Transactions of the Institute of British Geographers
Royal Geographical Society with IBG
Advancing geography and geographical learning

'This restless enemy of all fertility': exploring paradigms of coastal dune management in Western Europe over the last 700 years

Journal:	*Transactions of the Institute of British Geographers*
Manuscript ID:	Draft
Manuscript Type:	Regular Paper
Keywords:	coastal management, dunes, ecosystem services

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Introduction

Coastal dunes cover an area of ca. 700,000 ha of the Atlantic coast of Western Europe (Doody, 2001), including both the small dune-fringed bays of the British Isles and Ireland and the large stretches of dunes in southwest France, the Netherlands and western Denmark (Figure 1). It has been estimated that up to 44% of this area has been 'lost' since 1900 to a

combination of development (urbanisation, recreation) afforestation and reversion to scrub (Doody, 2001), with some of these changes being easier to reverse than others. The management of these dune landscapes has become an issue of local, national and international concern, reflecting different understandings of their value in scientific, socio-economic, cultural and aesthetic terms. Dune landscapes have been variously regarded as: wastelands, either drawing parallels with the deserts of North Africa (Greenly 1919) or simply as economically unproductive marginal land; as sources of sand invasion threatening settlements and agriculturally-productive coastal lands (Angus and Elliott 1992); as bulwarks against the invading sea (van der Meulen and van der Maarel 1989); and as valuable, but vulnerable, ecosystems (Martínez *et al.* 2004). Dunes have been utilised for grazing cattle and rearing rabbits (Baeyens 1989), for commercial forestry generating timber, resin and turpentine products (Blanchard, 1926; Sargos, 1997), for ground water resources (van Dijk 1989) and as the source of raw materials for activities as diverse as mat making (Griffiths, 1997) and glass making (Roberts, 2003). Since the 19th century, coastal dune areas have also been actively developed as sites for recreation (Winter, 1999) and nature conservation. The incompatibility of some of these uses presents a challenge for contemporary dune management.

Over the last 700 years, different approaches to coastal dune management and the control of inland movement of sand (i.e. sand drift) have developed in Western Europe. The factors combining to facilitate sand movement and dune-building are: sand supply, strong turbulent winds and the absence, or removal, of stabilising vegetation. Aggrading sandy beaches provide a potential source of sand for deflation and movement inland while removal of dune vegetation permits reactivation of sand movement. The changing paradigms of coastal dune management reflect a complex series of factors including the nature of land ownership and

land use and the impact of legislative and policy frameworks driven by both private and public agendas, including, most recently, the 1992 EC Habitats Directive (Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora) and associated Biodiversity Action Plans (Everard *et al.* 2010).

The paper begins by reviewing the historical records of coastal sand movement and then examines the changing human responses to sand inundations and reflects upon how these responses should be used to inform current dune management practices.

Dunes as wastelands: the sand drift hazard

Over the last 700 years, sand driven inland by storms, threatened coastal settlements and productive agricultural land in Western Europe and often had literally overwhelming impact at the local level. The drifting sand has been described as "*this restless enemy of all fertility*" (Hamilton 1797, 37) and *"like a pestilence (that) swallowed thousands of square miles of the coast lands of France*" (Anon 1841, 229). The earliest records of sand drift in Western Europe come from the mid 10th century and many date to before the start of the Little Ice Age (ca. 1570) (Matthews and Briffa 2005) (see Table 1). The records of sand drift are inevitably patchy but churches, in particular, represent high value properties, and therefore their loss, and sometimes their subsequent recovery, tends to have been highlighted in documentary records. In Britain records of loss can be found from Cornwall, South Wales and Lancashire. In Cornwall, churches threatened by sand drifting in from the Atlantic coast include Gwithian (Lewis 1992) described in the late 16th century as "*a parish standing near St Ives Baye, much anoyde with the sea sande, which flyeth at lowe water with the winde out the chocked haven into the Lande, swallowing up much of the lande of the inhabitants to their great impoverishment*" (Norden, 1597-1604); the Oratory of St. Piran (Perran), in Perran Bay,

buried by sand intermittently since the 10th century: "..*the light sand carried up by the North wind from the sea shore daily continueth his covering, so as the distress of this deluge, drave the Inhabitants to remoove their Church*.." (Carew 1603, 148R); and St Enodoc, Trebetherick, which was restored in the 1850's having been buried for most of the 17th and 18th centuries (Hitchens and Drew 1824; Daniell 1880).

Commenting on the timings of sand invasion along the South Wales coastline of Glamorgan, Higgins (1933) draws attention to the start of sand movement in the early 14th century at a number of different sites which he links to the onset of severe coastal storms and floods. The Hermitage of Theodoric, near Kenfig, was overwhelmed by sand by 1300 (Higgins 1933), the Roman coast road, the Via Julia, was covered by sand between 1344 and 1480 and the Kenfig church was finally abandoned in 1428 (Higgins 1933). Travelling in the area in 1538, John Leland described "*a little village on the est side of Kenfik and a Castel boeth in Ruins and almost shokid and devoured with the sandes that the Severn Se ther castith up*" (Hearne 1711 Vol 4, 33). The nearby church of St. Mary at Pennard was completely buried by sand by 1528 and by 1650 little of Pennard Castle was visible and what was left was surrounded by sand (Higgins 1933).

