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Regional vegetation change and implications for local conservation: An example from West Cornwall (United Kingdom)

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ABSTRACT

This study tracks local vegetation change in West Cornwall (South West England) within regional context, using historic herbarium (pre-1900) and recent vegetation records (post-1900). The focus centres on species lost from the region over the past century. For this study we used a collection of herbarium records published in 1909 (Davey's "Flora of Cornwall") and contemporary records from the "New Atlas of British and Irish Flora" downloaded from the National Biodiversity Network (NBN), online database. Both data sets were spatially analysed using ArcGIS in order to detect local scale species loss. Our results showed that species loss was highest in the south (11 plant species), compared to the loss from middle areas (6 plant species) and in the northern area (8 plant species) of West Cornwall. Results on species change at the local scale were different to the changes that are happening at the national scale. Loss from West Cornwall was detected for two plant species, Mountain Melick (*Melica nutans*) and Field Eryngo (*Eryngium campestare*). These key results amplify the importance of local scale research and conservation in order to protect ecosystems functioning, genetic diversity, ecosystem services and regional identity.

1. Introduction

Recent climate change has led to changes in the geographical distribution and phenological responses of plant species and in some places, to species extinction (Hannah et al., 2002; Parmesan and Yohe, 2003; Thomas et al., 2004; Thuiller et al., 2005a). It has been generally accepted that anthropogenic climate change, during the 20th and 21st century has induced changes in plant species geographic distribution which have mostly followed two patterns: poleward movements (Auer and King, 2014; Chen et al., 2011; Pacifici et al., 2015; Parmesan, 2006; Parmesan et al., 1999; Parmesan and Yohe, 2003) and/or elevation shifts (Feagan, 2007; Kelly and Goulden, 2008; Lenoir et al., 2008; Moritz and Agudo, 2013; Parmesan, 2006; Root et al., 2003; Walther et al., 2005, 2002). For example changes in the altitudinal range of 1–4 m per decade have been detected for plant species in the European Alps in response to climate change (Grabherr et al., 1994), as well as changes in the altitude of tree lines associated with seasonal warming. However, the magnitude of such changes has been dependent on local annual and seasonal temperature change (Harsch et al., 2009; Körner and Paulsen, 2004). Furthermore, changes in latitudinal range have been observed for European forest herb species (Skov and Svenning, 2004), as well as in woody plant species in the

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Arctic region (Crawford and Jeffree, 2007), and distributional change of plant species in the UK (Braithwaite et al., 2006). Some authors have suggested that changes in geographical distribution result in an increase in the risk of extinction, as changes in distribution lead to habitat fragmentation and reduction in population size (Dawson et al., 2011; Krauss et al., 2010; Potts et al., 2010; Spielman et al., 2004). It is likely that such changes will be even more pronounced given the climate change predicted for the end of 21st century (Chen et al., 2011; Parmesan, 2006; Thomas et al., 2004). Nevertheless, the magnitude of extinction risk will vary regionally and locally depending on the magnitude of climate change in the region but also on other factors such as the rate of land use change (e.g. habitat destruction and fragmentation) (Loarie et al., 2009; Ordonez et al., 2014). Vegetation loss will impact species individually, as some species will not be able to adapt to rapid climate change due to a lower range in their climatic envelope (i.e. climatic conditions in which species can persist) and therefore will become more vulnerable to regional and local losses (Corlett and Westcott, 2013; Davis and Shaw, 2001; Gilbert and O'Connor, 2013; Pignatti et al., 2001; Thomas et al., 2004; Thuiller, 2004).

