Tourism and recreation: a common threat to IUCN red-listed vascular plants in Europe

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Abstract

Tourism and recreation are large industries employing millions of people and contribute over US$2.01 trillion to the global economy. Unfortunately they also have diverse and sometimes severe environmental impacts affecting many species, including those that are rare and threatened. To assess the extent to which these industries threaten vascular plants, we reviewed data in the IUCN Red List for 462 Critically Endangered, Endangered and Vulnerable European species. Tourism and recreation were listed as threatening 42% (194 species) of these species from across 50 families, mostly herbs (70%). They were listed as threatening plants in 9 of the 10 bioregions in Europe and in 25 of the 40 countries assessed. Popular tourism destinations such as the Canary Islands (41 species) and mainland Spain (40 species) had the greatest diversity of species listed as threatened by tourism and recreation. The most common of these threats were trampling (61 species), plant collection (59), the maintenance/construction of tourist infrastructure (43) and habitat degradation due to the urbanisation of tourist sites (13). Additional species assessments and more research on the impacts of tourism and recreation may add to these values. It is clear that these industries pose an important threatening process on plants in Europe based on the IUCN Red List data and hence deserve greater recognition in terms of research, conservation and management.

Key Words

Endangered species, vegetation trampling, plant collecting, infrastructure impacts, Mediterranean flora

Introduction

Tourism and recreation are large, rapidly expanding global industries (Cornelissen 2005; McCool and Moisey 2009; WTTC 2012). During 2011 there were 983 million tourist arrivals worldwide; up 4.6% from 2010 (UNWTO 2012). In Europe, tourism and recreation contributed 8% to gross domestic product in 2011, with an expenditure of >US$1,700 billion and the provision of nearly 10 million jobs

(WTTC 2012). In the same year Europe experienced the most rapid growth in tourism globally, receiving 504 million tourist arrivals; over half of all international tourist arrivals worldwide (UNWTO 2012). This growth is likely to continue with tourist arrivals predicted to reach 628 million by 2022 (WTTC 2012). Within Europe, tourism is highly concentrated in a few particular hotspots with the majority of international arrivals in the Mediterranean (Amelung and Viner 2006).

The benefits of tourism and recreation come with costs including those from a range of negative environmental impacts on water, soil, animals and plants (Liddle 1997; Myers et al. 2000; Van der Duim and Caalders 2002; Butchart et al. 2010; Steven et al. 2011). Damage to plants includes obvious effects of vegetation removal and changes to soils during the construction and maintenance of tourist and recreational infrastructure such as coastal resorts, golf courses and ski-runs (Buckley et al. 2000; López-Pujol et al. 2003; Peñas et al. 2011). However, even comparatively low-key nature-based activities such as hiking can trample plants reducing vegetation cover, biomass and height (Liddle 1997; Cole 1995; Cole 2004; Pickering et al. 2011). Some visitors to natural areas harvest flowers and other plant parts threatening charismatic species such as rare orchids (Ballantyne and Pickering, 2012a). In addition, there are other less obvious impacts such as tourists spreading weeds and pathogens, altering fire regimes and degrading habitat quality and functioning (Benninger-Truax 1992; Kelly et al. 2003; Buckley et al. 2004; Pickering and Mount 2010; Müllerová et al. 2011). As a result, sensitive plant communities and species may decline while resistant species such as weeds dominate modified ecosystems (Liddle 1997; Cole 2004; Leung and Marion 2000; Pickering and Hill 2007a; Hamberg et al. 2008; Pickering et al. 2010; Monz et al. 2010). These impacts can be particularly severe for species and communities already threatened with extinction (Kelly et al. 2003; Lavergne et al. 2005; Rossi et al. 2009; Moxham and Turner 2011).

Despite such well recognised environmental impacts, there is limited specific, experimental and quantitative research on the impacts of tourism and recreation on threatened plants (Pickering and Hill 2007a; Ballantyne and Pickering 2012a). A few exceptions include work in the USA (Maschinski et

al. 1997), Spain (Peñas et al. 2011) and Italy (Fenu et al. 2013). The majority of available information is observational, and this data is often used within threatened species listings and for comparative reviews. These listings have been drawn upon for comparing threats to plant families (Ballantyne and Pickering 2012a) as well as threats to plant species within countries (Kelly et al. 2003), but few have used them to assess impacts to plant species across larger continents or bioregions.

Europe has high biodiversity including around 20,000 species of vascular plants (Euro+Med Plantbase 2012), many of which are endemic and many of socio-economic value (Kell et al. 2008; Sharrock and Jones 2009; Bilz et al. 2011). With the cessation of traditional farming practises and the increase in intensified modern agriculture and urbanisation, populations of many plant species are declining (Luijten et al. 2000; Walker et al. 2004; Raijmann et al. 2006; Peñas et al. 2011; Bilz et al. 2011). By 1997, around 3,250 species (30% of them from Spain) had been listed as threatened to some degree (Walter et al. 1997) and today 650 species are documented as extinct or facing extinction (Planta Europa, 2008).

The contribution of tourism and recreation to this process is not widely recognised nor addressed in conservation policy documents such as the current European Strategy for Plant Conservation. A few reports (Montmollin and Strahm 2005; Bilz et al. 2011) briefly mention tourism and recreation as an important threat and highlight that the expansion of these industries must be closely monitored and managed if they are to develop sustainably.

Here we advance on this knowledge by reviewing the extent to which tourism and recreation threaten IUCN red-listed European plants. Using the European database for the International Union for the Conservation of Nature (IUCN), we assess: i) the number of species threatened by tourism and recreation, ii) where these species are threatened, iii) the types of plants most at risk, iv) the common types of threats from tourism and recreation and v) the implications for future tourism, recreation and plant conservation in Europe.

Methodology

Critically Endangered, Endangered and Vulnerable vascular plant species and subspecies from Europe were identified from the IUCN Red List (available at http://www.iucnredlist.org/) during April and May 2012. In the current study we used 'Europe' to refer to the 10 million km2 of continental land and islands that extends from the Azores and Iceland in the Atlantic Ocean as far east as the border with Asian Russia, Turkey and the Caucasus and as far north as Svalbard (Norway) and south to the Canary Islands in the Atlantic and Cyprus in Mediterranean Sea. Within this area there are 10 recognised bioregions: Alpine, Atlantic, Black Sea, Boreal, Continental, Macaronesia, Mediterranean, Pannonian, Steppe and Arctic (European Commission 2012). We did not look at species from Turkey and Russia as their floras are also largely part of the Asian region. The Spanish and Portuguese island territories of Macaronesia, however, were included as they form part of the European geopolitical area. National level assessments and other red lists were not used for this initial listing as: i) a species may be threatened in one country but not throughout its entire distribution, ii) there are inconsistencies in the classification of threat statuses among national lists and iii) they often lack information on threatening processes for individual species (Sharrock and Jones 2009; Bilz et al. 2011).

For each species identified on the IUCN Red List as native to Europe, information was entered into a database including scientific and common names (incl. synonyms), growth-form, IUCN status, population trend, listing year, native distribution (countries), whether the species was a national or regional endemic, habitat type and bioregion. The Angiosperm Phylogeny Group III system was consulted for information on each species' family (Angiosperm Phylogeny Group, 2013). Growth form was determined either from the in-text IUCN profile information for each species or by researching each species in online herbaria or botanical journals. For those species whose distribution overlapped two or more bioregions, the one with the majority of populations was used. Furthermore, plants were only listed in the Alpine bioregion if they were recorded growing between

the tree-line (roughly 1,800m) and the permanent snow line (roughly 2,500m) of Europe's Alps, Carpathians, Pyrenees and Apennines.

Using the details provided within the IUCN Red List, information about tourism and recreation as a threatening process was entered for each species. The criteria we used for listing tourism as a threat were either that the terms 'tourism' and/or 'recreation' were specifically stated as a threat in the Red List, or if one or more populations of the species were stated to be directly threatened by tourism and recreation activities, impacts or infrastructure. Plant collecting was included as a threat only if the listing stated that the plants were being collected by visitors, tourists or enthusiasts and not for medicinal or commercial purposes and the populations where they were being collected were in protected areas or tourism hotspots. Despite tourism and recreation contributing to the spread of weeds and pathogens (Pickering and Mount 2010; Pickering and Hill 2007a), we did not include these types of threats in our analysis because detailed information was not provided on whether they were a result of tourism or recreation. Similar IUCN Red List-based methods have also been used for other comprehensive reviews on the threats, and benefits, of tourism and recreation toward birds, frogs and mammals (Steven et al. 2011; Morrison et al. 2012; Buckley et al. 2012).

