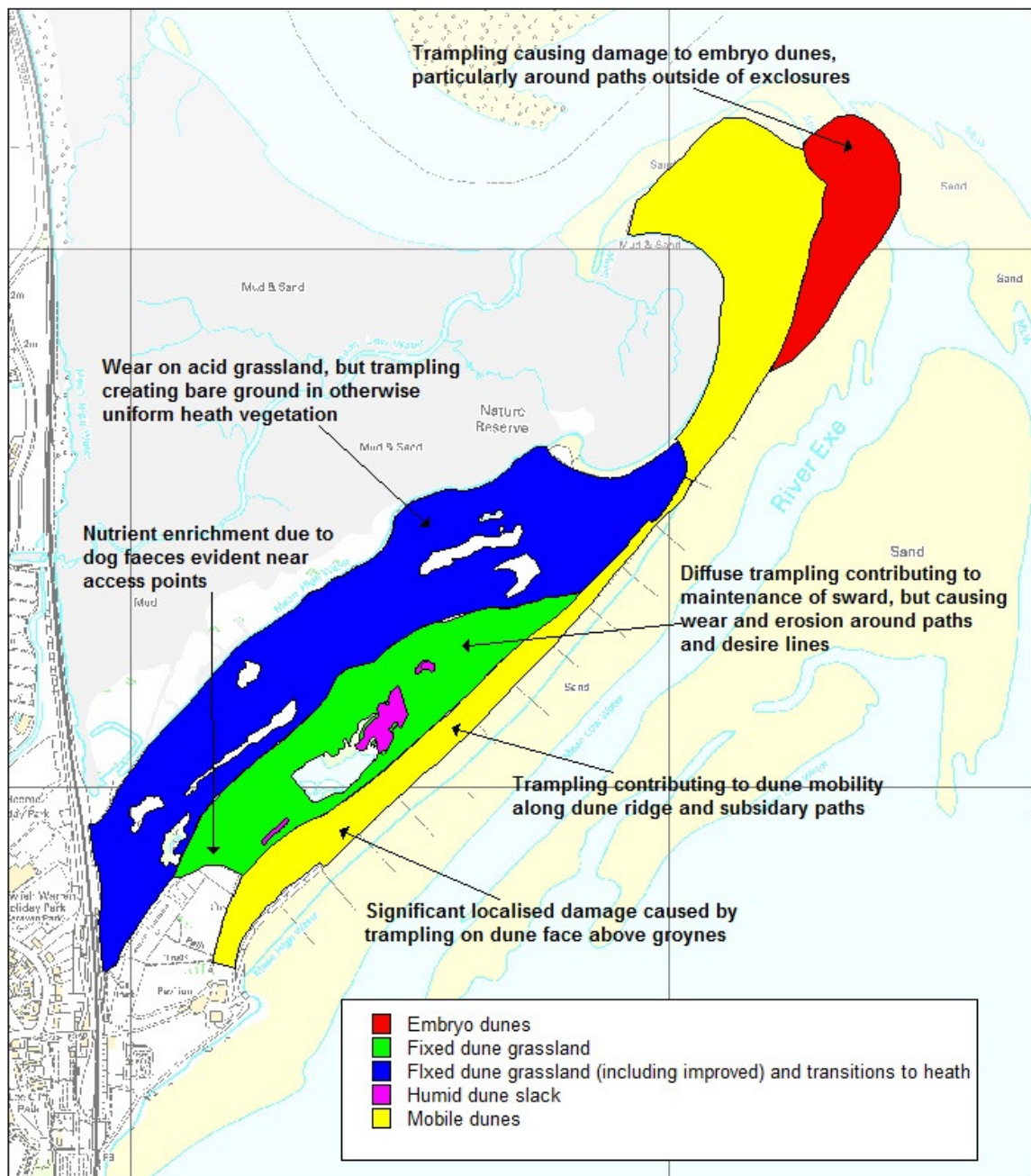


Figure 5: Recreational impacts on SAC habitats at Dawlish Warren.