Sand hills (or 'hawes') have dominated the coast of southwest Lancashire between the rivers Mersey and Ribble since the 11th century (Harrop 1985). Many of the old place-names include the word 'meols', the Old Norse term for sand-hill (Harrop 1984). At North Meols (now Southport) in the early 17th century Jameson (1636 p.4) refers to "*those chaffe sands which doe in mountains rise…windie tempest blows them up in heapes*". Although the changing nature of the Lancashire coastline is captured in tales of 'lost villages' (Argarmeols, Ravenmeols) (Ashton 1909) and the 'lost farm' between Birkdale and Ainsdale (Harrop 1985),

a detailed record exists of the impact of sand movement on some of the settlements. In the early 18th century blown sand advanced on the settlement of Formby and eventually forced the dismantling and removal of St. Peter's church between 1739 and 1746 (de Rance 1877) to a new site 1.5 miles inland where it was reconsecrated in July 1747 (Beardwood 1970). de Rance (1877, 112) attributes the onset of sand blowing to the onshore movement of a sand bank and its subsequent deflation by westerly winds commenting "*in a short time the cultivated ground, gardens, orchards and the streets of Formby were entirely covered up*".

In south-west France advancing sand dunes from the 15th century onwards threatened to engulf parts of settlements along the Gascony coast including Soulac, Lege and Mimizan (Guinaudeau 1974) and a similar story is evident from the coast of western Jutland in Denmark where records of sand drift date from 1427 and with the village of Tibirke in northern Sjaelland, for example, abandoned by 1726 (Lamb and Frydendahl 1991).

By the 1700s sand drift was posing serious problems for those trying to make a living along the coasts of France, Denmark, Britain and Ireland, but the scale of the problem is captured more than 200 years earlier in the first piece of legislation concerning sand drift that was passed into law in Britain in 1554, this was a Public Act of Parliament, *An Acte Touching the Sea Sandes In Glamorganshire* (Figure 2) , that set out "*to reform the great hurte, nuisance and losses that cometh and chanceth to the Queen Highness and her Subjects by reason of the sande Rising out of the sea and driven to land by storms and winds whereby much good ground lying on the sea coast in sundry places of this realm and especially in the County of Glamorgan, bee covered with suche sande rising out of the sea that ther comethe no profitte of the same, to the greate losse of the Quenes Highnes and her loving subjectes and more ys lyke to ensue yf spedye remedie be not therin provided"* (1554 – 1 Mary St.3 c10.11). This Act

appears to have been drafted in response to the successive losses of land reported at Pennard, Kenfig and other places along the south Wales coast (Higgins 1933). The Act of Parliament extends the preexisiting powers of the Commission of Sewers to give them "*full power and authoritee…to make suche Lawes Provisions Ordinances Judgementes and Decrees within the said Countye of Glamorgan, for the redresse and saving the sayd groundes from hurt or destruction by reason of the saide Sandes..*" (1554 – 1 Mary St.3 c10.11). The Commissions of Sewers were originally established in 1427 (6 Henry VI. c.5) to deal with inundations of water both inland and along the coast by building and maintaining structures including ditches, causeways and weirs. The 1554 Act captures the seriousness and scale of the problem and explicitly extends the meaning of inundations to include those of sand as well as of water.

Strategies for combating inundations of sand and water

In the historic record inundations of both water and sand were seen as a constant source of worry for coastal populations with dunes often acting as a first line of defence against coastal flooding (Roeland and Roelse 1995). The implications of any breaching of these coastal barriers were considerable and therefore their importance was well understood. In this context we can identify a number of different paradigms of dune management in Western Europe:

(1) Unmanaged retreat: do nothing to arrest the movement of sand, abandon houses and land and move away.

(2a) Stabilisation with dune grasses: encourage the planting of dune grasses, particularly marram, and control the removal of vegetation from dunes by strictly regulating coastal land use.

(2b) Stabilisation with trees: plant pine (*P. pinaster, P. sylvestris*) and other tree species to fix dunes and provide an additional income/industry for the local economy.

(3) Maintain the dune system by allowing it to develop naturally (i.e. Dynamic dune management): inland movement of sand is no longer seen as a problem. The management strategy involves the removal of dune vegetation to allow areas of sand to remobilise, allow blowouts to develop, to promote sand movement and dune building.

The key factors governing the various responses are ones of scale and of the availability of resources of both capital and labour. The different paradigms are explored in turn below.

Unmanaged retreat

The first paradigm is one of unmanaged retreat: do nothing to try to stop sand moving inland, abandon houses and land and move away, and such an approach is seen in small embayments on western Ireland (Quinn 1977) and along the south Wales coast at Kenfig (Higgins 1933). This approach reflects a teleological view of the natural world, the scale of the problem, particularly the volume of sediment involved, and perhaps the lack of any perceived aesthetic value in such a landscape. Hamilton (1797, 34) writing of the western coast of Ireland comments: "*The waste and dreary solitude of extended barren sands, which almost every sea coast exhibits, is generally passed over with rapidity, as useless to the philosopher, from the incalculable fluctuation of its surface; and wearisome to the traveller, by its disgusting uniformity*". Hamilton's is also a traveller's view. A different but most desperate view is expressed in a letter written in 1792 from Felix Gallagher to the second Viscount Palmerston concerning his landholding on the Sligo estate in the west of Ireland: *"..When I*

first … took a lease of the part I hold of your Lordship's estate it looked and promised well, I could not then see nor could it enter the mind of man what ravages of Blowing Sand has made since that time.." (BR150/17/11).