National extent mapping of plant species is frequently used to identify species current distribution and conservation status (Braithwaite et al., 2006; Preston et al., 2002), however it does not carry much useful information about patterns of such changes at the local scale. Local and regional scale research is important for conservation as it helps to elucidate an understanding of species geographical changes and their current distribution patterns (e.g. extent of habitat fragmentation) as well as fine scale extinction rates (Foley et al., 2005; Maclean et al., 2015). Such research can identify the species that experience changes in local distribution or loss local locally, and this can be important for assessing and understanding regional identity or by the 'terroir' concept (Bassett et al., 2007; Feagan, 2007; Paasi, 2012; Van Leeuwen and Seguin, 2006). Regional identity is defined as an important trait of a region (e.g. landscape, biodiversity, place names, historical monuments, dialects, local food), (Paasi, 2012) where the terroir approach considers social dimension and geographical characteristics of local areas (e.g. climate, topography, soil) and uses this in driving policy making (Bassett et al., 2007; Van Leeuwen and Seguin, 2006). Both concepts are crucial for policy making (keeping species locally and regionally) in order to preserve local and regional landscape and socio-natural heritage, and suggesting the direction of planning, marketing and conservation in order to maintain and improve regional economic development.

Changes in species range and their loss at the local and regional scale leads to changes in ecosystem composition, and consequently this can affect the delivery of ecosystem services (e.g. provisioning, regulating, cultural and supportive services), which are thought to be essential in supporting human wellbeing (Beaumont et al., 2011; de Oliveira and Berkes, 2014; MEA, 2005; Rands et al., 2010). Ecosystem composition could be changed with a loss of single 'key species' (species that play an important role in ecosystem composition) or even multiple species, but it is still unknown to what extent this can impact ecosystem functioning (Bertrand et al., 2011; Hooper et al., 2005; Lavergne et al., 2006). Therefore an approach to management has been developed which places the focus on species that have been identified throughout the literature as "keystone-species", "identity species" or "landscape species". These are assessed as being crucial for regional ecosystem identity and ecosystem services (Gibbons and Boak, 2002; Manning et al., 2006; Mills et al., 1993; Natural England, 2012; Rates, 2001; Sanderson et al., 2002; Schaich et al., 2010; Simberloff, 1998). We argue that conservation should not solely focus on threatened or rare species. The characteristics of common species differ from those of rare species (Kunin and Gaston, 1993); however, both are susceptible to population genetic response to habitat fragmentation (Honnay and Jacquemyn, 2007). Instead of focusing on just rare and/or a common species (Gaston and Fuller, 2008) at the local or regional scale, more is gained by improving an understanding about which species are vulnerable (i.e. species experiencing loss and not just part of IUCN Red List) locally or regionally (Matthies et al., 2004). With this information, appropriate conservation strategies can be put in place to protect vulnerable plant species (McCarty, 2001; Rands et al., 2010; Root et al., 2003; Thuiller et al., 2005b). This research here is based on the approach that analyses vegetation change using historical records at a local versus national scale. We argue that this is important for the appropriate management of vulnerable plant species and provides a baseline for better projections in the face of climate change (Beissinger and Westphal, 1998; Thuiller et al., 2008).

The area on which this research is focused is West Cornwall (1335 km^2), the south western Peninsula of Great Britain (Fig. 1). West Cornwall and its 'regional identity' is of particular importance to the United Kingdom given its outstanding natural beauty and diverse habitats (i.e. wetlands, headlands, woodlands) as well as its cultural and historical heritage (Cornish hedges, old mining sites, archaeological sites). Furthermore, West Cornwall is suitable for this type of research as it has a good data availability and spatial coverage of historical and current vegetation records (Davey, 1909; NBN, 2013) and climate records.