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Mobile dunes: Trampling pressure can have a positive effect on mobile dunes by enhancing sand mobility. This is an issue at Dawlish, where ongoing scrub management is necessary to prevent over-stabilisation of the dunes. Recreational pressure may therefore have a role to play in preventing further scrub encroachment on marram dominated areas. However, walkers tend to use existing paths rather than strike off through the marram grass (or scrub). In fact scrub can be used as a natural barrier, helping to influence visitor routes (N. Stewart 2003). Many of the paths are therefore heavily used and characterised by loose sand. This is unsuitable for burrowing invertebrates, which need a degree of stability, although some of the paths are sufficiently eroded to have “walls”, some of which appear suitable. Between groyne 4 (the sea defences are exposed west of this point) and groyne 9 (where recreational impacts appear to drop off) paths leading down through the dunes to the beach were noted approximately at least every 10 metres, reducing to about every 20m by groyne 8. Impacts are particularly evident where the paling fencing stops (between groynes 4 and 5) with numerous paths and significant exposed areas at path nodes (see Figure 6). The contrast with areas where access is more limited can clearly be seen by looking at the area just west of here, where the dunes are protected by a paling fence (see Figure 7).

- 4.2.6 Patterns of visitor use on the dunes have changed in recent years due to coastal erosion (Phil Chambers, pers. comm.). Storm events have caused the loss of significant quantities of sand from the beach (e.g. a depth of five metres), and the beach is also now more pebbly. Visitor use of the dunes has therefore increased, partly because they are sandier than the beach, partly because at high tide the beach is narrower. Ongoing coastal erosion is likely to exacerbate this problem regardless of any potential increase in numbers of visitors to the site.
- 4.2.7 We would suggest that visitor pressure is currently having a negative effect in localised areas of this habitat, most notably between groynes 4 and 5, at groynes 8 and 9 (where many walkers and dog walkers enter or leave the dunes for the beach) and to the seaward side of the paling fence (up to groyne 4), which successfully concentrates visitor pressure on the seaward side of the fence. This negative impact is likely to increase even if visitor numbers remain static.



Figure 6: Extensive path network and erosion at nodes seen in the mobile dunes between groynes 4-5



Figure 7: Erosion to the seaward side of the paling fence protecting the dunes behind, between groyne 3-4.

- 4.2.8 **Fixed dune grassland:** Dawlish Warren was, as the name indicates, a rabbit warren from at least as early as 1280 (TDC 2010). Although it is not known when active warrening ceased, the site has received high grazing pressure in the past and this high level of disturbance is likely to have contributed to the development of the current characteristic flora with a requirement for a short, open sward. Given the significant decrease in rabbit numbers, the role of trampling may be key in maintaining suitable conditions for many of the plant species present such as bulbous meadow-grass *Poa bulbosa*. It also produces bare sand areas/paths which, although too mobile to benefit early successional plants, can include edges suitable for invertebrates such as sand wasps. Figure 8 shows locations of the rare species recorded from the site in 2002. These appear to be clumped, rather than spread across the habitat, suggesting that suitable conditions are patchy. It is possible that this could be indicative of the fine balance between too little and too much trampling, although no doubt other environmental factors play a role also.
- 4.2.9 Anecdotal evidence (Phil Chambers pers. comm.) suggests that there has been an increase in sward height and a reduction in the area of bare ground since a perceived decrease in dog walking on this habitat. The fixed dunes support a diversity of species (see Stewart 2003). There is currently no evidence available to compare species diversity in 2010 with that from the last survey (Stewart, 2003).
- 4.2.10 The main paths are generally bare ground, and the substrate is often loose. Less used paths and “desire lines” support very sparse vegetation, often very species poor (although some of winter annuals may be found in this vegetation).
- 4.2.11 Sand crocus *Romulea columnae* monitoring is carried out annually (Dawlish Warren is one of only two sites for this species in mainland Britain). Figures available from site staff suggest that the size of the population in the area known as the crocus compound adjacent to the visitor centre (where they were introduced) has dropped. The reason for the decline is not clear, although particularly high numbers in the 1990s are thought to be due to differences between surveyors (Mary Rush pers. comm.) (see Figure 9). The population in the Greenland Lake slack is considered to be stable. Monitoring is no longer carried out on the golf course, and the status of the population there is not known, although anecdotal evidence suggests that it is declining (Phil Chambers, pers. comm.)