Initially, 425 species were identified as threatened by tourism and recreation based on the IUCN Red List, but when this was cross-checked with the European Red List of Vascular Plants (Bilz et al. 2011) an additional 64 species were identified that had IUCN threat profiles but which were not identified using the search engine, and an additional 59 species were identified which did not have IUCN profiles but were listed as threatened within Europe under EU or regional policy instruments (namely CITES, EU Habitats Directive, Bern Convention and EU Wildlife Trade Regulation). These species were often not restricted to Europe and/or were subspecies for which official nomenclature is ambiguous (e.g. *Anchusa crispa* subspecies). Of this expanded list of 548 species in the database, the 59 species without IUCN profiles and a further 27 species which lacked information on threats were excluded from further analysis leaving a final total of 462 species that could be assessed.

Data Analysis

The total number and proportion of species listed by growth form that were threatened by tourism and recreation in Europe was calculated. Chi-square tests were performed to determine whether there were significant differences in threats depending on growth form. The total number of threatened species and number specifically threatened by tourism and recreation were calculated for each country and compared with the size of the national floras, the number of endemics and the percentage of land in protected areas. The numbers of species threatened by different types of tourism or recreational activities, impacts, and infrastructures were also calculated.

Results

Tourism and recreation was considered to threaten 194 (42%) of the 462 species assessed based on the information within the IUCN Red Listings. The terms 'tourism' and 'recreation' were used in the listing documents for 180 of these species and could be inferred based on details of threats for a further 14 species (online resource). Of this total, 136 species were herbs reflecting their high diversity in Europe and the large number of threatened herbs on the IUCN Red List (Table 1). There was only a handful of ferns (2 species) and aquatic plants (5) threatened by tourism and recreation but few of these plants were actually listed by the IUCN anyway. As a result, there was no significant difference among growth forms and in the likelihood that tourism and recreation was a threat among the red-listed species (Chi-square test, $p > 0.05$).

Tourism and recreation threatened a diverse range of plants from 50 families. Those with the most species threatened by tourism and recreation include the Asteraceae (32 species), Orchidaceae (15), Caryophyllaceae (15), Fabaceae (14), Brassicaceae (11) and Poaceae (6). Among the Asteraceae some genera had several species threatened by tourism and recreation including six species of star-thistle (*Centaurea*), four species of rock-centaury (*Cheirolophus*) and three species of everlasting daisy (*Helichrysum*): all from the Mediterranean or Macaronesia. Orchids threatened by tourism and

recreation included four species of vanilla orchid (*Gymnadenia*) from the Alps and four species of helleborine (*Epipactis*) from central Europe. Four sandworts (*Moehringia*) from the Caryophyllaceae family were also threatened by tourism and recreation and all from southern Europe.

The vast majority of species threatened by tourism and recreation were single country endemics (87%) with only 15 species' native distributions extending beyond Europe into North Africa or West Asia. There was a geographical bias in the location of plants threatened by tourism and recreation (Table 2). Many were from the Canary Islands (41 species), mainland Spain (40), Greece (17), mainland Portugal (16), Italy (16), Sardinia (11) and Madeira (11). As these locations are part of the Mediterranean and Macaronesian bioregions, the two bioregions had proportionally more red-listed species threatened by tourism and recreation; 51% and 29%, respectively (Table 3). In contrast there were few species threatened by tourism and recreation in the Alpine (15 species), Continental (12), Steppic (4), Black Sea (4), Pannonian (3), Atlantic (1), Boreal (1) and Arctic (0) bioregions. For the latter 3 bioregions, this partly reflects their naturally low plant diversity.

When the proportion of red-listed species threatened by tourism and recreation was calculated out of the total species listed per country, a different pattern emerged (Table 2). In this case, countries where most, or all, IUCN red-listed listed species were threatened by tourism and recreation included Slovakia (100%), Switzerland (100%), Montenegro (100%), Slovenia (86%), Portugal (82%) and Austria (75%) although all of them, other than Portugal, also had few species listed (Table 2).

A total of 35 species were listed as threatened by tourism and recreation but did not include details specifying how. For those species where details were provided, there were 15 types of activities, 6 impacts and 5 types of tourism and recreation infrastructure listed as threats (Table 4). Two thirds (65) of the species were threatened by more than one activity, impact and/or infrastructure. The most commonly listed threatening activities were collecting plants (59 species), rock-climbing and mountaineering (12), driving recreational vehicles (10), camping/picnicking (5), horse-riding (5), and trail/mountain-biking (3). Among tourism and recreation impacts, those frequently listed were

trampling (61 species), habitat degradation resulting from urbanising tourist sites (13), altered fire regimes (3), physical vegetation damage (3) and erosion by walkers (2). The maintenance and/or creation of tourist infrastructure (including ski-runs, hotels, pools, restaurants and golf-courses) affected 43 species while the construction/maintenance of walking tracks, roads and car-parks for tourism and recreation threatened 16 species.

Plant collection threatened many charismatic and showy plants such as orchids (*Epipactis* and *Gymnadenia*), fritillaries (*Fritillaria*) and daffodils (*Narcissus*) but was also important for other families such as the Fabaceae and Plantaginaceae. Collecting was a threat to 52% of listed bulb or pseudobulb species. Trampling frequently threatened low-growing herbs, sub-shrubs and shrubs including members of the Asteraceae (9 species), Boraginaceae (5), Plumbaginaceae (5), Fabaceae (5) and Campanulaceae (3). The maintenance and construction of tourist infrastructure threatened a wide variety of growth forms and families but particularly daises (Asteraceae, 10 species). Habitat degradation as a result of urbanising tourist sites was a threat for rare grasses (Poaceae) on the Black Sea coast. Driving of recreational vehicles threatened herbs and bulbs such as the plantain *Plantago almogravensis*, the bugloss *Anchusa crispa* and the Corsican Saffron (*Colchicum corsicum*). As would be expected water-sports and riparian activities threatened aquatic plants while rock-climbing/mountaineering threatened cliff-dwelling (rupicolous) species such as *Borderea chouardii.*

Many species threatened by tourism and recreation had populations within publicly-accessible protected areas. For 38 red-listed species, >75% of their remaining populations were in protected areas (supplementary material) with the populations of 19 of them listed as being in rapid decline. Therefore, despite the conservation benefits of many protected areas in mitigating threats such as urbanisation and forestry, tourism and recreation as allowed activities in these locations may yet remain an issue for many red-listed plants.

Discussion

Tourism and recreation poses a significant threat to at least 42% of European IUCN red-listed vascular plants. It is considered to threaten species in 9 of Europe's 10 bioregions and in 25 out of the 40 countries and territories assessed, ranging from Finland in the north to the Canary Islands in the south and from the Azores in the west to the Ukrainian steppe in the east. It is considered to threaten plants from 50 families and a variety of growth forms, predominantly herbs. Even if those species for which threats were inferred are excluded, tourism and recreation were still directly-listed threats for 39% (180) of European red-listed vascular plants.

The number of species identified here may be an underestimate of those currently threatened by tourism and recreation in Europe. We only included species where specific information about threats was included in the listing documents. It may be likely that some listed species for which details about threats were not available, are also threatened by tourism and recreation. In addition, tourism and recreation may threaten species that have not yet been assessed, particularly as some countries and regions in Europe, particularly the Balkans, have not conducted extensive surveys of threats to biodiversity (Griffiths et al. 2004; Convention on Biological Diversity 2008). Furthermore, the political instability of countries such as Kosovo has meant that monitoring threats to biodiversity has not been of primary concern. Further research on the impacts of tourism and recreation on plants is likely to identify more species threatened and more ways in which tourism and recreation threaten them (Kelly et al. 2003; Pickering and Hill 2007a).