2. Aims

When concepts of natural and static distributions are more unstable than ever, and when many geographic distributions are likely to show little overlap between current and future distributions (Thomas, 2013), it is becoming increasingly important to understand whether vegetation conservation strategies should aim at local and/or regional scales. Protection of existing ecosystems will be far less expensive than losing them (Cardinale et al., 2012; Purvis and Hector, 2000; Rands et al., 2010), because the loss of species at local and/or regional scale will result in the need to either 'import' or travel to 'benefit' from unique ecosystem services, which will be more costly than having them at hand (Queiroz et al., 2015; Turner et al., 2007). Here, we concentrated on the following three aims. First, we investigated changes in plant species distribution at the local scale. Second, we examined whether changes in plant species distribution over the local scale mirror the changes at the national scale. Third, we sought to identify which plant species were lost from the region in the period since 1900. We

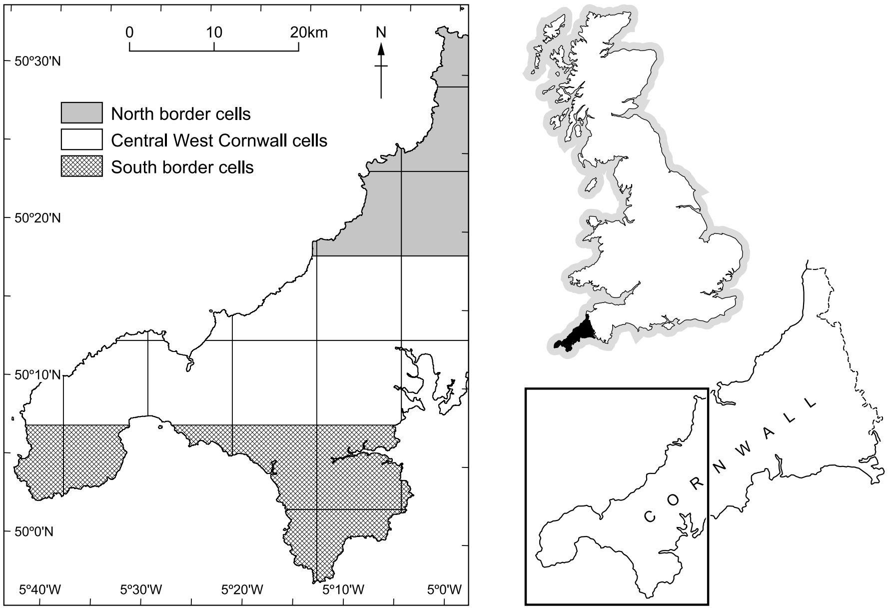

Fig. 1. Study site of West Cornwall divided in three areas: North Border Cells, Central West Cornwall Cells and South Border Cells.

chose not to analyse the gain of plant species post-1900 given that contemporary records have better spatial coverage than historical ones. This could lead to biased results if species gains were measured (e.g. species that might have been present pre-1900, but not recorded, would be mistaken as gain) (Bellamy and Altringham, 2015; Elith and Leathwick, 2007; Graham et al., 2008).

3. Data and methods

This study analysed changes in the local geographic distribution of vegetation over West Cornwall, (Fig. 1). Historical vegetation data (pre-1900) from "The Flora of Cornwall" (Davey, 1909) and contemporary vegetation records (post-1900) were obtained mainly from the "New Atlas of British and Irish Flora" and downloaded from National Biodiversity Network (NBN) online database (NBN, 2013; Preston et al., 2002). Both data sets were used to investigate and map the past and present geographical distribution of 123 plant species over West Cornwall. Historical vegetation records (pre-1900) that were found in Davey's collection (1909), were geo-referenced as accurately as possible using Google Earth and cross-checked with online Ordnance Survey maps (1:2500), (OS, 2010). Specimens which were found to have very ambiguous locality descriptions (e.g. "West Penwith"— which covers a large area) were excluded from the study. Furthermore, species with incorrect taxonomy or synonyms were also excluded from the database and the analysis, and this was consistently followed.