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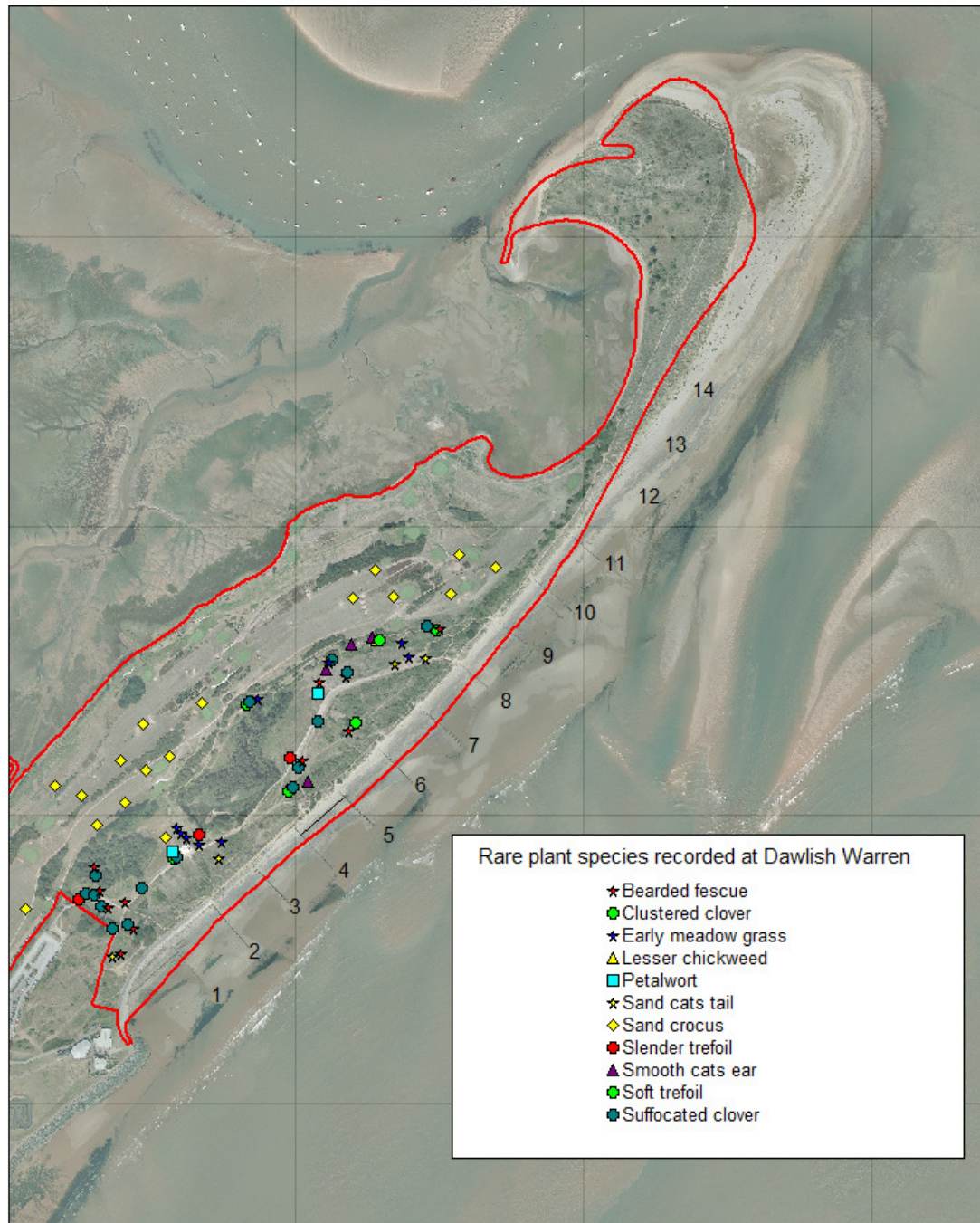