Recognition of the generality of threats posed by tourism and recreation is important, as the industry and its impacts are increasing in intensity and spread across Europe (WTTC 2012). For example, more people are now travelling to previously poorly-visited destinations such as the former Yugoslav republics, Albania and northern Cyprus (WTTC 2012; Bramwell 2004; Page and Connell 2009; Doda 2012). These regions have few protected areas and, even where species do occur in such reserves, they are still at risk of increasing disturbance from the rise in visitation.

Without adequate recognition of the magnitude of the problem, it's hard to effectively manage these threats either in-situ or via legislative processes.

Unfortunately, tourism and recreation as threatening processes are not well recognised in many Europe-wide and national policy documents (Secretariat on the Convention on Biological Diversity 2009; CBD 2012a). One of the few exceptions is the European Red List of Vascular Plants (Bilz et al. 2011), where tourism and recreation was listed as the second-most important threat for the species assessed. Many were threatened by the development of tourist infrastructure and activities as well as the wider-scale damage due to urbanisation of coastlines for tourism. Similarly, a report on 50 of the most endangered plants in the Mediterranean bioregion found tourism and recreation developments and coastal urbanisation in general to be the most important threats to plant species (Montmollin and Strahm 2005). However, the report by Bilz et al. 2011 does not give details of exactly how, where and which species are affected by tourism and recreation, and the latter by Montmollin and Strahm 2005 is limited to just 50 species in one bioregion.

The threats from tourism and recreation are not evenly spread over Europe. Here we have shown that tourism and recreation threaten at least 98 species of plants in the Mediterranean bioregion and 56 species in the Macaronesian bioregion of which 86 (44%) were from Spain and its island territories. Tourism and recreation, however, threaten only 4 species each in the Steppic and Black Sea bioregions and 1 each in the Boreal and Atlantic. Three factors may be contributing to the apparent concentration of tourism and recreation threats in the Mediterranean and Macaronesian bioregions. They have high biodiversity, contain many popular tourism destinations, and there is comparatively more information and research effort about threats to species in these bioregions than others in Europe.

The Mediterranean basin contains 25,000 native plant species of which 13,000 are endemic, making it a biodiversity hotspot containing 4.3% of the global flora (Mooney 1988; Médail and Quézel 1997; Myers et al. 2000; Francisco-Ortega et al. 2000; Cuttelod et al. 2008). The Macaronesian region also

has many endemic, rare and threatened species (Bramwell 1990; Bilz et al. 2011). The Canary Islands alone have 570 endemic plants, of which 20% are endangered (Francisco-Ortega et al. 2000). Many are African palaeoendemic relicts that evolved unique lineages on the islands (Cronk 1997).

The Mediterranean is also one of the most visited tourist destinations globally with visitation ranging from 100 million to 246 million tourists annually (Amelung and Viner 2006; Cuttelod et al. 2008). The Mediterranean attracts so many visitors largely due to ease of access for many people from the rest of Europe, its favourable climate and attractive coastline (Davenport and Davenport 2006). The robust growth of Europe's tourism economy during 2011 was largely driven by visitation to the Mediterranean region with Greece, Portugal and Spain attracting the most tourists (UNWTO 2012). Tourism in these places has contributed to the removal of native vegetation through urbanisation of coastlines (López-Pujol et al. 2003; Montmollin and Strahm 2005; Cuttelod et al. 2008) and the construction and use of popular tourism infrastructures such as resorts and golf courses (Fenu et al. 2011; Peñas et al. 2011). Other impacts come from trampling (Andrés-Aballán et al. 2006), plant collecting (Cuttelod et al. 2008) and other types of physical damage such as beach contouring, cleaning and path maintenance (Mus and Rita Larrucea, 2006). Environmental impacts associated with mass tourism and urbanisation along the Mediterranean coast contribute to declines in many species particularly around the popular Iberian peninsula (López-Pujol et al. 2003; Sharrock and Jones 2009; Fady and Conord 2010).

The Macaronesian islands are also very popular, with the Canary Islands receiving 12 million visitors in 2002, which contributed >50% of the islands' GDP (Garín-Muñoz 2006). These islands have one of the most urbanised, crowded coastlines in Europe and the highest road density of all European islands (Gil 2003; Delgado et al. 2007). Due to their isolation, post-settlement change has largely been driven by tourism with pronounced effects on biodiversity from tourist infrastructure and the spread of weeds (Arévalo et al. 2005; Delgado et al. 2007; Arteaga et al. 2009).

The third factor contributing to the apparent geographical bias is the greater research effort ascribed to many western European countries and the limited effort and data from other parts of Europe. For instance, countries such as Bosnia-Herzegovina have high floral biodiversity (including over 30% of entire Balkan-endemic flora) and rapidly increasing tourism and recreation industries (Fady and Conord 2010; Doda 2012; Convention on Biological Diversity 2012b) but the threat status of many species has not been assessed (Sharrock and Jones 2009; Convention on Biological Diversity 2012b). These types of geographical biases due to differential sampling effort affect many international conservation databases and hence the primary targets of many conservation strategies (Hortal et al. 2007; Planta Europa 2008; Secretariat on the Convention on Biological Diversity 2009). Following the hotspot approach (Myers et al. 2000) it is important that we focus on areas of high botanical diversity across the European continent in order to logistically direction conservation approaches for wild plant species. Such an effort will require extensive site surveys of these regions for centres of biodiversity (Pérez-García et al. 2012) as well as hotspots of tourism and recreation impacts. Committing to such an inventory on a continental scale will require scientific rigour as well as political collaboration, but will improve on a largely western-biased, observation-based knowledge as it stands.

There was variation in how tourism and recreation threatens plants in Europe. Trampling by hikers and other visitors threatens at least 61 species. Impacts of trampling by hikers has been documented for many plant species and communities in Europe (Lemauviel and Rozé 2003; Davenport and Davenport 2006; Grunewald 2006; Rossi et al. 2009; Bernhardt-Römermann et al. 2011) as well as other continents (Rickard et al. 1994; Maschinski et al. 1997; Cole 2004; Pickering and Hill 2007b; Pickering et al. 2011). Impacts include direct damage from trampling as well as impacts due to changes in soil ecology such as compaction and alteration of nutrient and hydrological cycles (Cole 2004; Pickering and Hill 2007b; Light and MacConaill 2007). Plants vary in their resistance to trampling and in how rapidly they recover; hence their tolerance to this type of disturbance (Rickard et al. 1994; Leung and Marion 2000; Hill and Pickering 2009). Herbs threatened by trampling in

Europe included the lily *Lilium rhodopeum* in Bulgaria and the pink *Dianthus diutinus* in Hungary. Unfortunately peak visitation to the areas where these species grow coincides with peak flowering reducing seed production and hence threatening population viability (Rossi et al. 2009; Bazos and Petrova 2011; Király and Stevanović 2011). Similarly alpine and upland species such as the stork's-bill *Erodium rupicola* and the daffodil *Narcissus nevadensis* are threatened by trampling because they have peak growth and flowering during summer months. Summer tourism and recreation in mountain regions worldwide is growing and diversifying and this may increase trampling effects on such plants which are often sensitive to disturbance (Liddle, 1997; Buckley et al. 2000; Geneletti and Dawa 2009).

Trampling also threatens many sub-shrubs in Europe including the rock-rose *Helianthemum teneriffae*, the trefoil *Lotus kunkelii* and the rock-centaury Cheirolophus falcisectus reflecting the general low trampling tolerance of woody, sclerophyllous plants (Rusterholz et al. 2004; Andrés-Aballán et al. 2006; Bernhardt-Römermann et al. 2011). Recreational vehicles are a threat to herbs and shrubs in part because of the greater mass load of vehicles compared to other recreational activities such as hiking and climbing (Rickard et al. 1994; Kutiel et al. 2000).