Historical vegetation records (pre-1900) were imported into ArcGIS and the first step was to address the spatial uncertainty of plant species localities and determine the spatial extent of that uncertainty, so that it could be applied to each geo-referenced record of historical vegetation dataset (Lavoie, 2013; Riordan and Rundel, 2014; Rocchini et al., 2011). This spatial uncertainty metric was calculated using a point radius method, developed for historical data without geographic coordinates (Beaman et al., 2004; Guralnick et al., 2006; Wieczorek et al., 2004). To arrive at a suitable radius size to best represent this uncertainty, a maximum distance (from the centre of the species locality to their furthest end) for the localities of 50 random plant species was established using Google Earth. Then the upper quartile of this distance was calculated and found to be 1.5 km. This value was used as an uncertainty radius around the location of each specimen in ArcGIS. Upon creation of 1.5 km uncertainty buffers in ArcGIS, all plant specimens were attributed to the of 10 km grid cells in West Cornwall. To achieve this we used "spatial joint" function in ArcGIS. Contemporary records were imported from the NBN Gateway (NBN, 2013), and also attributed to 10 km grids cells in ArcGIS, to analyse the changes in geographic distribution and loss between contemporary and historical vegetation data.

In the following list, we describe the methodologies that were used to address each of the three aims:

1. Our first aim was to analyse changes in geographical distribution over the study area (West Cornwall) (Fig. 1). To analyse changes in plant species geographic distribution and loss locally the study site (West Cornwall) was divided into three areas: North Border Cells (NBC), Central West Cornwall Cells (CWCC) and South Border Cells (SBC). These terms will be used throughout this study (Fig. 1). Such division was made to show changes in species distribution and species loss locally, at their southernmost range in the United Kingdom as poleward movement could reduce their national range size (Chen et al., 2011; Francisco-Ortega et al., 2000; Hampe et al., 2005; Kueffer et al., 2014; Lesica and McCune, 2004), and minimise their adaptation and migration potential (Aguilar et al., 2008; Gaston and Fuller, 2009; Imbach et al., 2011;

Table 1
Loss of plant species from 10 km grid cells in South Border Cells, Central West Cornwall Cells and South Border Cells. Those in bold/italic are lost species belonging to the IUCN Red List and those in bold are species belonging to the BAP list of species (IUCN, 2014; JNCC, 2010).

South cells-lat. and common name	Central cells-lat. and common name	North cells-lat. and common name
Alchemilla filicaulis subsp. Vestita/no common name	*Anagallisarvensis subsp.foemina/Blue Pimpernel*	*Althaea hirsuta/Rough Marsh Mallow*
Clinopodiumacinos /Basil Thyme	*Carduuscrispus/Welted Thistle*	*Alchemilla filicaulis subsp. Vestita/no common name*
Cystopterisfragilis *Droseraanglica/Great sundew* **Eryngiumcampestre/Filed Eryngo**	*Droseraanglica/ Great Sundew* *Festucaarenaria/ Rush-leaved Fescue* *Legousia hybrid/ Venus's-looking-glass*	*Anagallisarvensis subsp.foemina/ Blue Pimpernel* *Carduuscrispus/ Welted Thistle* *Lavateracretica/ Cornish Mallow*
Festucaarenaria/Rush-leaved Fescue *Legousiahybrida/Venus's-looking-glass* *Lavateracretica/Cornish Mallow*	*Melicanutans/ Mountain Melick*	*Medicagosativa subsp. falcata* *Melicanutans/Mountain Melick* ***Oenanthepimpinelloides/Corky-fruited Water dropwort***
Lycopodium clavatum/ Stag's-horn Clubmoss *Medicagosativa subsp. Falcata/ Sickle medick* *Melicanutans/Mountain Melick*		

Vucetich and Waite, 2003). To achieve this, attributed tables (past vs. present) for each 10 km grid cells within each particular area (i.e. North Border Cells) in ArcGIS, were cross-checked to detect 'species loss' and detect the loss at the local scale between historical and contemporary records. The species that were present in the past but absent in the present were defined as 'species loss' for each particular 10 km grid cell within these three areas. We also tracked which of these species were on the IUCN Red List and BAP (Biodiversity Action Plan-volume 4) list (Natural England, 2012) in order to identify whether the loss within grid cells was related to those species that were most at risk or endangered.