Figure 8: Location of rare species recorded in 2002 (Stewart 2003). Sand crocus records date from 1992 (de Lemos 1992)

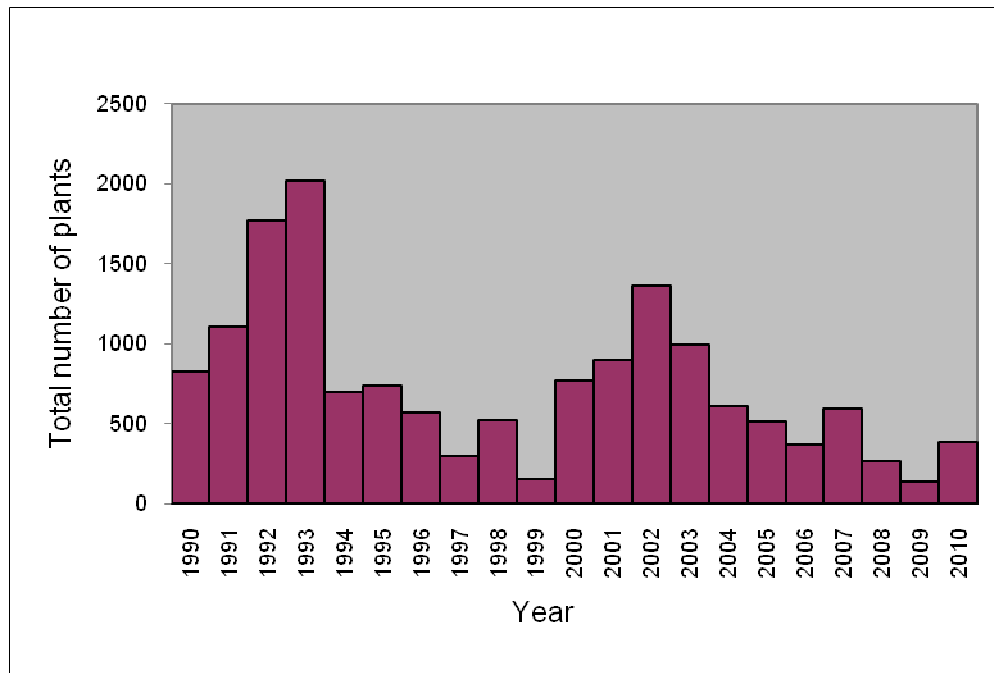


Figure 9: Changes in the population of sand crocus on Dawlish Warren NNR 1990-2010 (data supplied by site managers)

- 4.2.12 Trampling is currently contributing to the maintenance of a low, open sward that was previously created by rabbit grazing, which has declined markedly since the outbreak of viral haemorrhagic disease. Recent studies suggest that rabbits may be developing a genetic resistance to the disease. In the long term, there may be potential for pockets of resistance to develop and predictions are that an equilibrium will develop between the rabbit and the disease as per the myxomatosis experience (Rogers, Arthur, and Sorigeur 1994). Therefore it is not impossible that rabbit numbers at Dawlish Warren may increase again in the future.
- 4.2.13 It is clear from the literature that once trampling pressure is higher than a certain level, it will cause a decline in species diversity in this habitat. However, before species are actually lost from the site, it is hard to pinpoint the exact point where the balance tips and trampling becomes damaging and starts to reduce diversity. In addition, the impact will vary across the habitat - trampling is of course not equal across the habitat, but is focussed along paths and desire lines, and there is inherent variability within the habitat (such as slope, humidity etc.) which will make some areas more vulnerable.
- 4.2.14 Many of the species for which Dawlish Warren is notable are annual species, adapted to disturbed environments. As such they are likely to have a substantial seed bank (Grime, Hodgson, and Hunt 1988), allowing the species to exploit disturbance events and individuals to become established where they would otherwise be outcompeted by more robust species. However, at some point disturbance levels will become too great, preventing individuals from successfully setting seed, and replenishing the seedbank. Work looking at changes in the

seedbanks of these species over time would be necessary to judge when this threshold is reached.