One particularly notorious example of retreat is provided by the case of the Culbin Sands, on the coast of Fife in Scotland, in which the Barony of Culbin, with its fields and farmsteads, was supposedly buried by sand during a violent storm lasting a single night in 1694. The reality appears to have been more prosaic, the incursion of sand more gradual (Steers 1937; Bagnold 1937) and the scale of economic loss exaggerated (Ross 1992). But it is nevertheless interesting that the catastrophist vision of the action of a single (unrecorded) storm not only became embedded and embroidered in local folklore (Ross 1992) but has also entered the scientific literature (e.g. Lamb and Frydendahl 1992; Provoost *et al.* 2011) where it is treated as fact rather than fiction.

Stabilization with vegetation: dune grasses

The second paradigm is an economically-driven, pragmatic response, holding, and, in some cases, advancing the line, by using vegetation to prevent sand movement and encourage dune stabilisation. This approach has a very long history that is related to the extent to which coastal lands have been owned and actively managed in Western Europe. It also in part pre-dates the late 18th century move towards 'improvement' (Smout 2000) In Britain for example, the use of coastal dunes in Cornwall and Lancashire was the subject of cases dealt with by manorial courts and assizes. The relationship between dune vegetation and blowing sand appears to have been well understood and records going back to at least the 15th century indicate that dune vegetation was reinforced by additional planting while the removal of dune vegetation, without the landowners' permission, was prohibited.

What was this dune vegetation? In the earliest authoritative annotated plant lists dating from the late 16th and early 17th centuries the dune grass *Ammophilia arenaria* was described for the first time as English Mat Weede and initially given the name *Spartum Anglicanum* by Gerard (1597). He describes it as follows: "*English Mat weede hath a rushie roote, deeply creeping and growing in heapes of sand and gravel, from the which arise stiff sharp pointed leaves, a foot and a halfe long*" Gerard (1597, 39). Parkinson (1640) in his *Theatrum Botanicum*, identifies two types of Matweed or Mat Rushes: "*Our Matweed or Marram (Spartum marinum nostras)"* and "*The other of our Sea Matweedes (Spartum marinum nostras alternum)*", which is probably lyme grass (*Elymus arenaria*). Threlkeld (1726) describes *Spartum anglicanum* as "*Gramen Sparteum Spicatum folijs Mucronatis Longioribus, vel specâ seculinâ, English Sea-matweed, Marram or Helm..*" Although *Ammophilia arenaria* has a number of synonyms (*Arundo arenaria* (L), *Calamagrostis arenaria*(G), Smith, 1799) the use of the common names (matweed, marram, bent, bennet, starr, rush) is confusing since some of these names, bent for example, have in turn have been applied to a range of different grasses (Wright 1961, 244). Although marram is now the dominant common name for *Ammophilia arenaria*, it was originally a name only associated with the Norfolk and Suffolk coasts (Parkinson, 1640), in Lancashire the name was starr, in Cornwall it was rush, while in Scotland and Ireland the name bent was used. Whatever the name, there is evidence of the active planting of dune grasses to combat sand movement from the late 15th century onwards in Britain.

Issues of dune management, including both the planting and the removal of dune grasses, are highlighted in various estate records. In Lancashire the deed of covenant drawn up at Sefton between Sir Richard Molyneux of Sefton and Henry Halsall of Halsall dated 10th

January 1560 includes the following injunction: "*shall not permit nor suffer…any of their tenants farmers or occupiers.. or any other pson or psons to doe or comthe any acte or thinge as in getting of starr or distroing of the same with there cattell beastes or otherwise*" (LRO DDIN/49/11). 'Haweslookers', literally sand-hill watchers, were appointed by the manor court from the 1630s in Birkdale and Ainsdale and fines were imposed on those people caught removing the starr grass. From the mid 18th century 'starr-setters' were appointed to plant dune grasses (Harrop, 1985) a practise that continued on the Ince Blundell estates near Formby into the early 20th century (Royal Commission on Coast Erosion 1911).

On the Arundell Estate, near Gwithian in Cornwall there are records of payments to tenants to plant rushes "*on the sand to preserve the lord's land*" (CRO AR/2/982) and also of fines imposed when rushes were cut or removed without the permission of the landowner. Records from the Estate include payments of 6s to tenants for planting rushes in 1491/2, 1497/8, 1620/1, 1632, 1679-1688 and 1703 as well as lists of fines for cutting/removal of rushes in 1461/2 (6s, 8d), 1508-1510, 1528-9 and 1529-30. In the early 18th century the estate was still experiencing problems with sand drift as the following correspondence demonstrates:

"London, Saturday 3 April 1703. Sir Richard Arundell to George Bere, Lanherne

I am very sorry to finde by yours of 22 March that the overflowing of the sands have done this winter so much damage to our lands in yr mannor of Connorton. I hope your planting of rushes will provide successfull and that God will be pleas'd to blesse your endeavours in putting a stop to this desolation." (CRO AR10/164)

"*Lanherne 3 April 1704 George Bere to Lady Bellings, London*

I have been again at Gwithian planting rushes with I hope by Gods blessings may prevail this ruin which is…threatened by the sands." (CRO AR10/192)

