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„Effects of land use management on habitat development and plant diversity of wet grasslands in the biosphere reserve Wienerwald"

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Abstract

Grasslands in central Europe are facing severe threats due to agriculture intensification and abandonment. Wet grasslands are additionally threatened by decreasing soil water contents related to climate change. This development goes in hand with global biodiversity loss, as grasslands belong to the most species rich habitats worldwide when being looked at on small spatial scales. The UNESCO biosphere reserve concept seems to provide fitting solutions to secure the diversity of grasslands, aiming on connecting nature conservation and sustainable economic development. A further strategy is the implementation of agri-environmental schemes to promote sustainable land use. In our study we analysed development of wet grasslands in the biosphere reserve Vienna Woods. We revisited 92 sites belonging to the EU habitat types 6510 (Lowland hay meadows), 6410 (Molinia meadows) and 7230 (Alkaline fens) ten years after a first survey. To detect changes in habitat development we assessed the conservation status on site level according to Austrian schemes and compared the results with the prior study. We further conducted vegetation surveys to get more detailed information on diversity measures and species composition. To test for effects of AES measures on the given variables we compared habitat development and plant diversity between sites with different management regarding mowing regime and specific measures (e.g., amount of nutrient input).

On average, conservation status of the monitored grasslands declined by one rank within the last 10 years in the biosphere reserve. AES management weakened this deterioration although trends were still negative on managed sites. Further no influence of AES management on plant diversity or number of threatened species per plot could be found. Conservation status development was worst on Alkaline fens with an average decrease of – 1.7 ranks and a recorded loss of any assignable FFH habitat on more than 20% of the surveyed sites. AES management showed no detectable effect on development of Alkaline fens. Conservation status of Molinia meadows decreased on average by - 1.1 ranks. Mowing regime showed positive influence on development of Molinia meadows (-0.3 ranks on one-cut meadows compared to -1.5 ranks on two-cut meadows) but did not affect development of the other habitat types. Lowland hay meadows showed the least negative development with an average decrease of -0.7 ranks. Differences in habitat type development could be associated to nutrient and water demand of the different plant communities. Alkaline fens showed decreased moisture values on sites with a change in habitat type, indicating negative effects of decreasing soil water contents. Molinia meadows showed higher nutrient levels on sites with a bad conservation status, indicating negative effects of increased nutrient contents.

We conclude that AES measures in the current uptake are not sufficient to halt habitat deterioration of wet grasslands. Especially Alkaline fens are under acute threat of extinction in the biosphere reserve and seem not to be addressed by AES management due to their small spatial expansion. To stop

negative development additional measures are needed. A result-oriented approach might help in motivating farmers to set adequate actions. We further propose informational campaigns in the biosphere reserve to raise awareness of landowners for the current problems concerning wet grassland development.

Abstract – German

Landwirtschaftliche Intensivierung und Nutzungsaufgabe stellen eine beträchtliche Bedrohung für Wiesen und Grünland in Mitteleuropa dar. Feuchtwiesen sind weiters durch die abnehmende Wasserverfügbarkeit in Böden, bedingt durch den Klimawandel, gefährdet. Diese Entwicklungen gehen Hand in Hand mit weltweiten Biodiversitätsverlusten, da Wiesen zu den artenreichsten Ökosystemen weltweit zählen. Mit dem Ziel Naturschutz und nachhaltige ökonomische Entwicklung zu vereinen, scheint das UNESCO Biosphärenpark-Konzept eine passende Lösung darzustellen, um Grünland-Diversität zu erhalten. Weiters soll der Ausbau von nachhaltiger Landwirtschaft mittels der Implementierung von Agrarumweltmaßnahmen vorangetrieben werden. Für unsere Studie haben wir die Entwicklung von Feuchtwiesen im Biosphärenpark Wienerwald analysiert. Der Fokus lag hierbei auf den FFH-Lebensraumtypen 6510 (Flachland-Mähwiesen), 6410 (Pfeifengras-Streuwiesen) und 7230 (Basenreiche Kleinseggenrieder). Um Veränderungen festzustellen, wurden 92 Standorte, 10 Jahre nach einer ersten Studie, erneut untersucht. Um Änderungen in der Habitat-Entwicklung festzustellen wurde der erhobene Erhaltungszustand mit den früheren Daten verglichen. Weiters wurden Diversitätsmaße im Zuge von Braun-Blanquet-Aufnahmen erhoben. Um Effekte der Agrarumweltmaßnahmen zu ermitteln wurde die Habitat-Entwicklung und Biodiversitätsmaße zwischen Flächen mit unterschiedlichem Management, in Bezug auf Mahd-Regime und anderer spezieller Maßnahmen (z.B. Düngermenge), verglichen.

Im Durchschnitt verschlechterte sich der Erhaltungszustand der betrachteten Wiesentypen innerhalb des letzten Jahrzehnts um einen Grad. Die erfolgten Agrarumweltmaßnahmen konnten diese Entwicklung zwar verlangsamen, aber nicht aufhalten. Weiters hatten die Maßnahmen keinen erkennbaren Effekt auf die erhobene Phyto-Diversität oder die Anzahl an gefährdeten Arten pro Fläche. Basenreiche Kleinseggenrieder zeigten die schlechteste Entwicklung mit einer durchschnittlichen Erhaltungszustand-Verschlechterung um -1.7 Ränge und einem kompletten FFH-Typen-Verlust auf über 20% der Flächen. Die angewandten Agrarumweltmaßnahmen hatten keinen erkennbaren Effekt auf die Entwicklung dieses Lebensraumtyps. Der Erhaltungszustand der Pfeifengras-Streuwiesen verschlechterte sich im Durchschnitt um -1.1 Ränge. Es konnte ein starker Einfluss der Mahd-Häufigkeit auf die Entwicklung des Lebensraumtyps festgestellt werden. Einmähdige Wiesen verschlechterten sich im Schnitt um -0.3 Ränge, während zweimähdige Wiesen sich im Schnitt um -1.5 Ränge verschlechterten. Flachland-Mähwiesen zeigten die am wenigsten negative Entwicklung mit einer durchschnittlichen Erhaltungszustand-Verschlechterung um -0.7 Ränge. Wir konnten Unterschiede in der Entwicklung der Lebensraumtypen in Verbindung zu den unterschiedlichen Nährstoff- und Wasseransprüchen der Pflanzengesellschaften stellen. Basenreiche Kleinseggenrieder sind auf einen hohen Wassergehalt im Boden angewiesen. Hier konnten niedrigere

Feuchtewerte auf jenen Flächen festgestellt werden, die nicht mehr dem ursprünglichen Habitat-Typ entsprachen. Weiters konnten höhere Nährstoffwerte auf Pfeifengras-Streuwiesen mit einem schlechten Erhaltungszustand festgestellt werden. Diese Ergebnisse lassen darauf schließen, dass erhöhte Nährstoff-Werte und verringerte Wasserverfügbarkeit zur Verschlechterung der untersuchten Habitat-Typen beitragen.

Zusammenfassend kann gesagt werden, dass Agrarumweltmaßnahmen im aktuellen Ausmaß nicht ausreichen, um die Zustands-Verschlechterung von Feuchtwiesen aufzuhalten. Vor allem Basenreiche Kleinseggenrieder stehen unter akutem Aussterbe-Risiko im Biosphärenpark Wienerwald. Weiters scheinen Agrarumweltmaßnahmen keinen Einfluss auf die Erhaltung dieses Habitat-Typen zu haben, was in Zusammenhang mit der Kleinflächigkeit von Kleinseggenriedern gebracht werden kann. Um die negative Entwicklung zu stoppen, braucht es zusätzliche Maßnahmen. Ein Ergebnis-orientierter Ansatz könnte Landwirte dazu motivieren das Flächen-Management an die konkreten Habitat-Typen anzupassen. Weiters schlagen wir Info-Kampagnen im Biosphärenpark-Gebiet vor, um das Bewusstsein der Landwirte über die momentan vorhandenen Probleme in der Erhaltung von Feuchtwiesen zu erhöhen.

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Introduction

1 Background and motivation

In 2011 the Biosphärenpark Wienerwald Management GmbH launched a project with the goal of mapping the complete open land within the borders of the biosphere reserve (Staudinger et al., 2014). This project resulted in a huge data set including locations and spatial expansion of all found FFH habitat types (European commission, 2013) within the biosphere reserve, their conservation status according to Austrian assessment schemes (Ellmauer, 2005) and information about the number of Red List species on each site (according to the Austrian Red List after Niklfeld and Schratt-Ehrendorfer (1999)). For my master thesis, which was mainly realised in 2021, ten years after the first assessment, I analysed the development of some of the existing habitat types in the biosphere reserve. Experts of the biosphere management pointed out that especially wet grasslands such as the FFH habitat types 7230 (Alkaline fens) and 6410 (Molinia meadows) seemed to be in bad constitution within the biosphere reserve. We therefor focused the study on these habitat types and additionally analysed the habitat type 6510 (Lowland hay meadows) which represents a less threatened yet species rich habitat in the region.

As a second aspect of the study, we wanted to find out whether agri-environmental schemes such as the Austrian program for sustainable agriculture (ÖPUL) represent a useful tool for sustaining diversity of semi-natural habitats. We therefor compared different types of management regimes regarding their effects on habitat development and species diversity. The site-specific data was kindly provided to the University of Vienna by the Austrian federal ministry for Agriculture, Regions and Tourism.

This study aims to depict the development of some of the most threatened habitat types in Europe within a biosphere reserve over the last ten years and to further analyse the effects of AES measures on this development. Furthermore, we aim to translate the obtained results and conclusions into possible future management approaches for the biosphere reserve management.