4.2.15 We suggest that the level of trampling on the fixed dune grassland within the NNR may currently be having a positive impact in many places by contributing to a short, open sward in the absence of sufficient rabbit grazing. However, this level of trampling is also causing localised damage, most obviously around access points and path nodes, but also on some paths where a dynamic relationship between erosion and recolonisation appears to have ceased (Steve Ayres, pers. comm.). In these areas trampling intensity has already passed the threshold beyond which damage occurs. It is worth noting that an increase in disturbance could occur through a significant increase in rabbit grazing as well as through increased human trampling. Evidence of changes in species diversity over time together with data on visitor numbers and behaviour would allow a more exact assessment of the point at which trampling pressure becomes detrimental at different locations within this habitat.

4.2.16 Golf course: Extensive wear is visible on the fixed dune acid grassland characterising much of the golf course. This tends to be greatest along paths, particularly at pinch points (e.g. Figure 10: Damage to the fixed dune acid grassland caused by trampling at a pinchpoint on Dawlish Warren Golf Course and Figure 11), with a more diffuse impact visible on most of the fairways. The improved nature of much of the sward makes it difficult to judge the impact of trampling. The intensive mowing regime obviously helps maintain a low sward, and trampling (and divots) may play a role in opening up bare areas in an otherwise very uniform sward, particularly in the roughs. The roughs tend to support a transition acid grassland –heathland community that might be expected to be more widespread were the management of the site different. The short acid grassland is notable for the presence of sand crocus. However, sand crocus is not thought to be doing well on the site. The plants on the golf course have been noted to have a different morphology than those on the NNR, lying closer to the ground (de Lemos 1992b) which suggests that trampling is having a great effect here. Trampling is particularly noticeable in the area of the main sand crocus population opposite the club house. Management of this part of the SAC is such that the role of trampling is hard to isolate, but it is clearly causing localised erosion and possible loss of species diversity.



Figure 10: Damage to the fixed dune acid grassland caused by trampling at a pinchpoint on Dawlish Warren Golf Course.



Figure 11: Damage caused by diffuse trampling at Dawlish Warren Golf Course.

4.2.17 Humid dune slacks: Similarly to the fixed grassland, trampling is playing a role in maintaining a low open sward in the areas of dune slack on the site. The points raised in sections 4.2.8, 4.2.10, 4.2.12 and 4.2.13 also apply to this habitat.

4.2.18 Petalwort: Much of the suitable habitat for petalwort is felt to be associated with

diffuse trampling pressure together with rabbit grazing. An appropriate level of trampling is likely to contribute to the short, sparse sward required, while over-trampling may directly destroy individuals. The status of petalwort between 1997 (when it was first recorded at the site) and 2002 is discussed in Holyoak (2003). Natural fluctuations in the population size of petalwort due to rainfall differences, plus the difficulty in accurately identifying the species and carrying out population estimates mean that a long-term view in the status of populations is needed to assess their well-being. Petalwort has not formally been surveyed at Dawlish Warren since 2003, making it hard to judge the impact of current visitor levels.

- 4.2.19 Anecdotal evidence suggests that the population at Greenland Lake slack is currently healthy and that current trampling levels are appropriate for the maintenance of this population. Domestic livestock grazing cannot replicate the very short sward and areas of bare sand created by intense rabbit grazing, although it can go some way to meeting this, and so human trampling is likely to play a role in maintaining suitable habitat unless rabbit pressure increases significantly.
- 4.2.20 In contrast, the petalwort population near the visitor centre is thought to have reduced, and more data are needed to allow an assessment of whether current visitor levels may be impacting this population.
- 4.2.21 There are a number of factors related to visitor access to the site which effect all habitat types. These are now discussed.
- 4.2.22 **Wildfire:** Although barbeques are not permitted on the site, they are nonetheless a daily occurrence in the summer. Continual vigilance on the part of the site staff means that wildfires are fortunately rare. However, when they do occur, they destroy the standing vegetation and may damage invertebrate and sand lizard populations. While the vegetation re-colonises, it tends to be characterised by a greater number of ruderal species (Phil Chambers, pers. comm.). Figure 12 shows the aftermath of recent fires at Dawlish Warren.