The earliest record of marram planting on the Holkham Estate of the Earls of Leicester dates from 1746 and records a payment of £2 – 1s – 8d for "*planting 125 rods of the sea bank with marrum at 4d a rod*"(Holkham Hall Archive A/AU22). The planting of 'bent' on the sand dunes along the coast of the Palmerston's Sligo Estate was undertaken at the behest of the 3rd Viscount Palmerston at an annual cost of between £120 and £220 from the late 1820s to the 1860s. By 1833, Palmerston's Irish Agent was able to report: "*Bent Planting – this has succeeded beyond anything that could have been expected, not only in preventing the Sand from Blowing over the adjoining grounds but in converting an immense Tract of bare Sand banks as barren and uninviting as the Deserts of Arabia into a firm soil and a beautiful green pasture*" (BR145/5/20). The success of the bent planting was celebrated in an article that appeared in the Gardener's Chronicle and Agricultural Gazette of 5th April 1845 written by John Lynch, Palmerston's agriculturalist.

The situation with sand drift around the coasts of Britain was sufficiently serious that two Acts of Parliament were passed in 1695 and 1742 to prohibit the removal of dune vegetation. The original common name for *Ammophilia arenaria* of Matweed gives a hint of its potential utility and places like Birkdale, in Lancashire, and Newborough, in Anglesey, supported mat-making activities (Harrop 1985; Griffiths 1997).

The driving force behind the 1695 Act was the economic damage done to meadows and pasture lands "*ruined and overspread in many places of the Kingdom, by Sand driven from adjacent Sand-hills, the which has been mainly occasioned by the pulling up by the Root of*

Bent, Juniper and Broom Bushes, which did loose and break the Surface and Scroof of the said Hills" (William III c.30 1695). Specific reference is made in the Act to the loss of the lands of the Culbin estate and the owner of the estate lobbied parliament in 1695 to avoid paying land tax (cess) on the estate on the grounds that two-thirds of the estate were covered in sand (Ross 1992).

The second piece of legislation, an "*Act for the more effectual preventing of the cutting of starr or bent*" (6 George II c.33 1742) was directed at the problems of the north-west coasts of the Kingdom and specifically in the county of Lancashire where the "*Sea is bounded, and the adjacent Lands are prevented from being overflowed by large Sand-Hills*" The 1742 Act notes that "*when any violent strong west winds happen to blow, the sand is carried away and thrown on the adjacent lands, not only to the damage thereof but also to the great Terror and Danger of the Inhabitants who are thereby exposed to the indundation of the sea: And whereas it has been found by Experience, that the best Way to preserve the said Hills from being blown away as aforesaid, is to plant them with a certain Rush or Shrub called Starr or Bent, which proves an effectual Method for keeping the same firm and solid, and which the Owners of the said Lands are at great Costs and Charges, in yearly setting and Planting for that Purpose;* " (6 George II c.33 1742) thus highlighting the role of the dunes as the first line of defence against coastal flooding and the role of landowners in managing the sand-hills. The act also notes that people are cutting or pulling up the dune grasses and using them to make "*Mats, Brushes, and Brooms or Besoms*". While the 1695 act prohibited removal of vegetation by anyone, including the landowner, the 1742 act prohibited the pulling up and carrying off of dune grasses without the landowner's permission. The 1742 Act was certainly enforced in Lancashire in 1857 when Peter Wright was fined 20s with costs by the Magistrates at Southport on behalf of the landowner, Mr Thomas Weld-Blundell, for

possessing starr grass (LRO DDIN/66/39). Bailey (1955) observes that, as a consequence of the almost unheard of decision to enforce the Act, the basket makers of Birkdale had to make do with willow instead. But this was actually not the case, as an article in the Liverpool Mercury of 31st May 1889 records a meeting between the agent of Mr Charles Weld-Blundell and about 100 mat makers on Birkdale Common at which arrangements for permitted cutting of starr grass were announced (Liverpool Mercury 1889).

Active management of dune areas and the distinction between cutting and pulling up dune grasses is important since many researchers, including Doody (1989a) and Westhoff (1989), have regarded all sand drift problems as inherently caused by human activity. While cutting allowed for re-growth, pulling up of the whole plant, including the roots, did not. Writing of the Netherlands, Westhoff (1989, 48), claims that *"Until far into the previous (19th) century the North Sea coastal dunes were much more mobile and much less overgrown than they are nowadays, mainly as a result of exhaustive cropping by man…the dune area was rather like a desert"*. This scenario of feckless exploitation should not go unchallenged as it is apparent that some dune areas were subject to careful management. Marram grass was used for thatch and in 1692 the manor court for Birkdale and Ainsdale appointed officers '*to set people on where to get thatch starr so that no damage may ensue*' (Harrop 1985, 30). The mat making activities at Birkdale and Ainsdale were also controlled, with the landowner's agent noting that "..*bona-fide mat makers resident in Birkdale or Ainsdale would be permitted to cut the grass in the proper season (July) under the superintendence of the estate starr watcher, but must register their names and addresses at the estate office*."(Liverpool Mercury, 31st May 1889, 2). The establishment of mat-making and basket-making industries at Birkdale and Newborough suggests that in some areas the cutting of marram was sustainable. The 1871 census entries for the two settlements, record 57 individuals with occupations variously

described as Mat Maker, Table Mat Maker and Star Mat Maker in Birkdale while there were 122 Mat Makers in Newborough (of whom only three were male) equivalent to 45% of the female population. At Newborough, plots were leased for marram cutting and farm incomes depended on cutting and mat-making (Griffiths 1997). The Newborough Mat-makers Association (Figure 3), established in 1913, continued to flourish into the 1920s supplying horticultural mats to the Army and Navy Co-op Stores in Frances Street, London and rush rope to the London and North West Railway at Crewe (ARO WM/301) before declining by the late 1930s (ARO WM/2118).