Plant collecting was a particular threat for bulbs and herbs including orchids potentially due to their rarity and aesthetic appeal to enthusiasts (Oldfield 1984; Ballantyne and Pickering 2012a). The collection of orchids by tourists, including botanical tourists, has been documented in Europe and elsewhere and for many different species (IUCN/SSC Orchid Specialist Group 1996; Kelly et al. 2003; Ballantyne and Pickering 2012a). Lilies are especially attractive to collectors and many once-widespread species are becoming increasingly rare in Europe due to intensive collection (Mascarello et al. 2011). Collecting particularly unusual and charismatic flora such as Metlesics' Orchid (*Himantoglossum metlesicsianum*) and the succulent *Euphorbia handiensis* was reported from popular tourist locations in the Canary Islands (Mesa Coello et al., 2004; Marrero Gómez and Carqué Alamo). Such unusual species have particular appeal to botanical tourists and this increases the risk

of harvesting by collectors (Ballantyne and Pickering 2012a). Obtaining exact details of whom, why and when such plants are harvested by visitors is challenging however, due to the illicit nature of the activity (Kelly et al. 2003; Ballantyne and Pickering 2012a).

Rock-climbing and water-sports threatened plants restricted to cliffs (rupicolous) and riparian (riverine) habitats respectively. Climbing on the limestone cliffs of the Jura Mountains in Switzerland, for example, has reduced populations of rare rupicolous herbs and shrubs and in some cases catalysed a shift in composition towards novel, disturbance-tolerant communities (Rusterholz et al. 2004). Here we found that species affected by rock-climbing in Europe included the bedstraw *Galium sudeticum* in Poland, the cat's-ear *Tolpis glabrescens* on Tenerife, the mouse-ear *Cerastium dinaricum* in Slovenia and two catchfly (*Petrocoptis*) species in Spain (Bilz, 2011; Martín Cáceres et al. 2011; Garbajal et al. 2011; Villar et al. 2011). Water-sports and boating threaten the quillwort *Isoetes boryana* in France and the Bodensee Forget-me-not (*Myosotis rehsteineri*) in Austria (Commission of the European Communities, 2009; Lansdown, 2011). Much of the damage to aquatic and riparian plants can be attributed to the effects of wave-action and propeller turbulence on inland waters (Liddle et al. 1980; Vermaat and de Bruyne 1993; Mosisch and Arthington 1998).

A range of plants were threatened by the development and expansion of tourist infrastructure in Europe. The critically endangered herb *Centranthus amazonum* (a valerian) that is endemic to Mount Oliena, Sardinia is reduced to a few populations of just 50-100 plants which are threatened by the development of tourist trails and roads (IUCN Red List 2012). Also on Sardinia, the daisy *Nananthea perpusilla* is threatened by the construction of a campsite on one of its four remaining populations (Jeanmonod and Gamisans 2007). The catchfly *Silene nocteolens*, restricted to Teide National Park, Tenerife is threatened by the creation and use of walking trails (IUCN Red List 2012; Marrero-Gómez et al. 2003). There are just 97 isolated plants of the Canarian endemic tree, *Myrica rivas-martinezii* and they are threatened by infrastructure development and weed introduction (Bañares Baudet et al. 2011). Golf-course expansion contributed to declines in populations of the

Sandarac Gum Tree (*Tetraclinis articulata*) in Spain (Sánchez-Gómez et al. 2012). Golf courses and other resort amenities contributed to declines in other species in Europe, largely as a result of fragmentation which decreases the quality of remaining habitat (Leyva et al. 2006; Peñas et al. 2011). Walking and cycle-track development affects at least 10 European plants in this study, most of which were herbs. Impacts from tracks occur from the destruction of vegetation during construction, from the leaching of trail materials into the surrounding ecosystem over time and from internal habitat fragmentation (Godefroid and Koedam 2004; Müllerová et al. 2011; Ballantyne and Pickering, 2012b).

Tourism and recreation is not always bad for plants, with some conservation benefits arising directly and indirectly including in Europe. One critically endangered species, the soapwort *Saponaria jagelii*, for example, can benefit directly from tourism. Where access is restricted during the plants' flowering season but allowed during seeding, walkers can facilitate seed dispersal within its littoral habitat. In some cases, volunteer and other types of specialist tourism directly contribute to the conservation of rare plants in Europe by protecting them from vandalism and collection (Ballantyne and Pickering 2012a) and via other active conservation measures such as habitat restoration (Halpenny and Caissie 2003). More generally, tourism and recreation, particularly nature-based and eco-tourism, can provide economic and social support for the establishment and funding of protected areas which can help safeguard rare and threatened species (Leung and Marion 2000; Shackley 2004; Hamilton and Hamilton 2006; Buckley et al. 2012).

This work has provided evidence that the industries of tourism and recreation pose great pressures for some of Europe's rarest plants. However, it is important to recognise that these impacts do not act in isolation. Nearly all of the species here described are also threatened by other, more widely researched anthropogenic factors such as agricultural intensification, urbanisation and overexploitation. Europe has seen some of the most drastic modifications of natural ecosystems worldwide and there are a number of documents that illustrate the resultant impacts and what can be done about them (Planta Europa, 2008; Bilz et al. 2011). The Mediterranean in particular has

experienced some of the greatest land-use change and hence, biodiversity loss (Falcucci et al. 2007). We suggest that in order to further improve policy guidance for managing increasing threats, more quantitative and comparative research should be undertaken. In addition to simply listing impacts, sometimes based solely on observational work, frameworks should provide rankings of impact severity for individual threatened species and compare them between threats. If a standardised methodology was employed, such an approach would provide useful, integrated information on a continental basis and highlight which impacts are of greatest concern and where. It is likely, such an approach will take considerable political co-operation, but with increasing concern over biodiversity loss in Europe, it might be increasingly timely to initiate such an effort, using IUCN red-listed plants to 'pave the way'.

Conclusions

Tourism and recreation appear to be common threats to a wide variety of European IUCN red-listed plants, and are likely to threaten other plants in other popular tourism destinations as well. Greater emphasis should therefore be given to minimising the range of negative impacts from unsustainable tourism and recreation use, particularly in biodiversity hotspots such as the Mediterranean. Management plans for protected areas, and recovery plans for red-listed species need to more specifically address these types of threats. Moreover, in order to do so, increasing quantitative and experimental species-specific research should be undertaken to add rigour to the current, often observational-based listings. Finally, as tourism and recreation industries continue to grow in Europe, there needs to be more recognition and reduction of their impacts, particularly if they are to protect their triple bottom line (environmental, social and economic benefits) and reduce their contribution to the endangerment of Europe's flora.

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Table 1: The most common forms of tourism and recreation-related threats in relation to the totals of different growth-forms of red-listed vascular plants listed by the IUCN in Europe. The numbers of species affected by each activity are given in brackets. T&R = threatened by tourism and recreation.

Growth Form	Total	Total threatened by T&R	Most common threats
Tree	26	5	Maintenance/construction of tourist infrastructure (3); Trampling (2)
Shrub	55	11	Trampling (5); Non-specified (4); Collection of plants (3)
Sub-shrub	53	21	Trampling (10); Collection of plants (8); Non-specified (3)
Climber	3	0	Rock-climbing/mountaineering (1)
Herb	289	137	Collection of plants (46); Maintenance/construction of tourist infrastructure (40); Trampling (39); Non-specified (21); Habitat degradation from urbanising tourist sites (10); Walking/cycle-track development (9); Rock-climbing/mountaineering (8)
Succulent	9	6	Collection of plants (4); Trampling (2)
Aquatic	7	5	Water-sports/swimming (1); Leisure fishing (1); Trampling (1); Walking/cycle-track development (1)
Fern	2	2	Collection of plants (1); Trampling (1)
Graminoid	17	7	Habitat degradation from urbanising tourist sites (3); Maintenance/construction of tourist infrastructure (2); Rock-climbing/mountaineering (1)

Table 2: Total number of native and endemic plants per country in relation to the number listed as threatened (equiv. Critically Endangered, Endangered, Vulnerable) on national red lists, the IUCN Red-list and those found to be threatened specifically by tourism and recreation in this study. Proportions of national red-listed species also listed by the IUCN are given.