Figure 12: Site of a fire within the crocus compound c2005, and a wildfire destroying 4ha of marram dominated vegetation in 2006 (photos courtesy of Phil Chambers)

- 4.2.23 **Nutrient enrichment:** There are dog bins on the buffer zone, and one dog bin within the SAC. Implementation of a dogs-on-lead policy has also encouraged dog owners to “pick-up” after their dogs. However, the habitats present are inherently nutrient poor, and eutrophication through dog faeces remains an issue, particularly near access points. A localised decrease in nutrient sensitive species and an increase in coarser species characteristic of more nutrient rich vegetation can be seen.
- 4.2.24 **Vandalism:** At Dawlish Warren malicious damage to infrastructure sometimes occurs as a result of visitor access. This can impact on management, with the consequence that conservation objectives may be hard to achieve. For example, damage to fencing plus worries about the potentially difficult interface between livestock and visitors mean that the ideal livestock grazing regime has not yet been achieved. Grazing has to date been limited to pony grazing over winter, when visitor numbers are much lower. However, there are now plans to introduce some summer cattle grazing (TDC 2010).
- 4.2.25 **Non-native species:** Dawlish Warren has a significant seed bank of non-native invasive species such as buddleia, tree lupin, etc. Disturbance to the substrate brought about through trampling may expose the seedbank and lead to an increased likelihood of germination of these species. However, this could also be caused by management techniques such as livestock grazing or scrub clearance which would need to be increased in the absence of trampling.

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Table 3 Summary of current impacts of recreational pressure on SAC features

<i>Factor</i>	<i>Current effect</i>
Erosion through footfall – embryo dunes	<ul style="list-style-type: none"> • Negative impact on existing habitat. • Impact would be significant if changes to coastal management allow the recovery of this habitat.
Erosion through footfall – mobile dunes	<ul style="list-style-type: none"> • Localised negative impact on dune face, likely to expand and intensify if coastal erosion increases. • Erosion on dune ridge paths may contribute to sand mobility within the system which is over-stabilised.
Erosion through footfall – fixed dune grassland	<ul style="list-style-type: none"> • Positive impact in helping to maintain short, open sward suitable for characteristic species such as suite of winter annuals and sand crocus, plus providing stable sandy patches suitable for invertebrates. • Localised negative impact where trampling destroys vegetation and creates loose sand. • Impact dependent on other factors such as site management, weather, rabbit pressure. • Tipping point at which visitor levels will be damaging hard to pin-point.
Erosion through footfall – humid dune slacks.	<ul style="list-style-type: none"> • Positive impact in helping to maintain short, open sward suitable for characteristic species including petalwort. • Localised negative impact where trampling destroys vegetation. • Impact dependent on other factors such as site management, weather, rabbit pressure. • Tipping point at which visitor levels will be damaging is hard to pin-point.
Wildfire	<ul style="list-style-type: none"> • High fire risk due to extensive use of barbeques in summer, although strong staff presence on site reduces this. • Impacts of fire negative when it occurs due to large seed bank of ruderal and non-native species.
Nutrient enrichment	<ul style="list-style-type: none"> • Localised negative impact near access points with decrease of nutrient sensitive species and increase in unwanted competitive species.
Indirect effect of visitors presence on management techniques	<ul style="list-style-type: none"> • Grazing regime limited due to potential for vandalism and problems with livestock and dogs. • Managing visitor access detracts from other site management tasks and adds to management costs by requiring 7 day staff cover.