The management of dune areas also went beyond controlling marram use. In Lancashire, for example, dunes were '*not just heaps of sand but valuable economic units – in this case, rabbit warrens*' (Harrop 1985, 31) and on the Blundell and Formby estates rabbit warrens were carefully regulated and provided fur, flesh and fertilizer with no part of the animal going to waste (Harrop 1985). Not all coastal dunes were as well-managed, as exemplified by the Stewart Estate in County Donegal, Ireland, where marram was removed on the orders of the landowner during period 1914-1918 and the estate, including Horn Head House, was covered by the resultant sand drift (Quinn 1977). Another example of poor management involved forest clearance of the Island of Anholt, Denmark, by 1600, and it is thought that subsequent uncontrolled cropping of dune vegetation resulted in sand drift affecting much of the island (Christensen and Johnsen 2001).

Stabilization with vegetation: afforestation and the economic impact of stabilisation from landed estates to government agencies

The economically-driven paradigm took on additional force in the late 18th century with the use maritime pine (*Pinus pinaster*) to fix dunes not only to 'hold the line' but also to provide

additional income and industry to boost the local economy from the sale of pine resin and turpentine (Blanchard, 1926). The move to plant trees began in earnest in south-west France with the dunes of Aquitaine (Brémontier 1797) and the techniques used (Brown 1878) were subsequently adopted in Denmark, Great Britain and Ireland. By the end of the 19th century 90,000 ha of Aquitaine dunes were forested (Guinaudeau 1974; Sargos, 1997) along with 39,000 ha of dunes in Jutland (Skarregaard 1989). In Britain and Ireland afforestation of sand dunes from the mid-19th century relied on the efforts of individual landowners in County Sligo, Fife, Lancashire and Norfolk (Clarke and Rendell 2011). The perceived success of the Aquitaine planting attracted the attention of the 3rd Viscount Palmerston, then UK Foreign Secretary, who contacted the British Consul in Bordeaux in 1835 to arrange for seeds of maritime pine to be sent to Ireland for planting on his Sligo Estate (BR145/7/36). The first consignment of ca. 450 kg of seeds was stopped in customs and had to be extricated by Palmerston's Irish Agent whose letter to the Treasury concludes *"..it cannot be expedient or politic to prohibit the importation of an article which – if it should succeed may prove the means of rescuing & protecting large tracts of land upon the Western & Northwestern Coast of Ireland & other parts of the British Isles from the devastation by sand flood"* (BR145/8/4). Pine seed was sown directly into the sand hills of Mullaghmore, and seed continued to be imported through the 1840s and 1850s at a cost of ca. £20 per consignment. The planting was seen as a great 'experiment' which subsequently spread to Holkham in Norfolk. Although the planting strategy involved a substantial commitment of time and resources and it is worth noting that the economic incentives of the Aquitaine/Landes campaign (i.e. timber, resin and turpentine) were not necessarily exploited elsewhere, particularly at the smaller scale. At Holkham the planting was undertaken in the 1870s to fix the coastal dune barrier protecting newly drained agricultural land (Royal Commission on Coast Erosion 1911). The afforestation of coastal areas in Britain to provide both

employment and timber was one focus of the Royal Commission on Coast Erosion (1907 1909 1911). Afforestation remained the management tool of choice well into the 20th century in Britain with the fundamental aims of arresting sand movement as well as providing commercial forestry with the planting of Culbin (2,560 ha), Tentsmuir (1,500 ha) and Newborough (750 ha) before and after the second world war by the UK Forestry Commission (Clarke and Rendell 2011).

From pragmatic stabilisation to biodiversity and dynamic management

By the second half of the 20th century the coastal dunes of Western Europe were experiencing an unprecedented period of stability, resulting from planting of dune grasses and particularly coastal pine forests, but ecologists increasingly viewed afforestation as malign, destroying complex dune habitats and associated biodiversity (Martínez *et al*. 2004) by 'overstabilising' the sand dunes (Doody 2001). Regrets about afforestation were also shared by some geomorphologists. Writing in 1937, Steers rather wistfully comments that "*(w)hilst the afforestation has once again made Culbin a valuable national asset … the physiographer cannot help regretting that the nearest approach to a desert in the British Isles is rapidly disappearing*" (Steers 1937, 502). Ecologists were also alarmed by the rapid development of potentially damaging recreational activities and argued that remaining dune habitats required protection from such developments (Doody 1989a; van der Zande 1989). In Britain the post-war legislation (National Parks and Access to the Countryside Act, 1949) allowed for the establishment of both National Nature Reserves (NNRs) and Sites of Special Scientific Interest (SSSIs) and provided a new context for coastal dune management. The coastal dune sites of Ainsdale, Newborough, Kenfig, mentioned above, together with Braunton Burrows (Devon), feature in the list of the top 22 sites considered for conservation status by the Nature Reserves Investigating Committee in 1944 (Sheail 1976). Members of the British Ecological