Country/Territory*	**Total**	**Endemic**	**National red lists**	**IUCN Red List**	**IUCN T&R**	**% national red list on IUCN**	**% of land in PAs**
Albania	3,245	177	363	1	0	0.3	9.8
Austria	2,950	167	1,151	12	8	1	22.9
Belarus	2,100	-	173	0	0	0	7.2
Belgium	1,400	-	448	1	0	0.2	13.8
Bosnia-Herzegovina	4,569	450	63	1	0	1.6	0.6
Bulgaria	3,900	186	158	5	3	3.2	9.2
Croatia	5,347	485	760	7	4	0.9	13
Cyprus	1,738	143	238	19	6	8	10.5
Czech Republic	2,700	-	1,161	10	7	0.9	15.1
Denmark	1,000	-	197	2	0	1	4.9
Estonia	1,500	-	188	0	0	0	20.4
Finland	1,240	-	180	2	1	1.1	9
France	4,700	-	486	20	8	4.1	16.5
Corsica				9	5		
Germany	3,242	85	875	15	4	1.7	42.4
Greece	5,500	1,000	900	34	17	3.8	16.2
Crete				12	4		
Aegean Islands				1	0		
Hungary	2,200	695	605	8	6	1.3	5.1
Iceland	483	-	52	0	0	0	19.7
Ireland	900	-	68	1	0	1.5	1.8
Italy	6,711	1,314	1,020	28	16	2.7	15.1
Sicily				21	6		
Sardinia				18	11		
Capraia				1	0		
Latvia	1,937	-	426	0	0	0	18
Liechtenstein	1,531	-	379	0	0	0	42.4

Lithuania	1,796	-	339	0	0	0	14.5
Luxembourg	1,323	-	354	1	0	0.3	20
Macedonia	3,700	117	500	0	0	0	4.9
Malta	1,200	25	255	4	1	1.6	17.3
Moldova	1,989	-	242	2	1	0.8	1.4
Montenegro	3,250	223	415	1	1	0.2	13.3
Netherlands	1,490	-	335	0	0	0	12.4
Norway	1,253	-	181	2	0	1.1	14.6
Poland	2,468	-	506	10	4	2	22.4
Portugal	3,600	200	254	35	16	13.8	8.3
Madeira				33	11		
Azores				10	5		
Romania	3,700	57	210	4	2	1.9	7.1
Serbia	3,662	165	171	3	2	1.8	6
Slovakia	3,352	-	747	3	3	0.4	23.2
Slovenia	3,175	22	304	7	6	2.3	13.2
Spain	8,500	4,080	1,275	68	40	7.5	8.6
Balearic Islands				15	5		
Canary Islands				119	41		
Sweden	1,638	-	261	4	1	1.2	10.9
Switzerland	3,144	-	1,066	2	2	0.2	24.9
Ukraine	6,086	-	439	18	8	2.1	3.5
United Kingdom	1,756	-	52	5	1	9.6	26.4
Gibraltar				1	1		

*Information on number of species in each country, number of endemic species and number of species on national red-lists gained from most recent National Reports and National Biodiversity and Action Plans under Convention on Biological Diversity (DBD) signatory accessed at http://www.cbd.int/convention/parties/list/ and through information provided by European Information Platform for Plants accessed at http://www.plantaeuropa.org. Andorra, Kosovo, Monaco, San Marino and the Vatican City were not included in this database because they did not have any species profiles native to those regions and are not signatory nations to the CBD. Hyphens denote information that could not be found in the literature or policy documents.

Island territories belonging to signatory countries (e.g. Sardinia, Crete and Madeira) are italicised and apart from the number of plants on the IUCN Red List and tourism threat data, information is maintained within governing country's statistics. Percentage of land in protected areas based on 2010 data issued by the World Bank for terrestrial protected areas (% of total land area) accessed at http://data.worldbank.org/indicator/ER.LND.PTLD.ZS. T&R = number of species threatened by tourism and recreation, PAs = protected areas.

Table 3: Total number of vascular plant species affected by tourism and recreation (T&R) across the 10 European bioregions as set out by the European Commission. The most common tourism and recreation threats are also listed with total number of species affected given in brackets.

Bioregion	Total	Most common threats
Alpine	15	Non-specified (5); Collection of plants (5); Rock-climbing/mountaineering (2)
Arctic	0	n/a
Atlantic	1	Maintenance/construction of tourist infrastructure (1)
Black Sea	4	Habitat degradation from urbanising tourist sites (4)
Boreal	1	Non-specified (1)
Continental	12	Non-specified (6); Trampling (3); Rock-climbing/mountaineering (3); Driving recreational vehicles (2)
Macaronesia	56	Collection of plants (25); Trampling (25); Maintenance/construction of tourist infrastructure (9); Non-specified (5); Walking/cycle-track development (5)
Mediterranean	98	Maintenance/construction of tourist infrastructure (32); Collection of plants (31); Trampling (29); Non-specified (14); Habitat degradation from urbanising tourist sites (8); Driving recreational vehicles (7); Walking/cycle-track development (6)
Pannonian	3	Trampling (3); Horse-riding (1); Para-gliding/ballooning (1)
Steppic	4	Non-specified (4)

Table 4: Total number of IUCN Red-listed European vascular plant species threatened by different types of tourist or recreational activities, impacts and infrastructures.

Threat	**Total**
Non-specified	35
Activities	
Collection of plants	59
Rock-climbing and mountaineering	12
Driving of recreational vehicles	10
Camping/picnicking	5
Horse-riding	5
Water-sports/swimming	3
Winter-tourism/skiing	3
Trail/mountain-biking	3
Picking flowers	2
Game-driving	2
Riding of non-motorised recreational vehicles	2
Beach cleaning for tourists	2
Paragliding	1
Motor-biking/quad-biking	1
Leisure fishing	1
Impacts	
Trampling	61
Habitat degradation as a result of urbanising tourist sites	13
Vegetation damage by tourists	3
Altered fire regimes	3
Erosion by walkers	2
Littering	1
Infrastructure	
Maintenance/construction of tourist infrastructure	43
Walking/cycle-track development	10
Building of tourist roads	3
Tourist car-parks	2
Expansion of golf-courses	1

Supplementary Material – Table 1: List of 194 IUCN Red-listed vascular plant species affected by tourism and recreation in Europe. Threats include those from activities, impacts and infrastructure associated with tourism and recreation. The threats are listed as either 'stated' (i.e. IUCN classification scheme uses the words 'tourism' and/or 'recreation' to describe threats to the species) or 'inferred' (i.e. threats were a result of activities, impacts or infrastructure in a public protected area of tourism hotspot from which the threats were likely derived). Family taxonomy according to Angiosperm Phylogeny Group III system.

Family Name	Species Name	Stated	Inferred	Tourism/recreational impact	Protected Area (PA)	% population in PA	Native Range
Alismataceae	*Alisma wahlenbergii*	X		Non-specified			Finland; Sweden
Amaryllidaceae	*Allium corsicum*	X		Non-specified			Corsica
Amaryllidaceae	*Galanthus reginae-olgae*	X		Habitat degradation resulting from urbanising tourist sites			Greece; Sicily; Montenegro
Amaryllidaceae	*Narcissus alcaracensis*	X		Collection of plants by visitors	Unnamed protected area	?	Spain
Amaryllidaceae	*Narcissus longispathus*	X		Collection of plants by visitors	Unnamed protected area	?	Spain
Amaryllidaceae	*Narcissus nevadensis*	X		Trampling by tourists; collection of plants by visitors			Spain
Amaryllidaceae	*Narcissus nevadensis ssp. enemeritoi*	X		Trampling by tourists			Spain
Amaryllidaceae	*Narcissus radinganorum*	X		Collection of plants by visitors			Spain
Apiaceae	*Apium bermejoi*	X		Trampling by tourists; trail/mountain-biking			Minorca
Apiaceae	*Bupleurum capillare*	X		Winter tourism; maintenance/construction of tourist infrastructure			Greece
Apiaceae	*Bupleurum kakiskalae*	X		Rock-climbing/mountaineering	Samaria Gorge National Park	100	Crete
Apiaceae	*Ferula sadleriana*	X		Trampling by tourists	Unnamed protected area	95	Hungary; Romania; Slovakia