2 The biosphere reserve Wienerwald

The biosphere reserve concept was initiated by the Man and Biosphere program (MAB; UNESCO, 1972) of the UNESCO in 1974 with first assignations of biosphere reserves in 1976. The modern concept of biosphere reserves as areas of sustainable development and nature conservation was introduced via the Sevilla conference in 1995 (UNESCO, 1995). Hereby three main functions of biosphere reserves were stated. Namely the conservation of biodiversity in natural and semi-natural ecosystems, sustainable economic development of regional communities and the implementation of a worldwide network of conservation areas to enhance scientific research and education.

To reach these goals biosphere reserves consist of three zones each with a different purpose and character of landscape. Core areas are designated to the conservation of natural systems in the region. Therefor agricultural practice is prohibited or strongly restricted to certain sustainable forms, also access to these areas is often prohibited. Core areas are surrounded by buffer zones which serve as a spatial buffer to urban areas. Here mainly sustainable agricultural land use shapes the landscape. Transition areas, the third zone, are mostly shaped by urban areas. In these areas the concept of sustainable economic development should be promoted for example via model projects UNESCO, 1995).

The biosphere reserve Vienna Woods is one of four officially recognized biosphere reserves in Austria. It was officially designated in 2005 and comprises more than 1000 km² of land. More than 50 communities in Lower Austria with a total of 815.000 inhabitants are situated within the biosphere reserve. 81% of the area is designated as Natura2000 conservation sites and 15 strict nature reserves can be found within the borders of the Vienna Woods (URL 1). Out of the 1050 km² of land, 64% are designated as transition areas. The core areas are solely covered by forests and make up for 5% of the area. The dominating forest type in the region are beech forests. The buffer zones make up for 31% of the area and are dominated by meadows in the western and central parts, dry grasslands on the eastern borders and viticulture in the northern parts of the biosphere reserve (URL 3). Wet grasslands observed in our study were all located in buffer zones.

3 Original study

In 2011 the Biosphärenpark Wienerwald Management GmBH launched a project by the name of "Kartierung der Biotoptypen und der FFH-Lebensraumtypen im Offenland des Biosphärenpark Wienerwald", aiming to map all biotope types and FFH habitat types in the open land within the borders of the biosphere reserve (Staudinger et al., 2014). The main motivation was to get an overview over the region's valuable natural resources. Further the assessed habitat types should serve as additional information to adapt the current placement of buffer zones within the biosphere reserve. An additional goal was to create a so called "Landschaftskonto" meaning a collection of valuable nature sites in bad constitution and with a potential for restoration. These could then be proposed to regional communities as possible compensation areas for environmental impact assessments in the course of larger projects (European commission, 2011).

To account for regional characteristics a catalogue of biotopes was created following the Red List of biotopes for Austria of Essl et al. (2004,2008) and Traxler et al. (2005). Furthermore, for a precise distinction of the region's grasslands a field determination key of Willner et al. (2013) was incorporated in the catalogue.

The field study was conducted from 2011 to 2013. For grasslands on which this study is focused the biotope type or if applicable the FFH habitat type was determined and the conservation status was assessed according to Ellmauer et al. (2005). Also, sites were assigned as "Top-sites" if more than 10 threatened species according to the Austrian red list (Niklfeld and Schratt-Ehrendorfer, 1999) were found. In some cases a list of found vascular plant species for the site was created although these are not complete due to lack of time. All surveyed sites were included in a GIS-layer with the additional information.

4 Studied habitat types

6510 – Lowland hay meadows - Ranunculo repentis – Alopecuretum pratensis

"Lowland hay meadows" as classified by the EU habitats directive (European commission, 2013) cover a range of abiotic site conditions and combine a few plant associations. For this study, focused on wet grasslands, we therefor only considered the association *Ranunculo repentis – Alopecuretum* which is found on wetter soils compared to other communities of the habitat type. According to Ellmauer (2005) 6510 meadows are found at colline to submontane altitudes. Soil nutrient contents are intermediate (mesotrophic) and the characteristic plant community tolerates low to medium amounts of fertilizer input. Mowing regime differs from one to typically two to three cuts per year. Productivity is low to intermediate with an average hay yield of 3000-6000 kg/ha/a (Ellmauer, 2005).

Due to low or medium nutrient contents in the soil herbaceous species are well established in the community. Dominant grasses are the eponymous meadow foxtail (*Alopecurus pratensis*) which is well adapted to wet soils and the tufted grass (*Holcus lanatus*). Common species in the herbaceous layer include *Ajuga reptans*, *Lysimachia nummularia*, *Cirsium oleraceum* and the Austrian Red List species (after Niklfeld and Schratt-Ehrendorfer, 1999) *Lychnis flos-cuculi* (Willner et al., 2013; Mucina et al., 1993). With increasing amount of nutrient input grasses such as *Dactylis glomerata* get more abundant and herbaceous species are repressed (Ellmauer, 2005).

The relevant criteria for conservation status assessment according to Austrian schemes (Ellmauer, 2005) are patch size (typically 0.1 to 3 ha), species composition, availability of characteristic habitat structures (e.g., ratio between herbaceous and gramineous species) and abundance of disturbance indicators (mostly neophytes and ruderal vegetation). If species composition is ranked C the overall conservation status will be always ranked C thereby giving this factor more importance. The detailed scheme can be found in Appendix 1 (*Fig. A2*).

Fig. 1. *Lowland hay meadow belonging to the association "Ranunculo repentis-Alopecuretum pratensis"; Located in the vicinity of Alland, Lower Austria; late spring aspect; ©Elias Kapitany*

6410 – Molinia meadows – Succiso – Molinietum

Molinia meadows on calcareous, peaty or clayey-silt-laden soils (European commission, 2013) are accounted as low-productivity grasslands with average hay yields of 1500-3000 kg/ha/a. The habitat type is found on wet to intermittently wet soils in colline to montane altitudes (Elllmauer, 2005). Nutrient contents are typically lower than on 6510 meadows (oligotrophic to mesotrophic). Historically these meadows were mowed only once a year in early autumn due to low productivity and wet soil conditions. The gained hay was used in stables over winter (Mucina et al., 1993).

Many of the characteristic species such as the eponymous purple moor-grass (*Molinia caerulea*) depend on a late mowing regime to gain enough nutrients before winter. Species composition varies between wet forms (characterised by fen species such as *Carex davalliana* and *Valeriana dioica*) and drier and more nutrient rich forms (e.g., *Cirsium rivulare, Trollius europaeus*; Ellmauer, 2005). Characteristic species according to Willner et al. (2013) are for example *Galium boreale, Betonica officinalis, Succisa pratensis* and *Selinum carvifolia*.

The relevant criteria for conservation status assessment are patch size (typically 0.1 to 1 ha), species composition, soil hydrology, availability of characteristic habitat structures (e.g., ratio between herbaceous and gramineous species) and abundance of disturbance indicators (mostly neophytes and species adapted to nutrient-rich conditions). Hereby the same importance for species composition is implied as in 6510 meadows. Detailed scheme in Appendix 1 (*Fig. A1*).

Fig. 2. *Molinia meadow belonging to the association "Succiso-Molinietum"; Located in the vicinity of Laaben, Lower Austria; Characteristic light green cespitose growth of the eponymous Molinia caerulea is visible left to the centre of the picture; late spring aspect; ©Elias Kapitany*

7230 – Alkaline fens – Caricetum davallianae

In contrast to the previous habitat types, alkaline fens are accounted to natural grasslands by Mucina et al. (1993) and theoretically do not need any management. Alkaline fens are characterised by very nutrient-poor and at least partly water-logged soils although unlike in raised bogs the main water source is groundwater. Being mostly built up by small herbs and sedges alkaline fens show very low productivity. Vertical distribution ranges from planar to submontane altitudes in Austria (Ellmauer, 2005).

The typical species composition is characterized by low growing gramineous species, i.e., mainly sedges and rushes and low growing herbs. Depending on water and nutrient content in the soil species of nutrient richer meadows such as *Cirsium rivulare* or *Molinia caerulea* can become more abundant (Ellmauer, 2005). Characteristic species are for example *Carex davalliana, Carex hostiana, Valeriana dioica* and *Eriophorum latifolium* (Willner et al., 2013).

The relevant criteria for conservation status assessment are hydrology, vegetation structure and abundance of disturbance indicators (mostly ligneous plants and species adapted to nutrient-richer conditions). To account for the importance of soil water content the overall conservation status will always be C if hydrology is ranked C (Ellmauer, 2005). Detailed scheme in Appendix 1 (*Fig. A3*).

Fig. 3. *Alkaline fen belonging to the association "Caricetum davallianae"; Located in the vicinity of St. Corona am Schöpfl, Lower Austria; Characteristic community assemblage with a well-developed population of the orchid Dactylorhiza majalis in violet; late spring aspect; ©Elias Kapitany*

Publication manuscript

1 Introduction

Natural and semi-natural grasslands belong to the most diverse terrestrial ecosystems worldwide considering small spatial scales (Wilson et al., 2012) and play an especially important role for Europe's species and habitat diversity (Veen et al., 2009). However, most of these habitats are facing an increasing number of threats which can be observed worldwide (e.g., Jarvis et al., 2009; Török et al., 2018; Habel et al., 2013). Being mostly dependent on human management grasslands are nowadays both threatened by agricultural intensification as well as agricultural abandonment (Aune et al., 2018). For wet grasslands in particular climate change is a further big player as increasing temperatures and prolonged periods of drought can lead to reduced ground water levels and reduced water availability in general (Dawson et al., 2003; Thompson et al., 2009; Joyce et al., 2016). As the persistence of most central European grassland is prone to agricultural land use the conservation of its biodiversity cannot be accomplished via process protection areas such as IUCN national parks (IUCN, 1994). A possible solution can rather be found in the extensification of agricultural land use (e.g., Schley and Leytem, 2004; Wilson et al., 2003).