2. Our second aim was to compare changes in plant species geographic distribution at the local scale (West Cornwall) to changes in their distribution at the national scale (Braithwaite et al., 2006; Parmesan, 2006). For this, results from the first objective were used (i.e. species that showed a measured loss at the local scale) and compared to the results of a change at the national scale using data from *Change in the British Flora 1987–2004* (Braithwaite et al., 2006); which identified the changes by looking at (i) national range change in the individual species, (ii) national range change in the species group and (iii) national range change in the broad habitat (Braithwaite et al., 2006). Furthermore, Braithwaite et al. (2006) calculated the change by Change Factor (CF) and this for the national scale was calculated using a t-test with a significant decrease/increase if $p \leq 0.5$, or if $0.05 < p \leq 0.10$ this is considered marginally significant. More on this method was described in Braithwaite et al. (2006).
3. Our third aim was to analyse if any plant species experienced loss across the spatial extent of West Cornwall during the period post-1900. To address this, we analysed which plant species were lost in the post-1900 period from the study area of West Cornwall. In order to achieve this we analysed all 25 grid cells to detect any absence in post-1900 vegetation data. This was examined in a way to cross-check attribute tables of historical (pre-1900) and contemporary vegetation records (post-1900) in ArcGIS.

4. Results

4.1. Aim 1

In this study the loss of plant species was analysed within the SBC, CWCC and NBC. We found that 11 plant species had disappeared from the SBC, 6 species from the NBC and 8 species from the CWCC (Table 1). This first analysis showed a difference in the local geographic distribution of plant species, but more importantly it showed that not only IUCN Red List species or BAP list species were lost locally. For example Field Eryngo (*Eryngium campestare*), was lost from the SBC of West Cornwall. It is a food plant for the Common Snail *(Helix aspersa)* and also this species is important for medical uses (DBIF, 2008; Iglesias and Castillejo, 1999). This species also belongs to the coastal grassland habitat, a priority habitat identified as a part of landscape character associated with Cornwall's biodiversity action plan project (CBI, 2011). Another example is the Rough Marsh Mallow (*Althaea hirsuta*), which was lost at the NBC of West Cornwall. This plant is also important for medical purposes and as part of a priority conservation habitat within Cornwall's biodiversity action plan project and it has been recognised as a nationally rare species (CBI, 2011). Welted Thistle (*Carduus crispus*) was lost from NBC and CWCC, and this species is an important part of the hedges and hedgerows habitat, and also is known for its medical purposes (Zhang et al., 2002). Furthermore, *C. crispus* is important as a primary larval food plant of the Painted Lady *(Vanessa cardui)* (DBIF, 2008).

4.2. Aim 2

We found that 17 plant species were lost from different local sites in West Cornwall from looking at pre-1900 and post-1900 plant species distributions (Table 2). When comparing these results with change at the national scale from Braithwaite

Table 2
Changes in plant species distribution at the national scale for the 17 species that are disappearing from North Border Cells, Central West Cornwall Cells and South Border Cells of West Cornwall. Changes in species group and broad habitats are on the national scale. BH1-Broadleaved, mixed and yew woodland; BH3-boundary and linear features; BH6-Neutral grassland; BH7-Calcareous grassland; BH10-Dwarf shrub heath; BH11, 13 & 14-Wetland habitats; BH12-Bog; BH16-Inland Rock.