Society were prominent in driving the NNR designation agenda (Sheail 1976). The establishment of NNRs was not without problems and tensions, created by the conflicting demands of nature conservation, development, agriculture and recreation, and exacerbated by issues of land ownership and jurisdiction (Doody 1989a). Land ownership was often complicated as a result of the break-up of large estates such as the Ince-Blundell and Formby Estates in Lancashire (Jones *et al*. 1993). Management was however increasingly driven by the perceived need to accommodate (or facilitate) dune mobility rather than arresting it with vegetation (Nordstrom and Lotstein 1989; Westoff 1989; Wanders 1989; Doody 1989b, van Zoest 1992). This perception reflects both the understanding of dunes as inherently dynamic systems and the increasing role of ecological theory in informing conservation practice. The emergence of this more 'dynamic' management approach is captured in the proceedings of a series of conferences held in the late 1980s and early 1990s (van der Meulen *et al.* 1989; Gimmingham *et al.* 1989; Carter *et al.* 1990) and is effectively enshrined in the 1992 EC Habitats Directive 92/43/EEC. This piece of legislation requires, amongst other things, regular reporting from Member States on the conservation status of species and habitats, including coastal sand dunes.

The future: From dynamic management to utilitarian ecosystem services?

The logical consequence of the dynamic approach to coastal dune management is to increase the areas of bare sand by removing dune vegetation. One issue involves the choice of the size of the clearance area (Rhind and Jones 2009): too small and they rapidly revegetate, too large and extensive and sand blow may ensue. Initial experiments in removing dune vegetation in the Netherlands (Arens and Geelen 2006) suggest that scale is indeed a key issue, i.e. what may work effectively on a small plot (a 100-300m wide coastal

strip 3km long) in what was a supply-limited system may create problems of sand drift if undertaken on a larger scale. This is exemplified by the impact of marram removal on the Stewart Estate at Horn Head, County Donegal (Ireland) in the 1930s which created more than 100 ha of bare sand and sand drift subsequently covered local roads, threatened Dunfanaghy harbour (Quinn 1977) and blocked the upper part of the Sheephaven estuary creating the New Lake (Wilson and Braley 1997). The Estate was acquired by the Irish Land Commission who began a marram planting scheme on the bare sand areas in 1934, followed in 1946 by forest planting on the stabilized areas (Quinn 1977). One consequence of the more dynamic approach has been an increase in the clear-felling of some of the coastal forest areas particularly where the trees are deemed to be non-native species. In the Netherlands, considerable resource has recently been devoted to deforestation on sparsely populated islands such as Terschelling in order to re-mobilize the sand. On a visit to the island Durkin (2011, 2) comments '*Seeing the wind (on a relatively calm sunny day) move blizzards of sand from the fore shore to the dunes and seeing places where that volume of sand has piled 20 feet high in a week left me in awe of the potential of nature's architecture'*. This provides a different perspective on sand drift from that given in the historic accounts quoted above, as well as instantly capturing some of the associated issues such as scale. Ironically, in the case of the dunes on the Sefton Coast, the clear-felling of pine woodlands was opposed by local residents and the local council on the grounds that this would damage the red squirrels' (*Sciurus vulgaris*) woodland habitat (Hansard 2007): a habitat that owes its existence to dune stabilization in the late 19th century (Jones *et al.* 1993). A similar clear-felling proposal in relation to Newborough Dune Forest on Anglesey has also proved highly controversial (Rhind and Jones 2009). While the Countryside Council for Wales perceive the pine plantations of Newborough as a direct threat to the favourable conservation status of coastal dune habitats,

and in direct contravention of EU legislation, the plantations are regarded as highly valuable assets by local inhabitants and visitors (Rhind and Jones 2009).

The aim of the dynamic management approach appears to be to return the system to a notional pristine state. This is both a geomorphological and ecological challenge. The key question is whether vegetation clearance, particularly the clear-felling of coastal pine forests, can restore the desired sand dune habitats. While bulldozers can be used to recreate passable imitations of dune shapes and blow-outs, re-establishing floral and faunal communities is more difficult, particularly given that simple assumptions about succession can no longer be made (Miyanishi, and Johnson 2007; Johnson and Miyanishi 2008). The results from empirical studies involving vegetation removal are equivocal (Sturgess and Atkinson 1993; van Boxel *et al.* 1997; Lemauviel and Roze 2000; Arens and Geelen 2006) and gauging success depends in part on the ultimate restoration goal (Jones *et al.* 2010). According to the EC Habitats Directive, the goal is to ensure that a favourable condition of sand dune habitats is achieved or maintained and within the UK this is done by specifying targets as part of a Biodiversity Action Reporting System. Ironically, some moves to remobilise sand dunes may require the destruction of the protected habitat of grey dunes which is also in contravention of the EU Habitats Directive. Using an ecosystem approach to the management of coastal dunes, while appropriately holistic, also has the effect of polarising environmental attributes between the benign and the malign; active development of blow-outs, for example, is 'good' while proliferation of non-native species or the disruption of dune vegetation by trampling is 'bad'.