The UNESCO Biosphere Reserve concept seems to be a proper tool in conservation of semi-natural landscapes as it aims to connect biodiversity conservation and sustainable economic development and land use (UNESCO, 1996). In Austria the Biosphere Reserve Vienna Woods (BPWW), known for its high biodiversity due to its mosaic of wood- and open land, plays an important part in conserving grassland-habitats. From 2011-2013 the BPWW management GMBH conducted a comprehensive survey of the open land within the BPWW to get more detailed knowledge on the natural inventory of the region and the conservation status of the existing EU habitat types (Staudinger et al., 2014; European commission, 2013). On an area of more than 1050 km² more than 17 types of meadows can be found (URL 1; Willner et al., 2013). Additionally in a survey of Pfundner and Sauberer (2009) focusing on grassland sites within the biosphere reserve more than 700 vascular plant species were identified for the area.

Another approach to conservation of grassland biodiversity is the implementation of agri-environmental schemes (AES) which run under the name of ÖPUL in Austria. As of 2019, 83,3% of all registered Austrian farms took part in the ÖPUL program receiving a total of € 450,4 million in subsidies (BMLRT, 2020). By participating farmers are obliged to abide by certain standards in their agricultural practices. Additional subsidies can be obtained via several additional management measures (BMLRT, 2015a; BMLRT, 2015b). Especially measures like a "delayed first haycut" or "renouncement/reduction of fertilizers" might have a positive effect on semi-natural grasslands. However, the effectiveness of

AES is largely disputed and direct effects on grassland biodiversity seem to be rather week (Hülber et al., 2016; Wilson et al., 2007).

Given the recent trends in agricultural practice and its effects on biodiversity in Europe (e.g., Stoate et al., 2009) this study aims at depicting changes in the conservation status of three grassland types within the biosphere reserve Vienne Woods ten years after a first assessment (Staudinger et al., 2014) and to further evaluate effects which Austrian AES measures might have on patch development and phyto-diversity. We focused on mesic to wet grasslands belonging to the EU habitat types 6510 – "Lowland hay meadows", 6410 – "Molinia meadows" and 7230 – "Alkaline fens" (European commission, 2013). All three types are endangered in central Europe and were assigned with a bad conservation status and future prospects (Unfavourable - U2) for Austria according to the latest national article 17 report (Ellmauer et al., 2020). Especially habitat types 6410 and 7230 are facing severe threats up to acute risk of extinction in several EU-countries (Topic and Stancic, 2006; Paal, 1998; Wójcik and Janicka, 2016).

The following questions shall be addressed: (1) Are there significant changes in conservation status on patch level for the assessed habitat types within the last 10 years? Hereby we expect patches belonging to the habitat type 6510 to be in better condition as they are less susceptible to agricultural intensification (e.g. mowing regime and nitrogen input (Ellmauer, 2005)). (2) Do different AES measures affect patch development and diversity measures and are there differences between the habitat types? (3) Do AES measures affect the number of threatened species per site and are there differences between habitat types?

2 Methods

2.1 Study area and original survey

The Biosphere Reserve Vienna Woods is located at the foothills of the north-eastern limestone alps at altitudes reaching from ~200 to ~900 m a.s.l. Mean annual temperature ranges from 6°C to 10°C and mean annual precipitation ranges from 600mm to 900mm. In total the biosphere reserve covers an area of 1050 km² of which around 60% are covered by forest (with dominance of beech and oak-hornbeam forests). Although only covering 10% of the area grasslands play an important part for the region's landscape diversity (e.g., Willner et al., 2013).

Our survey was conducted on 92 sites which have been previously assessed from 2011 to 2013 (Staudinger et al., 2014). Available data concerned the EU habitat type, conservation status on site level and the information whether more than 10 threatened species (according to the Austrian Red-List after Niklfeld and Schratt-Ehrendorfer (1999)) had been found on the site ("Top-Sites"). We focused on mesic to wet grasslands belonging to the EU habitat types 6510, 6410 and 7230. To test for effects of AES measures six categories regarding mowing regime and specific management measures were derived from data provided by the Federal Ministry for Agriculture, Regions and Tourism. These were: One-cut meadows, Two-cut meadows, One-cut + Conservation measure (WF), Two-cut + conservation measure, Two-cut + Diversity measure (DIV), No AES measures. For patches assigned with the DIV-measure a delayed first hay cut, removal of mowed material and renouncement of pesticides and fertilizers is obligatory. For patches assigned with the WF-measure individual measures like the above stated are contractually defined. For each habitat type and category five patches were chosen via random sampling (the group “6510 – One-cut meadow” was excluded due to lack of cases).

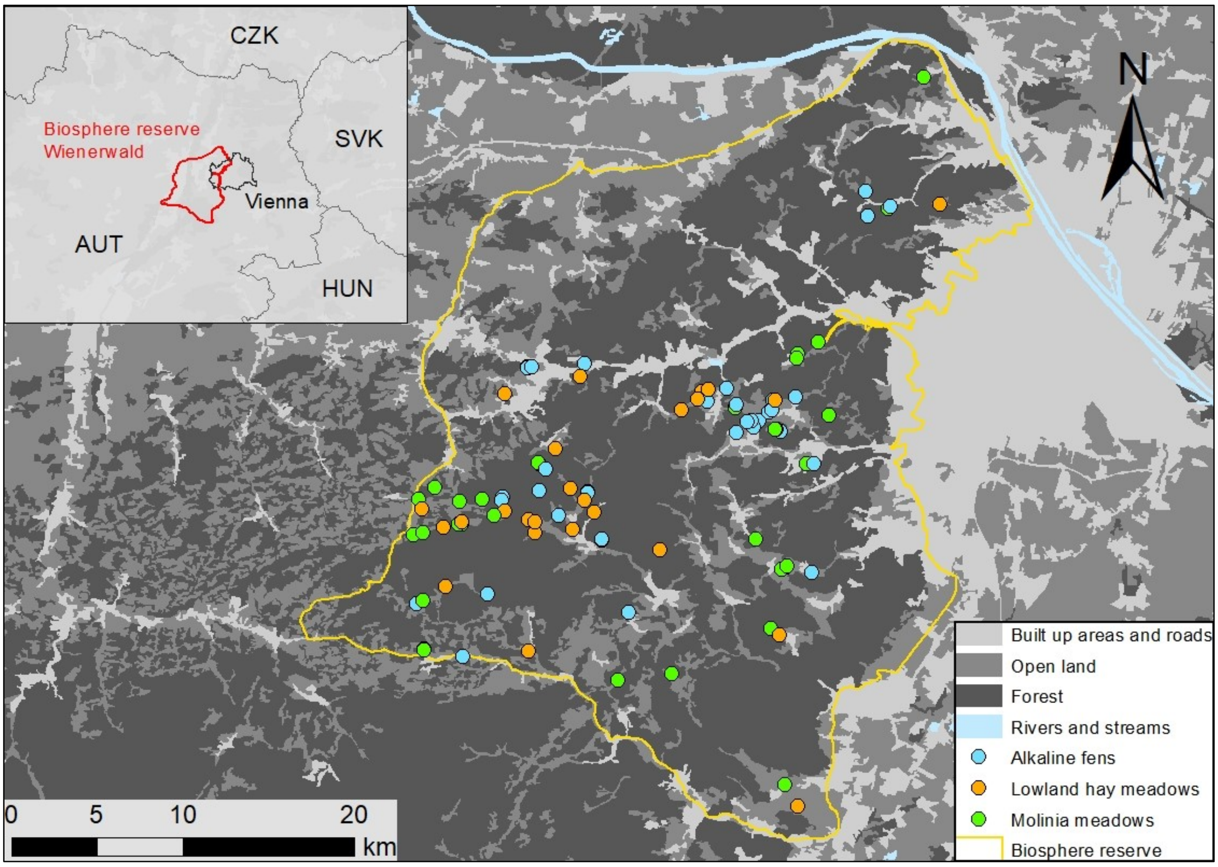

Fig. 4. *Location of 92 wet grassland sites within the biosphere reserve Vienna Woods; Sources: data.gv.at, ec.europa.eu/eurostat, Biosphärenpark Wienerwald Management GmbH*

2.2 Field survey

Sites were observed in May and June 2021. For each site the conservation status was assessed according to type specific schemes (Ellmauer, 2005). To depict changes in the assessed habitat types we introduced categories D and E. D states the change from one FFH-habitat type to another and E states that no habitat type could be assigned anymore mostly because of abandonment or intensification. To get more detailed information we also conducted vegetation surveys according to the Braun-Blanquet method (Braun-Blanquet, 1964) on 4 x 4 m plots. On patches ranked with E (e.g., intensive farmland) no vegetation survey was conducted.

2.3 Data analysis

Vegetation surveys were conducted on 77 out of the 92 sites. Obtained data was digitalized with TURBOVEG (Hennekens and Schaminée, 2001) and then transferred to JUICE 7.1 (TICHÝ, 2002) for further processing. In a first step the relevées were divided into clusters using TWINSPAN (Hill, 1979). For classification up to association level we used a field determination key which was specifically developed for grasslands of the Vienne Woods by Willner et. al (2013). Table manipulation and TWINSPAN analysis were done in JUICE 7.1. For visualization we performed a NMDS analysis (non-metric multidimensional scaling) in R.

To test for differences in abiotic site conditions we used mean Ellenberg indicator values (EIV; Ellenberg et al., 1992). We calculated mean EIV for nutrients and moisture assuming that these factors are most suitable to depict differences between the given habitat types and integrated the EIVs in the NMDS using vector surface fitting. Mean EIVs were weighted by species abundance for each site.

To test for effectiveness of AES measures on patch level and differences between habitat types we compared species richness, number of threatened species and mean EIV for nutrients (as a proxy for soil nutrient input) between AES categories and habitat types separately using Kruskal-Wallis tests and Nemenyi posthoc tests.