Plants name (absence from north/south border and middle), *lat. and common name*	National change individual species level	National change on a species group	National change on Broad habitats level	National importance for conservation
Althaea hirsuta/*Rough marsh mallow*	*no data*	*no data*	*no data*	Protected plant (Schedule 8)[a]
Alchemilla filicaulis subsp. Vestita/*no common name*	*no data*	*no data*	*no data*	Least concern
Anagallisarvensis subsp.foemina/*Blue Pimpernel*	*no data*	*no data*	*no data*	Least concern
Carduuscrispus/Welted Thistle	*decrease*	*no change*	*BH3-increase not significant*	Least concern
Crepisbiennis/*Rough Hawk's-beard*	*increase*	*increase not significant*	*BH6-no change*	Least concern
Clinopodiumacinos/*Basil Thyme*	*sharp decline*	*significant increase*	*BH16-decrease marginally significant, BH1- decrease marginally significant,*	Species of principle importance
Cystopterisfragilis/*Brittle Bladder-fern*	*decrease*	*significant decrease*	*BH16-decrease marginally significant, BH1-decrease marginally significant,*	Least concern
Dianthus armeria/*Deptford pink*	*no data*	*no data*	*no data*	Species of principle importance
Droseraanglica/*Great sundew*	*decrease*	*no change increase not significant*	*BH11,13 and 14-no change BH1-decrease marginally significant,*	Not threatened
Eryngiumcampestre/ *Field Eryngo*	*no data*	*no data*	*no data*	Critically endangered
Festucaarenaria/*Rush-leaved Fescue*	*no data*	*no data*	*no data*	Nationally scarce
Legousia hybrida/*Venus's-looking-glass*	*decrease*	*increase not significant*	*BH3-increase not significant*	Scottish biodiversity list
Lavateracretica/*Cornish mallow*	*no data*	*no data*	*no data*	Nationally rare
Lycopodium clavatum/*Stag's-horn Clubmoss*	*increase*	*no change*	*BH10-significant decrease*	Species of principle importance
Medicagosativa subsp. Falcata/*Sickle medick*	*no data*	*no data*	*no data*	Nationally scarce
Melicanutans/*Mountain Melick*	*decrease*	*significant decrease*	*BH1-, decrease marginally significant BH7-significant decrease, BH16-decrease marginally significant*	Least concern
Oenanthe pimpinelloides/*Corky-fruited Water dropwort*	*increase*	*increase not significant*	*BH6-no change*	Least concern

[a] Nationally rare-protected species (Braithwaite et al., 2006; NBN, 2013).

et al. (2006), the results showed a difference between all three categories; individual species level, group level, and habitat level (Table 2). For 8 out of 17 plant species (Table 2), a national scale comparison was not possible due to the lack of data analysis at the national scale (i.e. *A. hirsuta*/Rough Marsh Mallow) (Braithwaite et al., 2006). However, for 9 plant species a national scale comparison was possible. For example, Basil Thyme (*Clinopodim acinos*), was lost from SBC of West Cornwall and also declined on the national scale (Table 2). Basil Thyme is good indicator of a threatened habitat (the conversion of limestone and chalk pastures to arable land) and is an important food for the larva of the moth *Choleopora tricolour* (DBIF, 2008). Basil Thyme is also classified as of principal importance for conservation at the regional and national scale (Table 2) (CBI, 2011). Another example is the Great Sundew, (*Drosera anglica*) a part of bog habitat and the loss of this species was detected locally and nationally. On a habitat level this species is also a priority habitat for conservation in West Cornwall (Table 2) (DBIF, 2008). Species such as Rush-leaved Fescue (*Festuca arenaria*); a part of coastal habitats and an important host for invertebrates such as *Diptera* and *Lepidoptera*, experienced a decline on a local scale, and is also classified as a nationally scarce species (DBIF, 2008; NBN, 2013). *Festuca arenaria* is important for conservation as loss of this species can endanger butterflies and moths, such as *Danaus plexippus, a* rare migrant from North America. This is nationally scarce but with a particular concentration in Cornwall and Silly Isles. Cornish Mallow (*Lavatera cretica*), is a host plant for *Apion malvae* which is a nationally rare species, an important part of the Cornish ecological landscape and therefore important for regional identity (CBI, 2011; DBIF, 2008; Frank et al., 2012). There were no data on changes for these species in Braithwaite et al. (2006), however, as they are a nationally scarce species it is important to conserve them locally as a local loss (i.e. extinction risk) may turn into a national extinction risk.