However, the 'ecosystem approach' not only increasingly provides 'a framework for environmental policy development' (Holt *et al.* 2011, 213) but is also reinforced by the

Millennium Ecosystem Assessment with its emphasis on ecosystem services (Gómez-Baggethun and Ruiz-Pérez, 2011). In their paper addressing the societal importance of sand dunes, Everard *et al.* (2010) argue that since the only protection that coastal dune environments currently receive is derived from biodiversity considerations, embedded in the legislative framework of the EC Habitats Directive, their value in providing coastal defence 'services' is poorly recognised. Yet climate change impacts on coastal dune systems have largely been confined to discussions of the implications of sea level rise (e.g. Carter 1991; Rhind and Jones 2009) linked to the importance of coastal dune systems as bulwarks against coastal flooding. In addition, Psuty and Silveira (2010) highlight the importance of understanding changing sediment budgets, again in the context of sea level rise, but little mention is made of the changing magnitude and frequency of coastal storms in mobilising sediment.

The consensus amongst climate modellers is that Atlantic storminess, however defined, is set to either stay the same or increase in intensity during the 21st century (Clarke and Rendell 2011, Table 2). Under these conditions, and provided there is a source of sand, the devegetation of dunes will result in sand blow on a scale determined by the vegetation removal. Although Sherman and Nordstrom (1994, 263) regard sand drift as '*a nuisance rather than a danger*' and point out that, as natural hazards go, '*lives are not threatened and structures are not usually destroyed*', we have estimated that sand drift problems over the last 700 years affected over a quarter of a million hectares of coastal land in Western Europe (Clarke and Rendell 2011) which represents a 'nuisance' of considerable spatial extent. By ignoring the original biophysical drivers for planting dune vegetation, those promoting the ecosystem approach are taking a narrow and ahistoric view that is also closed to any consideration of 'ecologically inappropriate' coastal forests as having economic, aesthetic or

cultural values for local populations. Perhaps a place-based perspective (Potschin and Haines-Young, 2012) would provide a more appropriate framework for future management of coastal sand dunes.

Conclusions

In Western Europe, recent ideas of a managed naturalness or 'dynamic dune management' have evolved against a backdrop of unprecedented stability of coastal dunes. These ideas have also developed in an ecological framework within which anthropogenic influence is almost always regarded as inherently malign whether in initiating sand movement by removing dune vegetation or by stabilising dune systems with dune grasses or conifer plantations. This perspective fails to recognise both the extent to which dune areas were managed sustainably and the resources invested in the attempts to stabilise dunes areas on the part of local populations. The comparative lack of contemporary dune building and sand drift in Western Europe is the result of hundreds of years spent combating it and the substantial investment of resources on the part of landowners and local and national governments. This historic economic legacy needs to be factored into future management strategies and we make a plea for its inclusion within a place-centred ecosystem services approach. In the absence of such an approach and in the context of abundant sand supply together with unchanged or increasing Atlantic storminess the consequences of active devegetation of sand dune landscapes on even a modest scale are likely to be dramatic.

Acknowledgements

We thank the Parliamentary Archives, House of Lords, the Archives and Special Collections, Hartley Library, University of Southampton, for access to the Broadland Papers; the Holkham

Estate for access to their archives; the Public Record Office Northern Ireland (PRONI) and the Anglesey, Cornwall and Lancashire County Records Offices for their assistance.

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Figure Captions

Figure 1. Distribution of European coastal dunes (inset: sites mention in the text)

Figure 2. The 1554 Public Act of Parliament held in the House of Lords Parliamentary Archive: *An Acte Touching the Sea Sandes In Glamorganshire* (1 Mary St.3 c10.11)

Figure 3. The Newborough Mat Makers Association, Anglesey c. 1914. Founded by Colonel Cotton (seated centre).

Table 1. Earliest documentary records of sand drift in Western Europe grouped by century

Century	Locations	Sources of reference
AD 1000 - 1099	Lindhom Høje, Denmark	Kjærgaard, 1994
AD 1100 - 1199	Netherlands	Klijn, 1990
AD 1200 - 1299	Kenfig, Wales	Higgins, 1933
AD 1300 - 1399	Anglesey, Wales Cornwall, England	Owen, 1953 Polsue, 1868
AD 1400 - 1499	Lancashire, England Bordeaux, France Jutland & North Zealand, Denmark Orkney & Shetland, Scotland Marinha Grande, Portugal	Pye & Neal, 1993 Clarke et al., 2002 Lamb & Frydendahl, 1991 Somerville et al., 2003 Pinto, 1938
AD 1500 - 1599	-	
AD 1600 - 1699	Mullaghmore & Horn Head, Ireland Culbin, Scotland	Quinn, 1977 Ross, 1992