To address changes in site conservation status from 2011 to 2021 we introduced an ordinal scale reaching from +1 (e.g., from rank B in 2011 to A in 2021) to -4 (rank A to E). +2 (rank C to A) did not occur in our cases. We decided to use this procedure as the differences between ranks are mostly defined by continuous categories (e.g., number of habitat specific species or percentage of disturbed area) and the subsequent steps are quite equally sized (see Appendix 1.). Again, we compared development of the habitat types and effects of AES measures using Kruskal-Wallis tests and Nemenyi posthoc tests.

All statistical procedures were done in R (version 4.0.3; R Development Core Team, 2020).

3 Results

3.1 Phytosociological classification

The surveyed habitat types 6510, 6410 and 7230 correspond to the associations *Ranunculo repentis-Alopecuretum*, *Succiso-Molinietum* and *Caricetum davallianae,* respectively. Apart from these we identified three further associations, namely *Cirsietum rivularis, Filipendulo-Brometum* and *Filipendulo Arrhenatheretum*. Results of the NMDS analysis are shown in *Figure 5.a*. Clusters for the communities are visible although transitions are fluent. Special attention can be put on the cluster of *Filipendulo-Brometum*-meadows (green triangles). These relevés were former Molinia-meadows and might indicate a trend towards drier soil-conditions as *Brometum*-meadows belong to semi-dry grasslands, whereas *Molinia*-meadows are typically found on intermittently wet soils (Willner et al., 2013). In total 20 out of 77 relevés were assigned with a different association compared to the original survey.

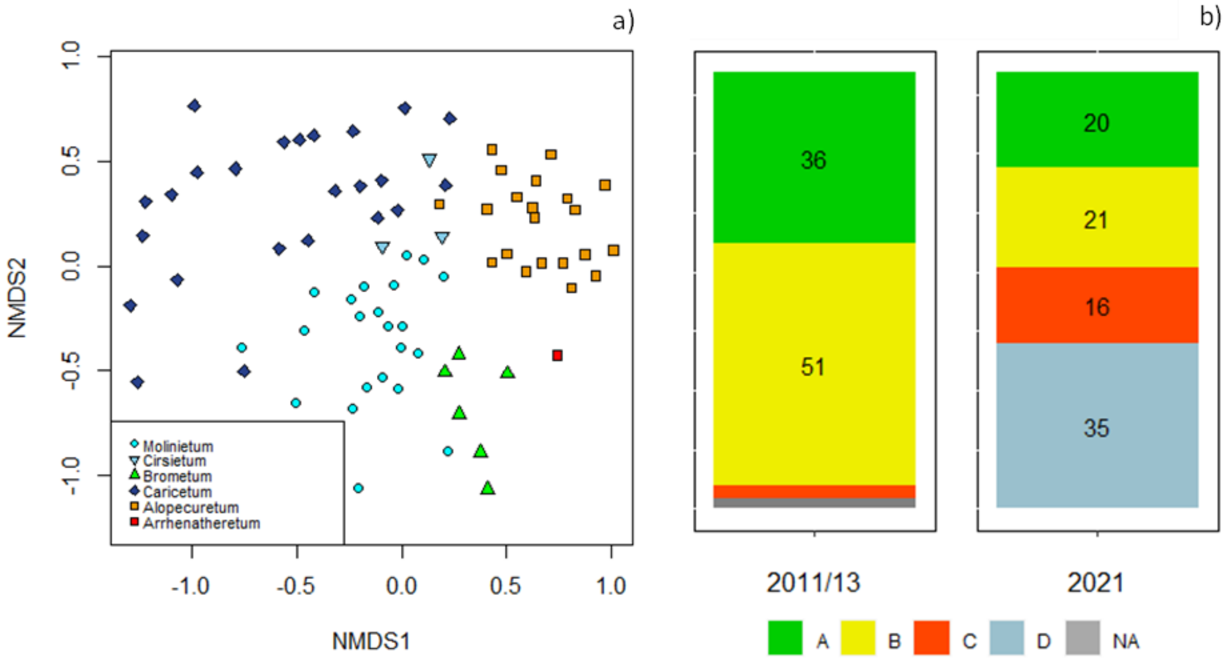

Fig. 5. a) *NMDS analysis (N=77), Legend top down: Succiso-Molinietum, Cirsietum-rivularis, Filipendulo-Brometum, Caricetum davallianae, Ranunculo-Alopecuretum, Filipendulo-Arrhenatheretum;* ***b)*** *Comparison of Conservation status distribution over all sites between 2011 and 2021 (N=92)*

3.2 Conservation status, Species diversity and Red-List species

Figure 5.b. shows an overall comparison of conservation status distribution between the first and second survey. A decline in sites ranked A or B is clearly visible. On more than one third of the sites the habitat type did not correspond to the former assignment.

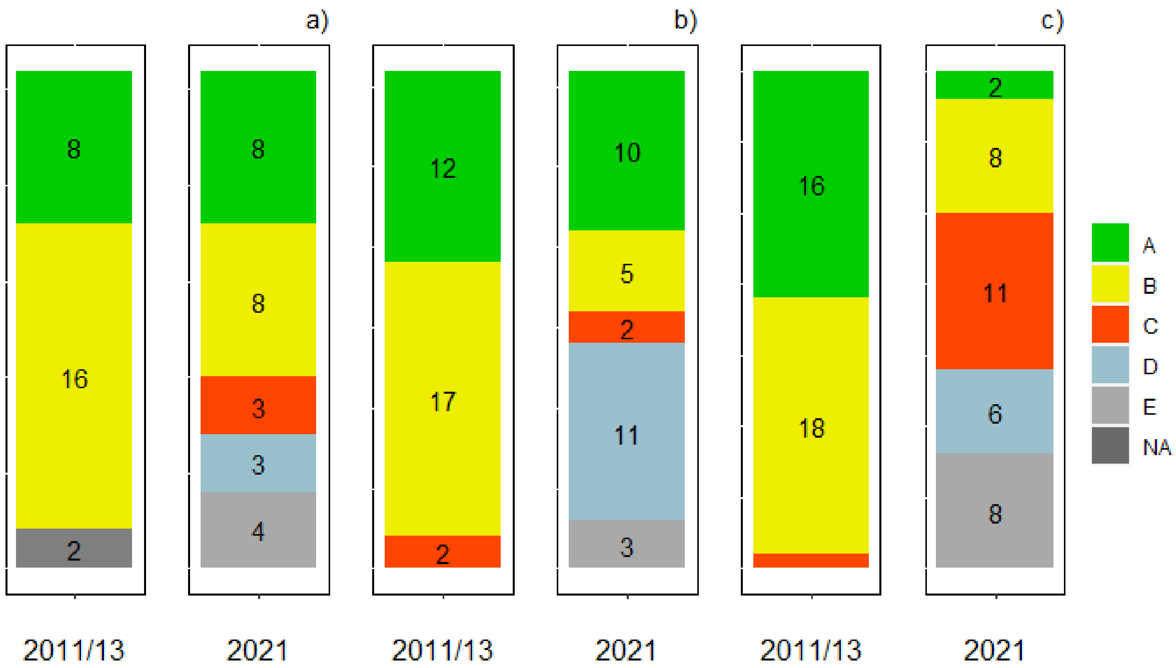

Fig. 6. *Comparison of conservation status distribution between 2011 and 2021 for 6510 (N=26)* ***a)****, 6410 (N=31)* ***b)*** *and 7230 (N=35)* ***c)***

Figure 6 shows differences in conservation status distribution between 2011/13 and 2021 for habitat types 6510, 6410 and 7230 respectively. For all habitat types negative trends are visible. For lowland hay meadows and Molinia meadows the number of sites ranked A stayed almost the same although the decline in sites ranked A or B combined indicates a negative trend. The most drastic changes can be seen in development of alkaline fens. Only 10 sites ranked A or B remained and 8 sites could not be assigned with a habitat type anymore.

Differences in mean change in ranks, shown in *Figure 7.a.,* correspond with these trends. The Nemenyi-test showed highly significant differences between 6510 meadows and 7230 fens with an average change of -0.7 and -1.7 ranks, respectively. Mean development of 6410 meadows lay in between with an average change of -1.2 ranks although differences were not significant. Similar results were obtained for phyto-diversity which is shown in *Figure 7.b*. The average number of species per plot was significantly higher in 6510 and 6410 meadows with means of 31.7 and 31.2, respectively, whereas on average 20.7 species were counted for 7230 fens.

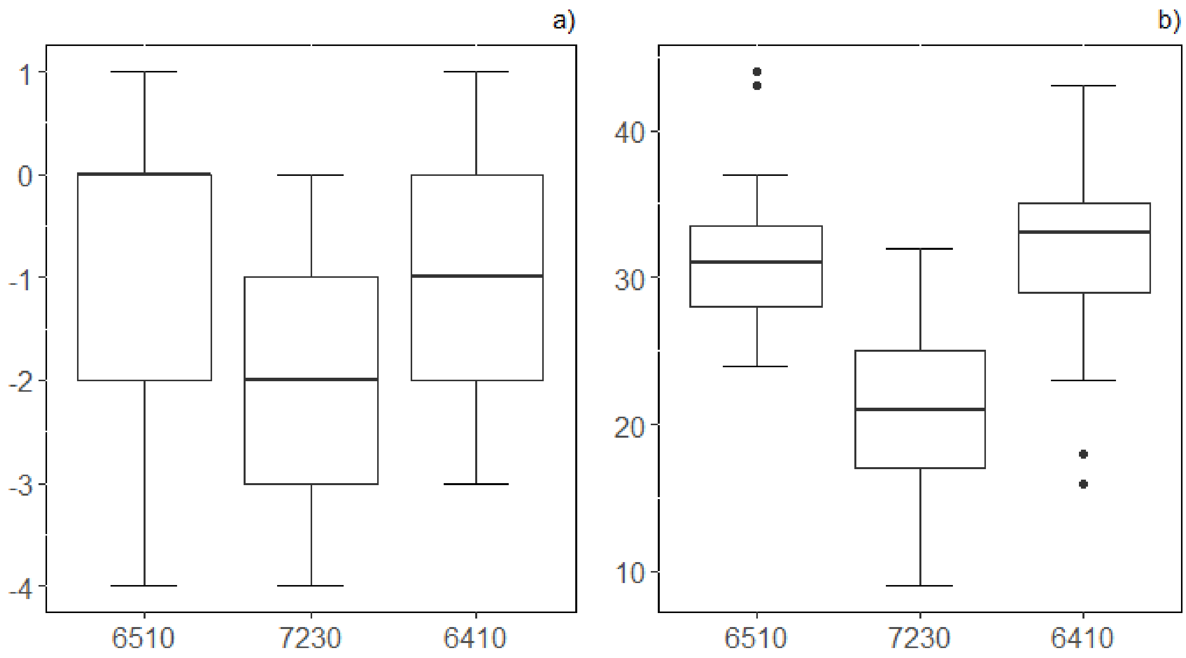

Fig. 7. a) *Change in ranks of conservation status between 2011 and 2021 (N=92) and* ***b)*** *number of vascular plant species per 16m² plot (N=57) for habitat types 6510, 7230 and 6410, patches ranked D or E were not included for species richness comparison*

Comparison of number of Red-List species per plot is shown in *Figure 8.a.* and *b*. Patches assigned as "Top-sites" (more than ten Red-List species found on the site) had significantly higher numbers of R-L species per plot than standard sites with on average 10.6 and 7 species per plot, respectively (*Fig. 8.a.*).