Apiaceae	*Monizia edulis*	X	Collection of plants by visitors	Madeira
Apiaceae	*Thorella verticillato-inundata*	X	Maintenance/construction of tourist infrastructure	Portugal; Spain
Araceae	*Arum purpureospathum*	X	Non-specified	Crete
Apocynaceae	*Vincetoxicum pannonicum*	X	Trampling by tourists; horse-riding; paragliding/ballooning	Hungary
Asparagaceae	*Asparagus arborescens*	X	Non-specified	Canary Islands
Asparagaceae	*Asparagus fallax*	X	Non-specified	Canary Islands
Asparagaceae	*Leopoldia gussonei*	X	Maintenance/construction of tourist infrastructure	Sicily
Asteraceae	*Andryala crithmifolia*	X	Collection of plants by visitors; maintenance/construction of tourist infrastructure	Madeira
Asteraceae	*Aster pyrenaeus*	X	Non-specified	France; Spain
Asteraceae	*Atractylis arbuscula*	X	Habitat degradation resulting from urbanising tourist sites; maintenance/construction of tourist infrastructure	Canary Islands
Asteraceae	*Calendula maritima*	X	Picking of flowers	Sicily
Asteraceae	*Centaurea akamantis*	X	Non-specified	Cyprus

Asteraceae	*Centaurea borjae*	X		Trampling by tourists; habitat degradation resulting from urbanising tourist sites; maintenance/construction of tourist infrastructure			Spain
Asteraceae	*Centaurea corensis*	X		Maintenance/construction of tourist infrastructure			Sardinia
Asteraceae	*Centaurea corymbosa*		X	Rock-climbing/mountaineering			France
Asteraceae	*Centaurea heldreichii*	X		Trampling by tourists; rock-climbing/mountaineering			Greece
Asteraceae	*Centaurea peucedanifolia*	X		Collection of plants by visitors; walking/cycle track development			Greece
Asteraceae	*Cheirolophus duranii*	X		Game-driving	Reserva Natural de Mencáfete; Reserva Natural de Tibataje; Paisaje Protegido de Timijiraque	100	Canary Islands
Asteraceae	*Cheirolophus falcisectus*	X		Trampling by tourists	Reserva Natural Especial de Güígüí; Parque Rural del Nublo	?	Canary Islands
Asteraceae	*Cheirolophus junonianus*	X		Trampling by tourists; driving of non-motorised vehicles, horse-riding; game-driving	Monumento Natural de los Volcanes de Teneguía	100	Canary Islands
Asteraceae	*Cheirolophus metlesicsii*	X		Trampling by tourists; vegetation damage by tourists	Parque Natural de Corona Forestal	100	Canary Islands
Asteraceae	*Crepis purpurea*	X		Non-specified			Ukraine
Asteraceae	*Erigeron frigidus*	X		Trampling by tourists; picking of flowers; vegetation damage by tourists	Parque Nacional de Sierra Nevada	100	Spain
Asteraceae	*Femeniasia balearica*	X		Path clearing			Minorca

Asteraceae	*Helichrysum gossypinum*	X		Building of roads in tourist area	Paisaje Protegido de La Geria; Paisaje Protegido Barranco de Tenegüime; Parque Natural Archipiélago Chinijo	100	Canary Islands
Asteraceae	*Helichrysum melitense*	X		Collection of plants by visitors; maintenance/construction of tourist infrastructure	Fungus Rock Nature Reserve	?	Malta
Asteraceae	*Helichrysum monogynum*	X		Driving of recreational vehicles	Parque Natural Archipiélago Chinijo; Paisaje Protegido de La Geria	100	Canary Islands
Asteraceae	*Lamyropsis microcephala*		X	Maintenance/construction of tourist infrastructure			Sardinia
Asteraceae	*Leontodon microcephalus*	X		Non-specified			Spain
Asteraceae	*Nananthea perpusilla*	X		Maintenance/construction of tourist infrastructure	Natural Reserve de Bouche de Bonifacio; Reserve des Finochiarola	?	Corsica; Sardinia
Asteraceae	*Onopordum carduelium*	X		Trampling by tourists	Reserva Natural Especial Los Marteles	100	Canary Islands
Asteraceae	*Onopordum nogalesii*	X		Collection of plants by visitors; maintenance/construction of tourist infrastructure	Parque Natural de Jandía	100	Canary Islands
Asteraceae	*Pericallis malvifolia*	X		Non-specified			Azores
Asteraceae	*Santolina elegans*	X		Non-specified			Spain
Asteraceae	*Senecio caespitosus*	X		Trampling by tourists; maintenance/construction of tourist infrastructure			Portugal

Asteraceae	*Stemmacantha cynaroides*	X	Collection of plants by visitors	Parque Nacional de Teide	100	Canary Islands
Asteraceae	*Sventenia bupleuroides*	X	Walking/cycle track development	Parque Natural de Tamadaba	100	Canary Islands
Asteraceae	*Tanacetum ptarmiciflorum*	X	Trampling by tourists; collection of plants by visitors	Paisaje Protegido de Las Cumbres; Monumento Natural Riscos de Tirajana	?	Canary Islands
Asteraceae	*Tolpis glabrescens*	X	Collection of plants by visitors; rock-climbing/mountaineering	Parque Rural de Anaga; Reserva Natural Integral de Pijaral	?	Canary Islands
Betulaceae	*Betula pendula var. fontqueri*	X	Non-specified			Spain
Betulaceae	*Betula pendula var. parvibracteata*	X	Maintenance/construction of tourist infrastructure			Spain
Boraginaceae	*Anchusa crispa*	X	Trampling by tourists; driving of recreational vehicles; camping/picnicking; motor-biking; quad biking			Corsica; Sardinia
Boraginaceae	*Echium acanthocarpum*	X	Trampling by tourists	Parque Nacional de Garajonay; Parque Natural de Majona	?	Canary Islands
Boraginaceae	*Echium decaisnei ssp. purpuriense*	X	Trampling by tourists; driving of recreational vehicles			Canary Islands
Boraginaceae	*Gyrocaryum oppositifolium*	X	Trampling by tourists; collection of plants by visitors			Spain
Boraginaceae	*Myosotis rehsteineri*	X	Camping/picnicking; water-sports; swimming			Austria; Germany; Italy; Switzerland
Boraginaceae	*Omphalodes littoralis ssp. gallaecica*	X	Trampling by tourists; car parking; driving of recreational vehicles; removal of beach materials; walking/cycle track development; maintenance/construction of			Spain

				tourist infrastructure			
Brassicaceae	*Arabis kennedyae*	X		Camping/picnicking; building of roads in tourist area	Troodos National Forest Park, Pafos State Forest	100	Cyprus
Brassicaceae	*Barbarea lepuznica*	X		Trampling by tourists	Vršačke Mountain Nature Park, Retezat National Park	?	Romania; Serbia
Brassicaceae	*Biscutella vincentina*	X		Habitat degradation resulting from urbanising tourist sites; maintenance/construction of tourist infrastructure			Portugal
Brassicaceae	*Brassica macrocarpa*	X		Trampling by tourists; maintenance/construction of tourist infrastructure; building of roads in tourist area			Sicily
Brassicaceae	*Cochlearia tatrae*	X		Non-specified			Poland; Slovakia
Brassicaceae	*Coincya rupestris*	X		Non-specified			Spain
Brassicaceae	*Crambe laevigata*	X		Walking/cycle track development	Rural Park Teno	?	Canary Islands
Brassicaceae	*Diplotaxis vicentina*	X		Walking track maintenance			Portugal
Brassicaceae	*Isatis platyloba*	X		Trampling by tourists			Portugal; Spain
Brassicaceae	*Monanthes wildpretii*		X	Collection of plants by visitors	Parque Rural de Anaga	100	Canary Islands
Brassicaceae	*Sinapidendron angustifolium*	X		Maintenance/construction of tourist infrastructure			Madeira
Campanulaceae	*Azorina vidalii*	X		Trampling by tourists			Azores