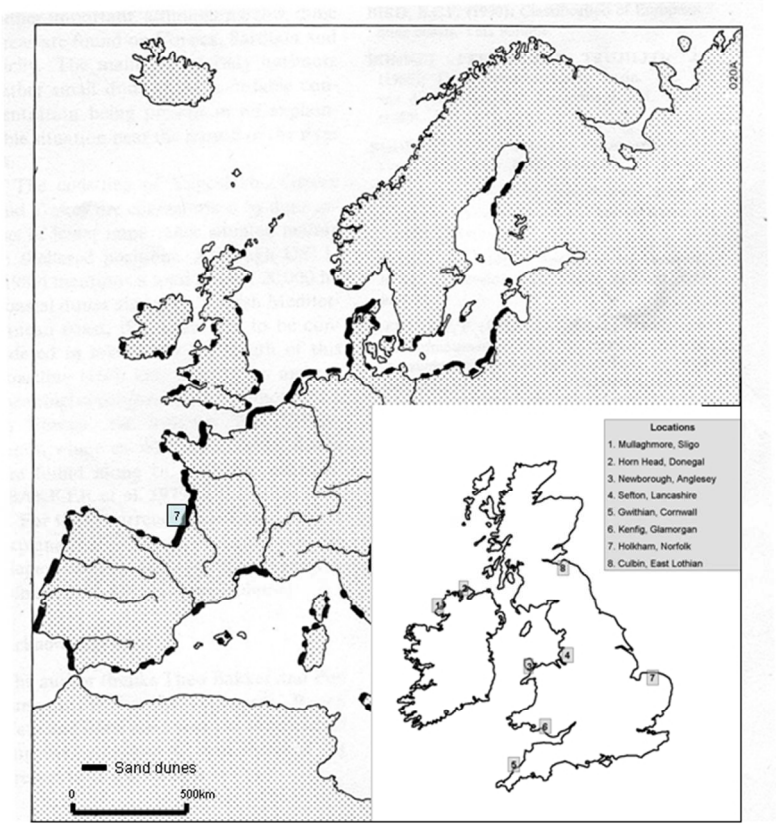

Figure 1. Distribution of European coastal dunes (inset: sites mention in the text)
190x254mm (96 x 96 DPI)

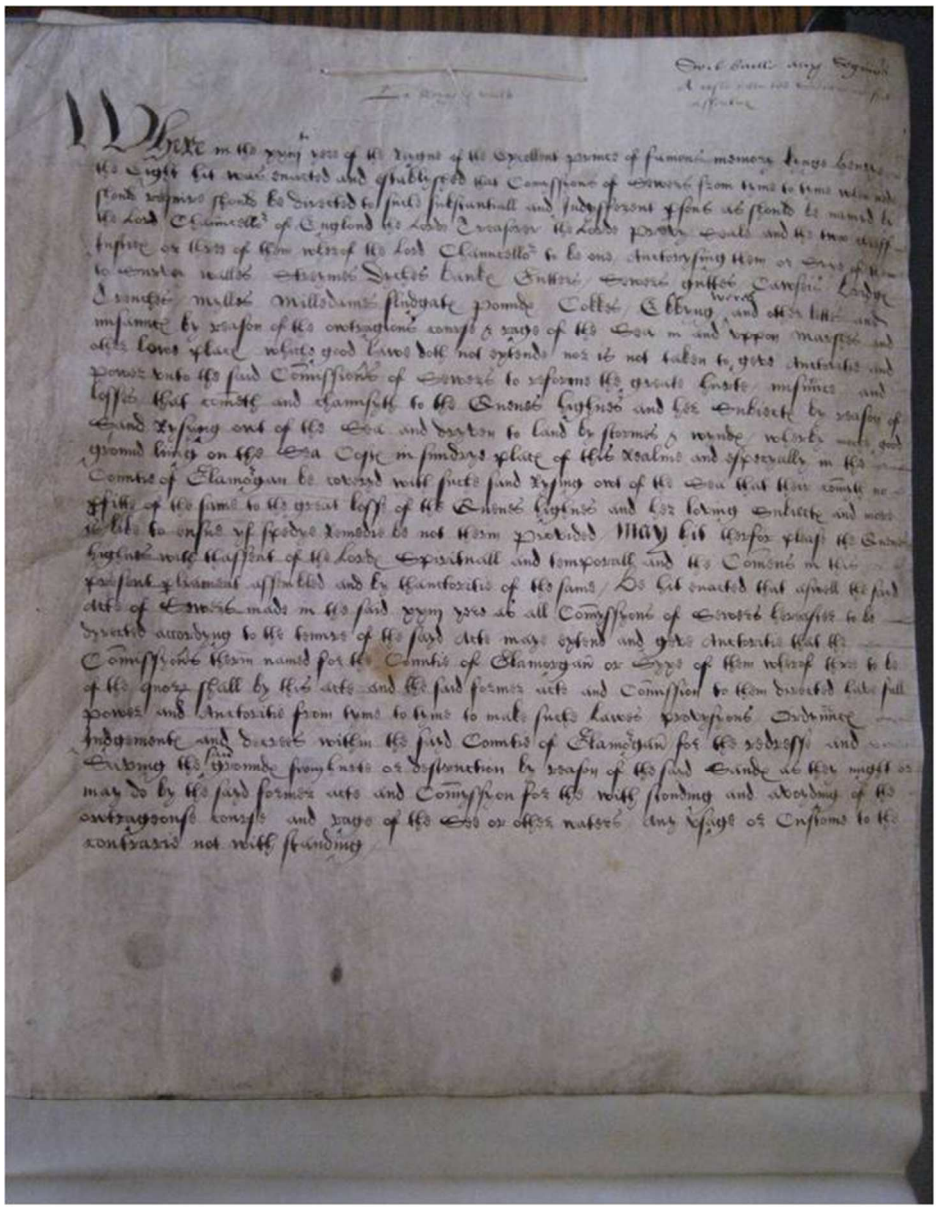

Figure 2. The 1554 Public Act of Parliament held in the House of Lords Parliamentary Archive: An Acte Touching the Sea Sandes In Glamorganshire (1 Mary St.3 c10.11)
115x148mm (150 x 150 DPI)

Figure 3. The Newborough Mat Makers Association, Anglesey c. 1914. Founded by Colonel Cotton (seated centre).
89x57mm (300 x 300 DPI)