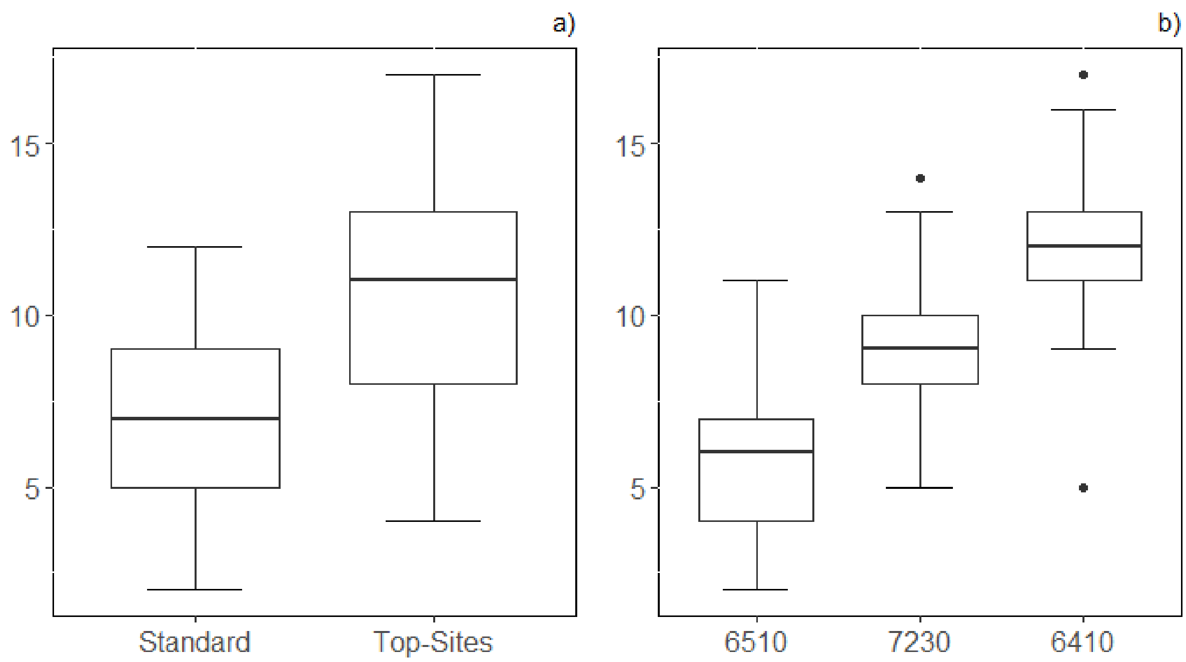

Fig. 8. *Mean number of Red-List species per plot.* ***a)*** *Comparison between standard sites and "Top-sites" (N=77);* ***b)*** *Comparison between habitat types, patches ranked D or E were not included (N= 57)*

Comparison between habitat types (*Fig. 8.b.*) showed significant differences between all three types with highest average numbers in 6410 meadows (12 species per plot) followed by 7230 fens (9 species per plot) and lowest numbers in 6510 meadows (5.7 species per plot).

3.3 Effects of AES-measures and mowing regime

To test for the effectiveness of AES measures we differentiated between "specific measures" (sites assigned with DIV or WF measure), "standard measures" (remaining sites in the programme) and "no measures". To test for general effects of the AES program we combined specific and standard measures and tested against sites with no measures. To test for effects of mowing regime (one-cut vs. two-cut) we excluded sites without AES measures because information on mowing regime wasn't available.

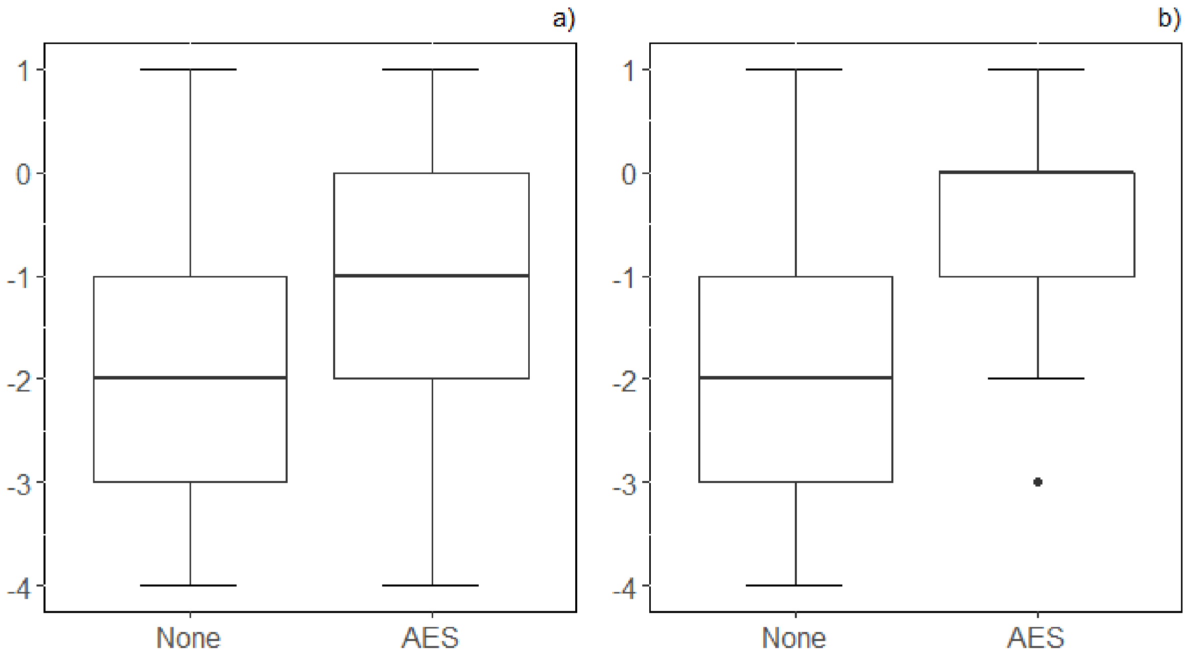

Fig. 9. *Change in ranks of conservation status between 2011 and 2021.* ***a)*** *Overall comparison between AES managed sites and sites without AES management (N=92);* ***b)*** *Comparison for 6510-meadows (N=25)*

Development of conservation status was significantly worse on sites without AES management with an average change of -1.8 ranks compared to -1.1 on AES managed sites (*Figure 9.a.)*. Biggest differences were found for 6510 meadows separately (-1.8 ranks on sites without AES management vs. -0.5 ranks on managed sites) although results were not significant (p=0.1; *Figure 9.b.)*. Comparing specific and standard measures no differences in conservation status development could be found (data not shown).

We further tested for effects of AES management concerning number of vascular plants per plot, number of R-L species per plot and mean EIV for nutrients (as a surrogate for nutrient input). Here as well no significant differences or even trends could be found between groups (AES vs. None, Specific vs. Standard and comparison of single categories; data not shown).

Comparing different mowing regimes, one-cut meadows showed better trends than two cut meadows with average changes of -0.8 and -1.2 ranks, respectively, although results were not significant (*Figure 10.a.*). Looking at 6410 meadows separately, differences between one-cut and two-cut meadows were highly significant with an average change of -0.3 and -1.5 ranks, respectively (*Figure 10.b.)*.