Campanulaceae	*Jasione lusitanica*	X		Trampling by tourists; horse-riding; removal of beach materials; erosion by walkers; walking/cycle track development; maintenance/construction of tourist infrastructure			Portugal
Campanulaceae	*Musschia wollastonii*	X		Trampling by tourists; collection of plants by visitors			Madeira
Caryophyllaceae	*Arenaria bolosii*	X		Trampling by tourists; collection of plants by visitors; camping/picnicking; altered fire regime; habitat degradation resulting from urbanising tourist sites			Mallorca
Caryophyllaceae	*Arenaria nevadensis*	X		Erosion by walkers	Sierra Nevada National Park	100	Spain
Caryophyllaceae	*Cerastium dinaricum*	X		Rock-climbing/mountaineering			Slovenia
Caryophyllaceae	*Dianthus diutinus*	X		Trampling by tourists	Unnamed protected area in Hungary	80	Hungary; Serbia
Caryophyllaceae	*Dianthus hypanicus*		X	Non-specified			Ukraine
Caryophyllaceae	*Dianthus morisianus*	X		Trampling by tourists			Sardinia
Caryophyllaceae	*Herniaria algarvica*	X		Car parking; driving of recreational vehicles			Portugal
Caryophyllaceae	*Moehringia fontqueri*		X	Walking/cycle track development	Sierra Nevada National Park	100	Spain
Caryophyllaceae	*Moehringia hypanica*	X		Non-specified			Ukraine
Caryophyllaceae	*Moehringia intricata ssp. tejedensis*	X		Collection of plants by visitors	Parque Natrual de Tejeda, Alhama y Almijara	?	Spain

Caryophyllaceae	*Moehringia tommasinii*	X		Trampling by tourists; collection of plants by visitors; rock-climbing/mountaineering			Italy, Croatia, Slovenia
Caryophyllaceae	*Petrocoptis grandiflora*	X		Rock-climbing/mountaineering			Spain
Caryophyllaceae	*Petrocoptis pseudoviscosa*	X		Rock-climbing/mountaineering			Spain
Caryophyllaceae	*Saponaria jagelii*	X		Trampling by tourists; driving of recreational vehicles			East Aegean Islands
Caryophyllaceae	*Silene nocteolens*		X	Walking/cycle track development	Parque National Teide	100	Canary Islands
Chenopodiaceae	*Salicornia veneta*	X		Non-specified			Italy, Croatia, Slovenia
Cistaceae	*Cistus heterophyllus ssp. carthaginensis*	X		Non-specified			Spain
Cistaceae	*Helianthemum teneriffae*	X		Trampling by tourists	Parque Natural de la Corona Forestal	?	Canary Islands
Cistaceae	*Tuberaria major*	X		Vegetation damage by tourists; littering; maintenance/construction of tourist infrastructure			Portugal
Colchicaceae	*Androcymbium rechingeri*	X		Maintenance/construction of tourist infrastructure			Crete
Colchicaceae	*Colchicum corsicum*	X		Driving of recreational vehicles			Corsica
Crassulaceae	*Aeonium balsamiferum*	X		Trampling by tourists; collection of plants by visitors	Parque Rural de Betancuria; Monumento Natural del Malpaís de La Arena; Parque Natural del Archipiélago Chinijo; Paisaje Protegido La Geria	?	Canary Islands

Crassulaceae	*Aeonium gomerense*	X		Collection of plants by visitors	Parque Nacional de Garajonay; Parque Natural de Majona	100	Canary Islands
Crassulaceae	*Aichryson dumosum*	X		Trampling by tourists			Madeira
Cupressaceae	*Tetraclinis articulata*	X		Golf-course expansion			Malta; Spain
Dioscoreaceae	*Borderea chouardii*	X		Rock-climbing/mountaineering	Pyrénées National Park	100	Spain
Dryopteridaceae	*Polystichum drepanum*	X		Collection of plants by visitors			Madeira
Euphorbiaceae	*Euphorbia bourgeana*	X		Altered fire regime	Parque Rural de Anaga; Parque Natural de la Corona Forestal; Parque Nacional de Garajonay	?	Canary Islands
Euphorbiaceae	*Euphorbia handiensis*		X	Collection of plants by visitors	Parque Natural de Jandía	100	Canary Islands
Fabaceae	*Astragalus macrocarpus ssp. lefkarensis*		X	Collection of plants by visitors; maintenance/construction of tourist infrastructure			Cyprus
Fabaceae	*Astragalus maritimus*	X		Habitat degradation resulting from urbanising tourist sites; maintenance/construction of tourist infrastructure			Sardinia
Fabaceae	*Astragalus setosulus*	X		Non-specified			Ukraine
Fabaceae	*Astragalus verrucosus*	X		Maintenance/construction of tourist infrastructure			Sardinia
Fabaceae	*Dorycnium spectabile*	X		Trampling by tourists; collection of plants by visitors	Parque Rural de Teno; Paisaje Protegido de las Siete Lomas	100	Canary Islands

Fabaceae	*Genista ancistrocarpa*	X	Collection of plants by visitors	National Park of Doñana	30	Spain
Fabaceae	*Lotus kunkelii*	X	Trampling by tourists	SCI Jinamar	100	Canary Islands
Fabaceae	*Lotus maculatus*	X	Trampling by tourists; collection of plants by visitors	Paisaje Protegido Costa de Acentejo	100	Canary Islands
Fabaceae	*Lotus pyranthus*	X	Collection of plants by visitors	Parque Natural de Las Nieves	100	Canary Islands
Fabaceae	*Medicago saxatilis*	X	Habitat degradation resulting from urbanising tourist sites			Ukraine
Fabaceae	*Medicago kotovii*	X	Habitat degradation resulting from urbanising tourist sites			Ukraine; Moldova
Fabaceae	*Teline nervosa*	X	Trampling by tourists; collection of plants by visitors; maintenance/construction of tourist infrastructure	Paisaje Protegido de Pino Santo	?	Canary Islands
Fabaceae	*Vicia bifoliolata*	X	Trampling by tourists; collection of plants by visitors			Minorca
Fabaceae	*Vicia costae*	X	Non-specified			Madeira
Gentianaceae	*Centaurium somedanum*	X	Collection of plants by visitors; trail/mountain-biking; walking/cycle track development	Parque Natural de Somiedop; Espacio Natural Valle de San Emiliano	90	Spain
Gentianaceae	*Gentianella bohemica*	X	Non-specified			Austria; Czech Republic; Germany; Poland
Geraniaceae	*Erodium rupicola*	X	Trampling by tourists; walking track maintenance	Parque Nacional de Sierra Nevada; Parque Natural de Sierra de Baza	?	Spain

Iridaceae	*Crocus cyprius*		X	Trampling by tourists	Troodos National Forest Park	?	Cyprus
Iridaceae	*Iris boissieri*	X		Collection of plants by visitors	Parque Natural Baixa Limia-Serra do Xurés; Peneda-Geres National Park	?	Portugal; Spain
Isoetaceae	*Isoetes azorica*	X		Leisure fishing; walking/cycle track development			Azores
Isoetaceae	*Isoetes boryana*	X		Water sports			France
Isoetaceae	*Isoetes fluitans*	X		Waterway clearing			Spain
Juncaceae	*Juncus sorrentinii*	X		Habitat degradation resulting from urbanising tourist sites			Greece; Italy; Sicily; Sardinia; Portugal; Spain
Lamiaceae	*Rosmarinus tomentosus*	X		Rock-climbing/mountaineering; swimming; maintenance/construction of tourist infrastructure	Paraje Natural Acantilados Maro-Cerro Gordo	?	Spain
Lamiaceae	*Sideritis infernalis*	X		Trampling by tourists	Reserva Natural Especial del Barranco del Infierno	100	Canary Islands
Lamiaceae	*Sideritis javalambrensis*	X		Maintenance/construction of tourist infrastructure			Spain
Lamiaceae	*Sideritis marmorea*	X		Collection of plants by visitors	Reserva Natural Especial de Puntallana	100	Canary Islands
Lentibulariaceae	*Pinguicula nevadensis*	X		Trampling by tourists; camping/picnicking	Espacio Natural de Sierra Nevada	?	Spain
Liliaceae	*Fritillaria euboeica*		X	Maintenance/construction of tourist infrastructure			Greece
Liliaceae	*Fritillaria obliqua*		X	Collection of plants by visitors	National Forest Park of Parnitha	?	Greece
Liliaceae	*Fritillaria rhodocanakis*	X		Collection of plants by visitors			Greece