5. Likely impacts of increased access

- 5.1 On the NNR, any increase in access as a consequence of local development is likely to be mainly in year-round dog walkers and walkers, rather than seasonal beach users. This means that the main increase in pressure will be along the typical walk route along the beach and back through the dunes, or in some cases back through the fixed dune grassland and humid slacks (or vice versa). There may also be a proportionally smaller increase in the number of static visitors to the tourist beach. An increase in nutrient enrichment near access areas and the incidence of wildfire (caused by locals and tourists having barbeques) could also be expected.
- 5.2 We consider that any increase in walkers and dog walkers using the beach will exacerbate the erosion impact on the embryo dunes. Small increases in visitor pressure are likely to have a disproportionate effect. Any increase in this habitat in the future through changes to coastal management would be impeded by an increase in recreational pressure.
- 5.3 The effect of trampling pressure on the mobile dunes is likely to be in proportion to the increase in visitor numbers, and would probably lead to an increase in the number of interlinked paths, path widening and extension, and in the enlargement of path nodes. This would lead to an increase the area of bare ground, compaction, surface movement of sediment, and loss of vegetation species diversity and cover. It is not possible to quantify these changes, or to predict whether an increase in trampling could tip vegetation changes beyond a threshold where damage is irreversible. However, an increase in visitor pressure is likely to have negative impacts on this habitat.
- 5.4 It is less easy to predict the consequences of an increase in pressure on the fixed dune grassland and humid dune slacks. At some point, increasing visitor pressure will damage the integrity of the site. Comparison with the buffer zone (which receives far greater trampling pressure due to its proximity to the car park and position between the car park and the beach) is useful. The buffer zone is generally characterised by clumps of scrub and coarse grasses in an otherwise very short sward supporting a few rosette species tolerant of trampling. This suggests that increasing the level of disturbance on the NNR to that experienced by the buffer zone would result in a decrease in the conservation value of the NNR. The buffer zone also illustrates how difficult it is to manage for high visitor pressure on this type of habitat - despite removing scrub and increasing the accessible area, providing boardwalks and paths and litter and dog bins, the quality of the habitat is considered to be decreasing (Steve Ayres, pers.comm.). Within the NNR, the threshold beyond which further visitor pressure is likely to be damaging will vary (due to the patchy nature of visitor pressure). Regular monitoring will be needed together with a clearly defined means of identifying the point at which a given level of visitor pressure is deemed to be damaging to the overall integrity of the site.
- 5.5 The effect of an increase in trampling on petalwort will depend in part on the status of the populations at Dawlish Warren, which is not currently completely clear. In the absence of a significant increase in rabbit grazing, trampling will continue to play a

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key role in providing suitable habitat for this species. However, once trampling becomes frequent enough reduce the population size through direct damage to individuals or the substrate they are growing on, it will be detrimental. Monitoring is needed to assess when and whether this threshold is reached.

- 5.6 The size of the rabbit population will also influence the impact of recreation pressure on Dawlish Warren. A significant increase in rabbit grazing would reduce the threshold number of visitors at which negative impacts occur.
- 5.7 Any increase in recreational pressure may also impact the fixed dune grassland and humid dune slacks in particular by making other management options untenable. Livestock grazing is useful for reducing areas of ranker vegetation away from visitor routes and for reducing some exotic species. However, if visitor pressure increases such that the overall disturbance level is tipped over the threshold beyond which damage is incurred on more fragile areas, it may be necessary to remove livestock.
- 5.8 Any increase in the amount of nutrient enrichment through dog fouling and the incidence of wildfires will have a negative impact on the SAC features, although it is not possible to quantify this.
- 5.9 On the golf course, it is not clear what impact an increase in local development might have on site usage. Existing membership comprises both locals and visitors. The golf course is keen to recruit new members (Cathie Stokes, pers. comm.), and it is likely that there would be some new members as a result of local development. However, through a management agreement with NE membership is capped at 600 (although it is not clear how this figure was reached). The increasing use of electric trollies may exacerbate the effects of trampling, as they are heavier than conventional trollies or bags. Given the apparent fragile nature of the vegetation on the site and the decline in sand crocus, it is not possible to say that an increase in use of the golf course would not negatively impact the fixed dune grassland and humid slacks present.
- 5.10 Current nature conservation objectives for Dawlish Warren include maintenance of the range of habitats and associated species reflecting the different stages of succession by maintaining, or restoring where necessary, the natural processes and dynamics of dune development and succession. Given the evidence set out above we suggest that there is clearly potential that these objectives may not be achievable should recreational pressure increase.