4.3. Aim 3

The third aim was to investigate species that had become disappeared from vegetation records analysed from West Cornwall throughout the 20th and 21st centuries. Two species were found as present in historical records (pre-1900) but not in contemporary vegetation data (post-1900). These species were Field Eryngo *(E. campestare),* and Mountain Melick *(Melica nutans)* and they are not part of the IUCN Red list and BAP list species. Mountain Melick *(M. nutans)* is a host plant for the moths *Elachista apicipunctella* and *gangabella*, and a part of priority conservation habitat at the local scale (DBIF, 2008). Two species were extinct from West Cornwall post-1900. Locally 11 species were lost in SBC, NBC lost 8 species and for CWCC loss was detected for 6 species. These 'local differences' in species loss showed that species could be conserved locally and therefore kept locally and in the region of Cornwall.

5. Discussion

A previous study on climatic variability in West Cornwall showed positive trends in mean and maximum temperatures over the 20th and 21st century (Kosanic et al., 2014). The highest positive seasonal trends were detected for spring and autumn mean and maximum temperatures. In contrast to these results there were no positive trends in precipitation over the 20th and 21st century (Kosanic et al., 2014). The changing climatic conditions (mainly related to temperature) in West Cornwall may be causing changes in plant species distributions (Maclean et al., 2015). For example, the data presented here suggest that range reduction and range shifts might occur at the small scale. Such changes may increase species risk of local loss and extinction given their inability to adapt (Davis and Shaw, 2001; Jump and Peñuelas, 2005; Thomas et al., 2004).

Results from this study showed differences in loss of plant species at (1) the local scale, (2) in local vs. national area and (3) across West Cornwall as a whole. These changes may have wider implications. For example, Sickle Medick (*Medicago sativa subsp. Falcate*) (Table 1), a nationally scarce species, was lost from SBC of West Cornwall and such small scale range reductions could lead to habitat fragmentation. This would create isolated populations of smaller sizes and of lower genetic diversity (e.g. bottleneck effect) (Coates, 1992; Frankham, 1995; Pullin, 2002; Spielman et al., 2004; Walther et al., 2002). Furthermore, small fragmented populations with a higher differentiation rate and lower dispersal abilities will have lowered levels of genetic variation (Alsos et al., 2012; Reed and Frankham, 2003). This can happen through genetic drift and inbreeding depression, resulting in reduced population fitness (O'Grady et al., 2006; Reed and Frankham, 2003). We know that populations which experience reduced genetic diversity will consequently have reduced ability to adapt to environmental change (e.g. climate change), (Frankham, 1995; Reed and Frankham, 2003; Spielman et al., 2004). Sickle Medick (*Medicago sativa subsp. Falcata*), (Table 1) as well as other species, for which loss from SBC of West Cornwall was detected, can be identified as marginal populations in the context of the United Kingdom. However, NBC of West Cornwall can also be identified as a marginal population if species present there are lost from SBC and CWCC (Vucetich and Waite, 2003).