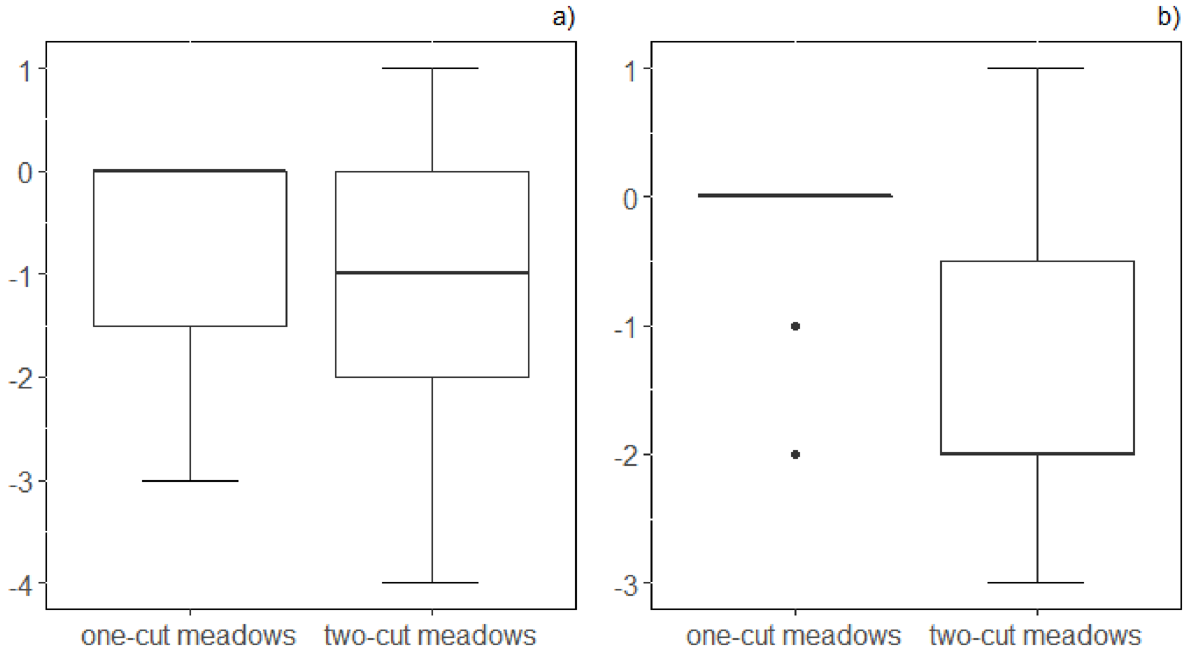

Fig. 10. *Change in ranks of conservation status between 2011 and 2021.* ***a)*** *Overall comparison between one-cut and two-cut meadows (N=74);* ***b)*** *Comparison for 6410-meadows (N=25)*

3.4 Abiotic site conditions

In *Figure 11.a*. and *11.b.* mean EIV for moisture and nutrients are overlaid with the NMDS to visualize differences in abiotic site conditions between the identified plant communities. Highest values for moisture were found on 7230 fens whereas highest values for nutrients were found on 6510 meadows. Driest conditions were found on the newly identified association *Filipendulo-Brometum.*

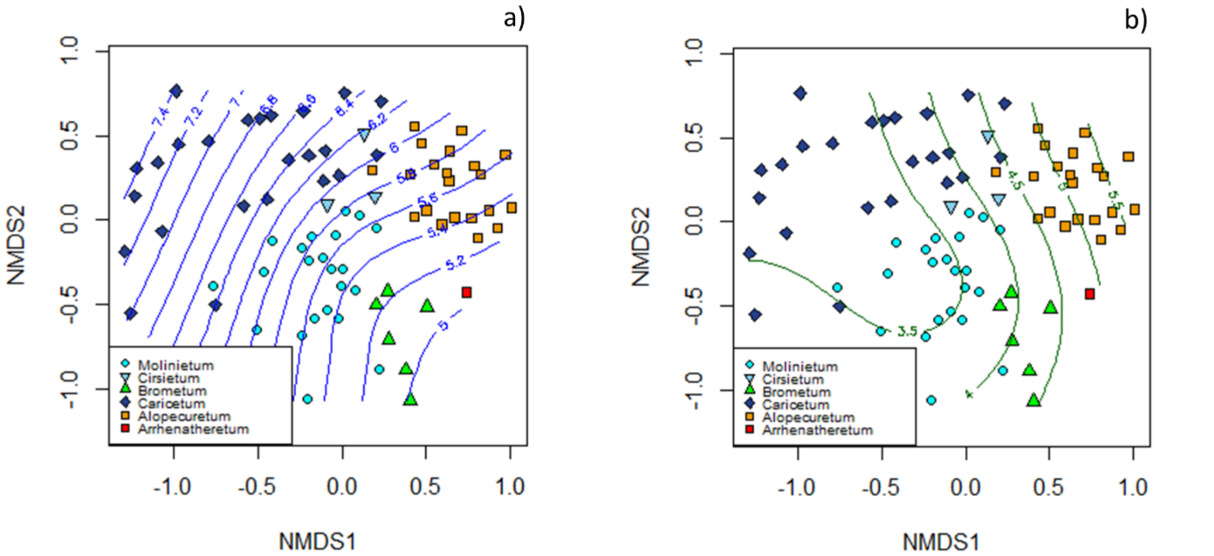

*__Fig. 11.__ NMDS analysis (N=77) overlaid with **a)** mean EIV for moisture and **b)** mean EIV for nutrients using vector surface fitting*

Comparing the surveyed habitat types, EIV for moisture was significantly higher on 7230 fens with an average value of 6.7 compared to 5.6 and 5.7 on 6510 and 6410 meadows, respectively (*Figure 12.a.*). EIV for nutrients was significantly higher on 6510 meadows with an average value of 5.2 compared to 3.6 on 7230 fens and 6410 meadows (*Figure 12.b.*).

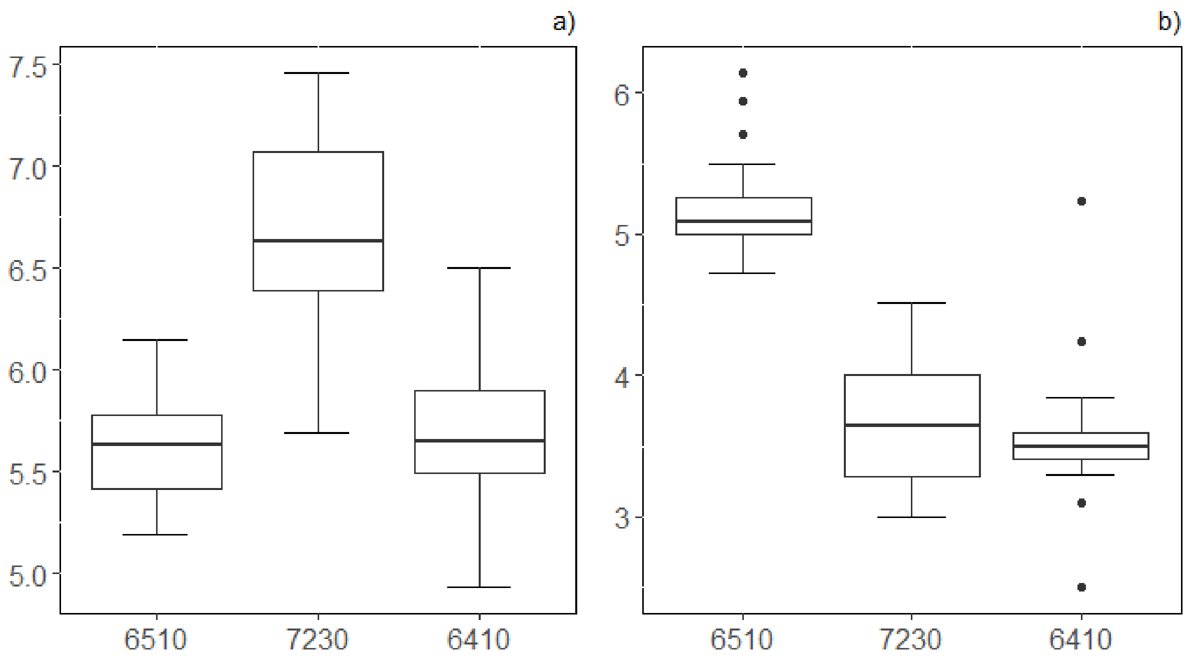

*__Fig. 12.__ EIV for moisture **a)** and nutrients **b)**. Comparison between habitat types. Meadows ranked D or E were not included (N=57)*

To test for the influence of abiotic site conditions on habitat development we compared mean EIV for moisture and nutrients between the different conservation status ranks. No significant differences were found for both EIVs when comparing all habitat types together. When looking on 7230 fens separately moisture values on sites ranked D (change of habitat type) were significantly lower than on patches ranked B or C with mean values of 5.7, 6.5 and 6.9, respectively. Also, when analysing 6410 meadows separately nutrient values on sites ranked C and D were significantly higher than on sites ranked A or B with mean values of 4.7, 4.0., 3.5, and 3.3, respectively. These results indicate lower soil moisture contents on former 7230 fens which were now assigned with a different habitat type and higher nutrient contents on 6410 meadows with a bad conservation status or change in habitat type.

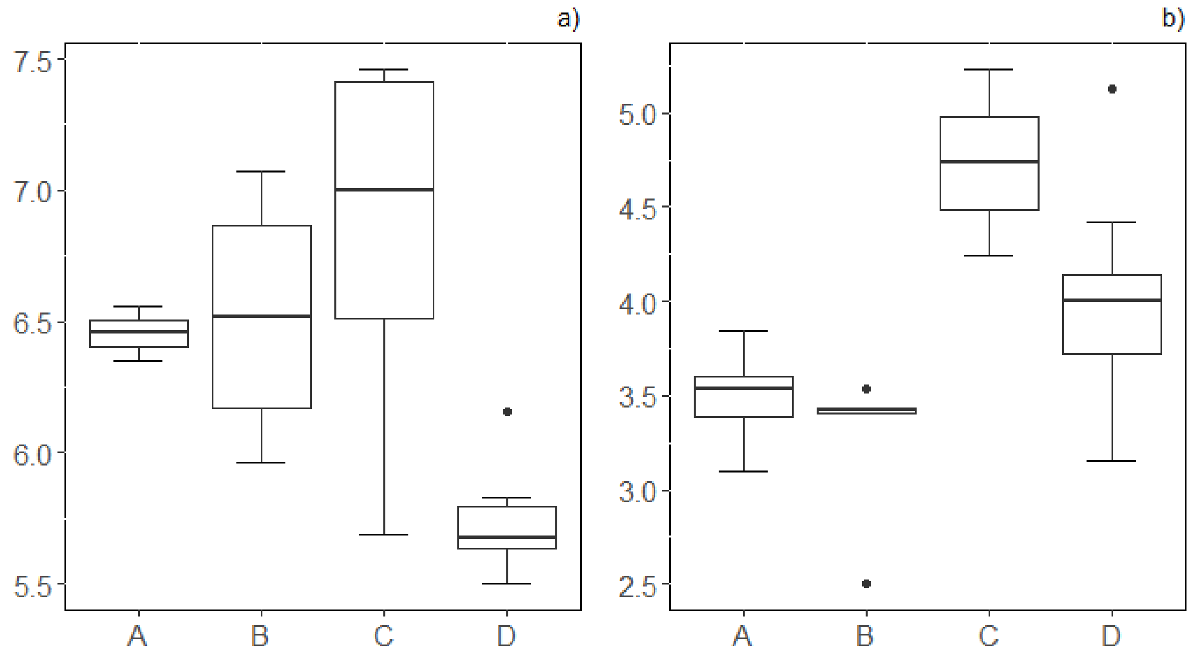

Fig. 13. a) *Comparison of mean EIV for moisture between conservation status ranks for 7230 fens (N=27).* ***b)*** *Comparison of mean EIV for nutrients between conservation status ranks for 6410 meadows (N=28)*