6. Recommendations for monitoring

- 6.1 Monitoring is needed to assess changes to habitats and species at Dawlish Warren corresponding to changes in visitor pressure. We therefore recommend the following monitoring should be implemented.
- 6.2 To assess the impact of changes to conservation features in relation to visitor numbers, it will be necessary to have a clearer idea of the number of visitors using the SAC and in particular long term trends in visitor numbers. This could be done in a straightforward and relatively inexpensive manner by installing automatic counters at key access points, notably the gate from the buffer zone or the gate outside the

visitor centre. Data can easily and conveniently be downloaded from the device straight to a computer. A range of types of device are available, for example infra-red beams, heat sensitive devices ('pyros'), pressure pads and magnetic devices.

- 6.3 A regular programme of habitat monitoring is required. Repeated NVC monitoring is listed within the 2010 – 2020 management plan (TDC 2010). However, this may not pick up subtle changes until they are quite significant. It is recommended that data from quadrats is recorded regularly (e.g. every 5 years at the same time of year) which could also be used as part of the NVC mapping. Ideally, the quadrat methodology should replicate that used in the 1994 and 2002 (Steward 2003) surveys to allow comparison. Following each survey, analysis should specifically consider the nature of any changes to species diversity, to ensure that changes may be spotted before any loss to species richness occurs. Fixed point photography is also recommended as a quick, inexpensive and very accessible form of monitoring. The current programme should be continued, and expanded if necessary to cover key areas in relation to recreational pressure. Fixed points should be recorded with a GPS, and copies of the previous years' photos used to help ensure exactly the same view is photographed. Care needs to be taken to update photographic archives in line with changes in technology.
- 6.4 Use of aerial photographs would be an ideal way to assess changes in the area of bare ground in the mobile dunes. Provided these can be obtained in the future, the area of bare ground can be mapped in a GIS e.g. MapInfo, and compared between years. Fixed point digital photography would provide an alternative if aerials are not available, and a useful yearly back up.
- 6.5 Yearly mapping with species target notes is likely to be the most useful way of monitoring changes to the embryo dunes. A GPS should be used, and data transferred to a GIS to ensure easy comparison between years.
- 6.6 Ongoing monitoring of petalwort populations is recommended. Surveys should be carried out by staff with sufficient familiarity with the species at its various reproductive stages, or by experts. Discussion of best practice for monitoring petalwort are given by Plantlife¹⁰ and are therefore not repeated, except to stress that petalwort can vary in abundance from year to year, probably as a consequence of variable rainfall affecting the water table, therefore a long view is needed.
- 6.7 It is noted that none of the monitoring programmes recommended will establish a causal relationship between changes in recreational pressure and habitats/species. It will therefore be necessary to look at any changes in the light of management work, climate, coastal erosion and changes in the rabbit population.

¹⁰ http://www.plantlife.org.uk/uploads/documents/Petalophyllum_ralfsii_dossier.pdf

7. Conclusions

- 7.1 Recreational access currently impacts on the vegetation of Dawlish Warren SAC. The main factors affecting vegetation are trampling, eutrophication from dog fouling and wildfire. Eutrophication and wildfire have a detrimental impact on the vegetation where they occur. Current levels of trampling may also be preventing the recolonisation of embryo dunes communities. In contrast, for some habitats, the effects of trampling are partially beneficial: in the fixed dune grassland and humid dune slacks, trampling helps maintain a very low, open sward suitable for a number of specialised and rare species in some areas. In the mobile dunes, trampling may help maintain sand mobility and prevent over stabilisation. However, beyond a certain intensity, trampling causes damage, leading to loss of vegetation and erosion. It is difficult to predict where this threshold lies, but in localised areas of the sites, notable along paths and at path nodes, the degree of erosion suggests that it has already been passed.
- 7.2 Any increase in wildfire and dog fouling will have a detrimental effect on the SAC. Any increase in trampling is likely to increase the degree and extent of damage already occurring. It is not possible to say that an increase in recreational pressure would have no effect on the integrity of Dawlish Warren SAC. Mitigation measures would be needed to offset the negative impacts of any increase in recreational pressure at Dawlish Warren SAC.

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