Liliaceae	*Lilium rhodopeum*	X	Trampling by tourists; collection of plants by visitors; maintenance/construction of tourist infrastructure	Unnamed protected area in Bulgaria	?	Greece; Bulgaria
Liliaceae	*Tulipa cypria*	X	Collection of plants by visitors			Cyprus
Marsileaceae	*Marsilea azorica*	X	Trampling by tourists			Azores
Myricaceae	*Myrica rivas-martinezii*	X	Trampling by tourists			Canary Islands
Orchidaceae	*Anacamptis boryi*	X	Collection of plants by tourists			Greece; Crete
Orchidaceae	*Dactylorhiza kalopissii*	X	Collection of plants by tourists; maintenance/construction of tourist infrastructure			Greece
Orchidaceae	*Epipactis greuteri*	X	Non-specified			Austria; Bulgaria; Croatia; Czech Republic; Greece; Italy; Slovenia
Orchidaceae	*Epipactis nordeniorum*	X	Non-specified			Austria; Croatia; Czech Republic; Germany; Hungary
Orchidaceae	*Epipactis placentina*	X	Non-specified			Czech Republic; France; Hungary; Italy; Sicily; Slovenia; Switzerland
Orchidaceae	*Epipactis tallosii*	X	Non-specified			Czech Republic; Hungary; Italy; Slovakia
Orchidaceae	*Goodyera macrophylla*	X	Trampling by tourists; collection of plants by visitors	Natural Park of Madeira	100	Madeira
Orchidaceae	*Gymnadenia archiducis-joannis*	X	Collection of plants by visitors			Austria

Orchidaceae	*Gymnadenia lithopolitanica*	X		Non-specified			Austria; Slovenia
Orchidaceae	*Gymnadenia stiriaca*	X		Non-specified			Austria
Orchidaceae	*Gymnadenia widderi*	X		Non-specified			Austria; Germany; Italy
Orchidaceae	*Himantoglossum metlesicsianum*	X		Collection of plants by visitors; walking/cycle track development; maintenance/construction of tourist infrastructure			Canary Islands
Orchidaceae	*Ophrys argolica*	X		Non-specified			Greece
Orchidaceae	*Orchis sitiaca*	X		Collection of plants by visitors; maintenance/construction of tourist infrastructure			Crete
Orchidaceae	*Platanthera micrantha*	X		Collection of plants by visitors; maintenance/construction of tourist infrastructure			Azores
Plantaginaceae	*Antirrhinum lopesianum*	X		Trampling by tourists; collection of plants by visitors	Parque Natural de Arribes del Duero	?	Portugal; Spain
Plantaginaceae	*Antirrhinum subbaeticum*	X		Collection of plants by visitors			Spain
Plantaginaceae	*Globularia ascanii*	X		Non-specified	Parque Natural de Tamadaba	100	Canary Islands
Plantaginaceae	*Linaria tonzigii*	X		Collection of plants by visitors; maintenance/construction of tourist infrastructure			Italy
Plantaginaceae	*Plantago almogravensis*	X		Trampling by tourists; collection of plants by visitors; driving of recreational vehicles			Portugal
Plantaginaceae	*Plantago famarae*		X	Trampling by tourists	Parque Natural del Archipiélago Chinijo	100	Canary Islands

Plantaginaceae	*Veronica oetaea*	X	Driving of recreational vehicles	National Forest Park of Oiti	100	Greece
Plumbaginaceae	*Armeria sampaioi*	X	Trampling by tourists; skiing			Portugal
Plumbaginaceae	*Limonium calabrum*	X	Trampling by tourists; collection of plants by visitors; maintenance/construction of tourist infrastructure			Italy
Plumbaginaceae	*Limonium dendroides*	X	Collection of plants by visitors	Parque Rural de Valle Gran Rey; Monumento Natural Barranco del Cabrito	100	Canary Islands
Plumbaginaceae	*Limonium fruticans*	X	Trampling by tourists; collection of plants by visitors	Parque Rural de Teno	?	Canary Islands
Plumbaginaceae	*Limonium legrandii*	X	Habitat degradation resulting from urbanising tourist sites			France
Plumbaginaceae	*Limonium perezii*	X	Collection of plants by visitors	Parque Rural de Teno	100	Canary Islands
Plumbaginaceae	*Limonium preauxii*	X	Trampling by tourists; collection of plants by visitors	Paisaje Protegido de Fataga; Parque Natural de Pilancones; Monumento Natural de Aguayro	?	Canary Islands
Plumbaginaceae	*Limonium strictissimum*	X	Trampling by tourists; maintenance/construction of tourist infrastructure	Parc Marin des Bouches de Bonifacio; Réserve Naturelle de l'Etang de Biguglia	?	Corsica; Sardinia
Poaceae	*Agropyron cimmericum*	X	Habitat degradation resulting from urbanising tourist sites			Ukraine

Poaceae	*Agropyron dasyanthum*	X	Habitat degradation resulting from urbanising tourist sites			Ukraine
Poaceae	*Avenula hackelii*	X	Maintenance/construction of tourist infrastructure			Portugal
Poaceae	*Festuca brigantina*	X	Non-specified			Portugal; Spain
Poaceae	*Poa riphaea*	X	Trampling by tourists; rock-climbing/mountaineering			Czech Republic
Poaceae	*Stipa veneta*	X	Maintenance/construction of tourist infrastructure			Italy
Polygalaceae	*Polygala helenae*	X	Non-specified			Greece
Polygonaceae	*Rumex rupestris*	X	Maintenance/construction of tourist infrastructure	Unnamed protected areas in France and the UK	85	France, Spain, United Kingdom
Primulaceae	*Primula apennina*	X	Collection of plants by visitors			Italy
Primulaceae	*Primula palinuri*	X	Collection of plants by visitors; altered fire regime; maintenance/construction of tourist infrastructure			Italy

Pteridaceae	*Pteris incompleta*	X		Trampling by tourists	Natural Park of los Alcornocales; Natural Parks of Garajonay, Majona and Tamadaba; Natural Reserve Tilos de Moya; Guelguen and del Pijaral; Rural Parks de Anaga and de Teno	?	Canary Islands; Gibraltar
Ranunculaceae	*Aquilegia barbaricina*	X		Collection of plants by visitors			Sardinia
Ranunculaceae	*Callianthemum kernerianum*	X		Trampling by tourists; soil-removal for ski runs			Italy
Ranunculaceae	*Delphinium caseyi*		X	Collection of plants by visitors	Karmi State Forest	?	Cyprus
Rosaceae	*Potentilla delphinensis*	X		Collection of plants by visitors	Parc National des Ecrins	100	France
Rosaceae	*Prunus ramburii*	X		Non-specified	Sierra Nevada National Park	100	Spain
Rosaceae	*Sorbus maderensis*	X		Trampling by tourists; collection of plants by visitors; maintenance/construction of tourist infrastructure			Madeira
Rubiaceae	*Galium cracoviense*	X		Trampling by tourists; driving of recreational vehicles; driving of non-motorised vehicles; horse-riding; trail/mountain-biking			Poland
Rubiaceae	*Galium sudeticum*	X		Collection of plants by visitors; rock-climbing/mountaineering	Karkonosze National Park	?	Czech Republic; Poland
Rubiaceae	*Galium viridiflorum*	X		Trampling by tourists; horse-riding	Parque Natural Sierra de las Nieves; Parque Natural Sierras de Tejeda, Almijara y Alhama; Paraje Natural los Reales de Sierra Bermeja	?	Spain

Saxifragaceae	*Saxifraga portosanctana*	X		Collection of plants by visitors			Madeira
Saxifragaceae	*Saxifraga presolanensis*	X		Non-specified			Italy
Saxifragaceae	*Saxifraga tombeanensis*	X		Collection of plants by visitors	Alto Garda Bresciano Park	?	Italy
Scrophulariaceae	*Verbascum litigiosum*	X		Trampling by tourists; habitat degradation resulting from urbanising tourist sites			Portugal
Thymelaeaceae	*Daphne rodriguezii*	X		Non-specified			Minorca
Valerianaceae	*Centranthus amazonum*		X	Maintenance/construction of tourist infrastructure			Sardinia
Violaceae	*Viola athois*	X		Maintenance/construction of tourist infrastructure			Greece