4 Discussion

4.1 Conservation status and phytosociological classification

The overall conservation status development over a period of only 8-10 years since the last assessment is alarming, although results are not entirely unexpected given the latest article-17-report for Austria (Ellmauer et. al, 2020). On average, conservation status on site level decreased by -1.2 ranks. Development of 6510 meadows was only slightly negative with an average decrease of -0.7 ranks whereas conservation status on 7230 fens decreased on average by -1.7 ranks and by -1.1 ranks on 6410 meadows. These differences correspond to our expectations as especially habitat types 7230 and 6410 belong to the most threatened ecosystems in Europe (e.g., Seer et al., 2014; Wójcik and Janicka, 2016; Ellmauer et al., 2020).

In total 35 out of 92 sites did not correspond to the priorly assessed habitat type. Again, changes seem to be worst in habitat types 6410 and 7230 with 14 sites ranked D or E each. Special attention must be put on the complete loss of any assignable habitat type (rank E) on 15 sites as this extent of change can only be explained by a change in agricultural management. This draws a concerning picture given the fact that all sites are based inside the biosphere reserve and most sites are AES managed to some extent. 7230 fens accounted for 8 of the 15 sites ranked E which might be explained by the difficulties in modern day agricultural management with heavy machines on these wet and loose soils and the extremely low productivity of the plant community (Mucina et al., 1993; Ellmauer, 2005). Both aspects might increase the willingness of landowners to either abandon or drainage those sites which poses one of the main threats for said habitat type (e.g. Grzybowski and Glińska-Lewczuk, 2020).

Looking at sites with changed habitat type (rank D) a trend towards drier and more nutrient rich environmental conditions is visible. Six out of eleven 6410 meadows ranked D were now classified as *Filipendulo-Brometum* meadows, a community which is found on drier soils compared to the original *Succiso-Molinietum* (Mucina et al., 1993). Two sites were now classified as *Cirsietum rivularis* meadows and one as 6510 meadow. Both communities are found on more nutrient rich soils. The same trend is visible in changed 7230 fens. Out of 6 sites with changed habitat type four were now classified as 6410 meadows indicating a trend from wet to intermittently wet soils and two sites were classified as a 6510 meadow and *Cirsietum rivularis* meadow indicating a trend to more nutrient rich conditions (Mucina et al., 1993). These changes show that increased nitrogen concentrations (e.g., Bobbink et al., 2010) and decreased water availability (e.g., Brouwer and Falkenmark, 1989) are also affecting the surveyed habitat types in the biosphere reserve Vienna Woods.

4.2 Vascular plant diversity and Red-List species

Vascular plant diversity was lowest on 7230 fens. This corresponds to our assumptions as abiotic site conditions on fens (such as waterlogged soils) lead to rather low numbers of vascular plants compared to species rich semi-natural grasslands as shown by Hettenbergerova et al. (2013). Mean numbers for 6510 and 6410 meadows resembled to those of other studies (e.g., Hülber et al., 2016; Kącki and Michalska-Hejduk, 2010).

Results for numbers of R-L species per plot showed that on average still more than ten R-L species could be found on Top-sites. Although exact numbers for the prior survey are not existent it can be assumed that there was no significant loss of endangered species on the surveyed sites. Furthermore, it can be stated that numbers on top sites are still higher than on standard sites. Of course, no conclusions can be drawn regarding changes in abundance of threatened species. Comparing the surveyed habitat types, number of R-L species per plot was highest on 6410 meadows followed by 7230 fens and 6510 meadows. This result was also expectable as many threatened plant species depend on very specific habitat conditions (e.g, Berg et al., 1994; Hettenbergerova et al., 2013) such as nutrient-poor and wet soils found in fens and partly on Molinia meadows. As these habitat types show strong areal decreases in the past years also the characteristic species become rare (e.g., Hájek, 2005; Umweltbundesamt, 2020). Another reason for these differences might be the dependence of many threatened species on extensive land use which is primarily performed on habitat types 6410 and 7230 (optimum of one cut per year) whereas 6510 meadows are more intensively used (up to three cuts per year; Ellmauer, 2005).

4.3 Effects of AES management

Compared to non-managed sites, the different AES measures had no detectable effect on number of vascular plants per plot, number of R-L species per plot or mean EIV for nutrients, both when analysing all plots together and habitat types separately. These results are in line with a study of Hülber et al. (2016) in the same area, showing that an overall decrease of vascular plant diversity and increase of mean EIV for nutrients between 1990/92 and 2011 was not influenced by the absence or presence of AES measures.

Regarding overall development we can state a less negative conservation status development for sites with AES management. Biggest differences were found for 6510 meadows, although results were not significant, probably due to lack of sample size for non-managed sites. Still managed sites changed by -1.1 ranks on average over the last 10 years and therefore could not halt negative development. The ambiguity of given results was also found in a comparative study by Kleijn and Sutherland (2003), stating that no clear answer can be found regarding effectiveness of AES management.

Clearly the most positive effect was found for mowing regime on 6410 meadows. Almost all one-cut meadows did not change in ranks whereas two-cut meadows changed on average by -1.5 ranks. This underlines the importance of a minimal mowing regime for said habitat type which is also proposed by Ellmauer (2005). Against our expectations we could not find similar results for 7230 fens.

4.4 Influence of abiotic site conditions

Results showed that species on 6510 meadows are best adapted to nutrient rich conditions whereas species on 7230 fens are best adapted to high soil water contents. Whilst not surprising, these results might point to an important factor affecting the different development of the surveyed habitat types. Both habitat types 7230 and 6410 are negatively affected by increased nutrient input (e.g., Höckendorff et al., 2021; Ellmauer, 2005) and reduced soil water content (e.g., Grzybowski and Glińska-Lewczuk, 2020). We could show that these effects were also apparent in our study as Molinia meadows showed highest nutrient levels on sites ranked C (bad conservation status) and D (change in habitat type) and moisture values on 7230 fens were lowest on sites ranked D. We therefor assume that these factors had significant influence on habitat development on the given sites.

4.5 Conclusion

Results of our study contribute to an ever-increasing number of records on the deterioration of natural and semi-natural habitats in central Europe and all over the world. Wet grasslands such as the surveyed habitat types belong to the most threatened ecosystems in the light of agricultural intensification and ongoing climate change (e.g., Joyce et al., 2016; Török et al., 2018). Especially habitat types 6410 and 7230 serve as important habitats for many threatened species and showed strong decreases in numbers in our study.

Measures applied in the Austrian AES program "ÖPUL" did not suffice to halt negative development of wet grasslands in the biosphere reserve Vienna Woods. Still, we can state some effects such as a diminished overall decrease in conservation status compared to non-managed sites. Further the obligatory implementation of measures such as a fixed number of cuts per year can benefit certain habitat types, as it was the case for 6410 meadows in our study. In contrast, the analysed measures seem to have had no significant effect on the development of 7230 fens in the region which can be put in context with the high number of sites ranked E (loss of habitat type). Apart from low agricultural yields a possible reason might be the small spatial extent of fens, often covering only a small part of larger meadows. This might lead to an implementation of general measures for the whole field which are inadequate for maintaining specific fen structures. To address those deficiencies a change to result-orientated approaches might help the problem (e.g., Burton and Schwarz, 2013). Hereby landowners receive subsidies for reaching agreed on targets instead of executing certain measures. In the case of Alkaline fens and Molinia meadows the preservation of certain key species might be an appropriate target. This approach could lead to better adapted management measures and might therefor also serve as a solution in combating habitat deterioration.

Earlier studies for Austria have shown both positive and negative results regarding the effectiveness of AES management (e.g., Wrbka et al., 2008; Hülber et al., 2016). We state that some effects on habitat development are visible. Still AES management in the current extent could not halt habitat deterioration on wet grasslands in the biosphere reserve Vienna Woods. Additional measures as well as adjusted management schemes are needed to assure the existence of wet grasslands in the biosphere reserve Vienna Woods in the long run.

Annex

1 Examples of site development

As a precaution the exact location of exemplary sites will not be stated in the thesis. The location will be described by stating the closest municipality. All municipalities belong to Lower Austria. Sites will be addressed by their specific code which was introduced in the study of Staudinger et al. (2014).

M13008 – Alkaline fen ranked C

Site M13008 is located north of the municipality Alland on a large southward facing clearing which is mostly covered by meadows. The fen is established around a narrow trench with increased water flow in between two meadows. The site is registered in the ÖPUL program without additional measures.

Fig. 14. *Site M13008, classified as Alkaline fen, ranked C in the present study. Visible tussocks are built by Carex vulpina and Molinia caerulea; Plant litter indicates renouncement of mowing*

In the prior study the site was ranked A. No acute threats or problems regarding habitat structure, hydrology or species composition were mentioned. 11 red-list species were listed for the site, including characteristic species such as *Carex davalliana, Eriophorum latifolium* or *Valeriana dioica*.