The centre periphery hypothesis argues that marginal populations are more vulnerable to extinction as they are genetically less diverse than central ones (Vucetich and Waite, 2003). This is important because species in West Cornwall are marginal populations of those in the wider United Kingdom and therefore have a higher extinction risk. However, some may argue that it is not important to locally protect them given that their presence in other regions ensures that they remain nationally present (Channell and Lomolino, 2000). We disagree with this view for the following two reasons. First, it was found that in some cases a change at the local scale was not identical to its change (e.g. increase) at the national scale in the category of species group (i.e. *C. acinos*-Basil Thyme). In this scenario, while it is problematic that the species experiences a loss locally, its future is secured given that its national range is extending. This may or may not be true depending on the extent of genetic diversity that is lost through local extinctions (Alsos et al., 2012; Dawson et al., 2011). There is evidence to show that genetic diversity is a priority for the protection of biodiversity (Frankham, 1995; Reed and Frankham, 2003; Spielman et al., 2004) and this may be even more critical for species such as *Festuca arenaria* or *Lavatera cretica* (Table 2), that we found were declining locally and nationally listed as rare species. This study also showed that two species (Field Eryngo-*E. campestare,* and Mountain Melick-*Melica nutans*), disappeared from West Cornwall post-1900 and are critically endangered nationally, showing the importance of local conservation. Clearly, local conservation has an important role in the protection of biodiversity. For instance, local scale research on climate variability and vegetation loss is the best starting point to identify the location and presence of micro-refugia (Ashcroft et al., 2012; Kosanic et al., 2014). Micro-refugia are important for biodiversity conservation and such refugium populations, which are characterised by microclimates have been argued to play an important role in protecting species from climate change as well as maintaining genetic diversity by minimising genetic isolation (Ashcroft et al., 2012). This is especially important at present when we still lack research on genetic diversity through the species national and global ranges (Moritz and Agudo, 2013).

Second, local species conservation will ensure the continuation of the cultural identity of a landscape, its regional identity and provisioning with ecosystem services. There is still a big gap in our current knowledge about the role that individual species plays within ecosystem services (Balvanera et al., 2013; Cardinale et al., 2012; Martinez-Harms et al., 2015). This may be because current conservation strategies are mainly directed towards IUCN and BAP species, neglecting the conservation of other 'vulnerable' species but which may be critically important from ecosystem services perspective and as such should be adequately protected. For example, a species such as Cornish Mallow (*Lavatera cretica*) is not IUCN or BAP listed species but is nonetheless a key feature of the Cornwall landscape, is part of the UK cultural identity and is an important medicinal species.

Losing these species at the local or national scale would therefore negatively impact Cornwall as well as the United Kingdom ecosystem services and its landscape (Miller et al., 2014; Natural England, 2012). *Lycopodium clavatum* is another example that may not be listed under the IUCN Red List, but is one of the earliest terrestrial plants on the planet and important for medical use (Pathak et al., 2006). It is regionally endangered due to pasture improvement and afforestation and nationally classified as a species of principal importance (Orhan et al., 2007).

6. Conclusion

This study has demonstrated a need to consider local conservation strategies in ecosystem assessment, using the example of West Cornwall. We identify two reasons why this is important: (1) local loss of plant species can differ to that at the national scale and therefore impact overall species genetic diversity (local–regional–national–global) increasing the risk of extinction; (2) species that disappear locally might be important as 'key species' and as a part of the cultural landscape and help create 'regional identity'. At present, conservation strategies are mainly focused on IUCN/BAP species and, as a result, other locally vulnerable species might be omitted. Currently, the Red list of IUCN does not take into account genetic diversity and it is not certain that only species that are presently defined as 'rare species' are truly endangered (Alsos et al., 2012; Rivers et al., 2014). Therefore more research on local scale genetic diversity is needed. Also, future research needs to be directed towards better identification of individual species and their role in ecosystem functioning, composition and evenness. This is because there is still a lack of knowledge about how biodiversity loss affects biochemical processes, and therefore sets of ecosystem services and interactions between them (Balvanera et al., 2013). Changes in vegetation will impact ecosystem services in West Cornwall and might affect the landscape character of Cornwall (Balvanera et al., 2013; MEA, 2005; Natural England, 2012; Schaich et al., 2010). However, it is still unknown to what extent changes in ecosystem composition and functioning affects ecosystem services (Balvanera et al., 2013). In order to minimise these uncertainties more local scale interdisciplinary research is needed linking biodiversity loss, ecosystem functioning and ecosystem services and regional identity (e.g. cultural landscape), using the same spatio-temporal scales (Balvanera et al., 2013; Schaich et al., 2010).

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