The site was revisited in late May 2021 and was ranked C in the present study. On first sight a considerable amount of plant litter was noticeable indicating that the fen had at least not been mowed in the last year, presumably longer than that. This assumption was confirmed by the landowner which by chance passed by the site that day. She informed me that the caretaker had left out the fen during mowing in the last couple of years and she herself showed interest in the reinstatement of mowing as she was interested in the fens plant community. Also, a change in vegetation structure was visible as the fen was dominated by larger tussocks of grass which turned out to be populations of *Molinia* *caeruela* (covered 1-5% in the vegetation survey) and mostly *Carex vulpina* (covered 5-25%). Both grasses were not mentioned in the species list of the prior survey and indicate increased nutrient input (probably from adjacent meadows) and renouncement of mowing (e.g., Ellmauer, 2005; Mucina et al., 1993). Still, the vegetation survey showed that most of the characteristic fen species such as the above stated (e.g., *Carex davalliana*) were still present. Furthermore 10 out of the 11 threatened species were still present on the site with exception of *Carex hostiana*, a characteristic sedge for said community which is listed as endangered (category 3) in the Austrian Red List.

Conservation status C was assigned as both vegetation structure (more than 30% of the sites structure is not typical for the habitat type) and abundance of disturbance indicators (more than 20% cover; in this case mostly *Carex vulpina* and *Molinia caerulea*) were ranked C (Ellmauer, 2005). Hereby it can be stated that the development of many of the alkaline fens ranked C corresponded to this case.

As the species composition on the site still largely resembles the intact form of the habitat type a possible improvement of the current state is realistic. A fixed mowing regime with removal of litter must be reinstated, ideally with one cut per year. To supress growth of *Molinia caerulea* and reinstate nutrient poor site conditions the hay cut should be performed earlier in the first two to three years, i.e., in late July to early August, until the vegetation structure is restored. Further nutrient input from the adjacent meadows should be impeded via buffer zones as this favours species such as the dominant *Carex vulpina* or *Dactylis glomerata*, which was also found on the site.

R113b – Alkaline fen ranked E

Site R113b is located in the vicinity of Eichgraben on a small northward facing hill. The originally assigned fen was found next to an old black alder in the upper part of the surrounding meadow on a wet cell. The landowner does not receive any subsidies via ÖPUL for the specific patch.

In the prior study the site was ranked B noting the small extent of the fen. Species composition was described as rather poor, still characteristic species such as *Carex davalliana, Eriophorum latifolium* and *Valeriana dioica* were documented. The site was revisited in June 2021 and was ranked E in the present study. None of the priorly documented characteristic fen species could be found anymore. Instead, the meadow was dominated by *Arrhenatherum elatius* and *Dactylis glomerata*. In this case no other FFH habitat type could be assigned which lead to rank E. The complete loss of any species adapted to wetter soil conditions indicates that a change in management must have happened on this site (e.g., drainage, fertilizer input).

Fig. 15. *Lower part of the priorly assigned alkaline fen shaded by a black alder tree. Species composition dominated by tall growing grasses such as Arrhenatherum elatius and Dactylis glomerata*

As both species composition and habitat structures are completely changed a reinstatement of the original habitat type is highly unlikely. Again, the situation is similar on other alkaline fens ranked E.

J111 – Alkaline fen ranked A

Site J111 is located in the vicinity of St. Corona am Schöpfl on a small clearing next to a larger complex of meadows. The fen makes up for more than two thirds of the clearing with an adjacent patch dominated by rushes such as *Juncus subnodulosus*. The clearing is assigned as nature-conservation patch in the ÖPUL program.

Fig. 16. *Alkaline fen belonging to the association "Caricetum davallianae"; Located in the vicinity of St. Corona am Schöpfl, Lower Austria; Characteristic community assemblage with a well-developed population of the orchid Dactylorhiza majalis in violet; late spring aspect*

The site was ranked A in the prior study. Especially a large population of *Dactylorhiza majalis* was mentioned. Other threatened species such as *Juncus subnodulosus* and *Carex hostiana* were also found.

For the present study the site was revisited in early June 2021 and could be ranked A in all categories. All of the priorly documented species were still present including a large population of *Carex hostiana* which was one of the rarest species in our study. Also, the population of *Dactylorhiza majalis* seemed equally abundant in numbers as in the prior survey. In total, 14 species listed on the Austrian Red List could be documented in the vegetation survey.

This site is one of the outstanding examples for the habitat type in the area and its current state should be maintained. As habitat structure and hydrology are in a good state the management should be presumed in the current manner.

V059 – Molinia meadow ranked D

Site V059 is located on the eastern margins of the biosphere reserve in the vicinity of Sparbach. The meadow is placed in a plain valley next to the Sparbach stream and is registered in the ÖPUL program without additional measures.

Fig. 17. *Former Molinia meadow now accounted to the association "Filipendulo-Brometum"; Location in the vicinity of Sparbach*

In the prior study the site was ranked A. It was already mentioned that the meadow continuously transformed from a wetter part alongside the stream with dominance of purple moor-grass to a drier part further away from the stream with dominance of upright brome (*Bromus erectus*). In total 21 threatened species were documented for the patch.

The site was surveyed in June 2021. As even the assumingly wetter part at the river was dominated by *Bromus erectus* and other indicators for drier conditions the site could not be assigned as a Molinia meadow and instead was now accounted to the association *Filipendulo-Brometum*. This development happened on five patches in the area and is probably not caused by change in land use. *Filipendulo-Brometum* meadows resemble largely in species composition to Molinia meadows and differ mainly in the dominance of some species which are better adapted to drier site conditions such as *Bromus ercetus* or *Tragopogon orientalis* (Willner et al., 2013). The reason for this might be a general decrease in rainfall and increase in prolonged periods of drought.

This development is probably difficult to counteract as it can be accounted to natural succession caused by climate change. 15 R-L species could be found in the plot which allows the assumption that the total number of 21 R-L species for the whole meadow did not significantly decrease. This, as well as the high number of vascular plants in the plot indicates that the current management of the meadow is appropriate to maintain the current state.

As a general trend towards drier conditions is expectable the development of Molinia meadows should be kept under focus and patches which still favour the dominance of species adapted to wetter soils should be maintained at all costs.

M312 – Molinia meadow ranked A

Site M312 is located in the vicinity of Untergrödl. The meadow makes up for the whole extent of a large clearing in the middle of a forest. This was one of the largest found Molinia meadows in the region. The meadow is assigned as nature-conservation patch in the ÖPUL program.

Fig. 18. *Molinia meadow belonging to the association "Succiso-Molinietum"; Located in the vicinity of Untergröbl and Schöpflgitte;r Visible yellow inflorescences belong to Scorzonera humilis, a characteristic species of the habitat type*

The site was ranked A in the prior study and assigned as Top-site with more than 20 documented R-L species. The site was revisited in May 2021 and ranked A. No deterioration in conservation status could be detected. Most of the species listed in the prior study were still present on the site and 17 R-L species could be documented in the surveyed plot.

Management of the meadow should be presumed in the current form as this is one of the best developed Molinia meadows. Due to the remote location of the meadow no current threats can be stated.

J021 – Lowland hay meadow ranked C

Site J021 is located in the vicinity of Klein-Mariazell. The meadow is situated in the southern part of a clearing with adjacent patches of intensively used farmland. The meadow is assigned as diversity patch in the ÖPUL program.

Fig. 19. *Lowland hay meadow belonging to the association "Ranunculo repentis-Alopecuretum"; Located in the vicinity of Klein-Mariazell; The meadow is dominated by tall-growing grasses such as Dactylis glomerata or Festuca pratense*

The site was ranked B in the prior study. Open soil patches due to grazing were documented but apart from that the meadow was described as oligotrophic. Threatened species such as *Dactylorhzia majalis, Trollius europaeus, Lychnis flos-cuculi* and *Primula veris* were documented for the site.

For the present study the site was revisited in early June 2021 and had to be ranked C. Vegetation structure was ranked C as the entire meadow was mostly dominated by tall growing grasses such as *Dactylis glomerata, Festuca pratense* and *Alopecurus pratensis*. Species composition was ranked C due to the absence of many characteristic herbs. Additionally, none of the above stated threatened species could be found on the site anymore.

Development of this site indicates changes in agricultural practice such as increased fertilizer input. Species adapted to nutrient-poor conditions almost entirely disappeared and cover of tall growing grasses increased. This development can be counteracted via renouncement of fertilizer input and a reduced number of cuts per year. In this case the applied ÖPUL measures clearly did not fulfil their cause. Meadows assigned with the diversity measure must be cut later in the year compared to similar meadows and fertilizer input before the first cut must be renounced. Looking at the species composition these measures were probably not performed.

M13019 – Lowland hay meadow ranked A

Site M13019 is located north of Mitterriegel in the northern part of a long drawn complex of meadows. The meadow complex is situated alongside the Agsbach stream. The meadow is assigned as diversity patch in the ÖPUL program.

Fig. 20. *Lowland hay meadow belonging to the association "Ranunculo repentis-Alopecuretum"; Located in the vicinity of Mitterriegel*

In the prior study the meadow was ranked A although the meadow complex was documented as one patch. As the AES measures differ between the adjacent parts, we divided the complex in units according to the management and hereby only surveyed the northern part with assigned diversity measure. For the whole complex ten R-L species were documented.

The site was revisited in May 2021 and ranked A. No visible changes could be detected compared to the documentation of the prior survey. Seven threatened species were documented for the surveyed plot. No acute threats were visible and management should be presumed in the current form.

2 Current trends and proposed management approaches

In this concluding chapter I want to sum up the obtained results and point out to occurring trends in habitat development for each habitat type. As one of the main goals of the biosphere reserve directive is the connection of biodiversity conservation and sustainable land use (UNESCO, 1996) I further want to propose possible approaches on counteracting current trends of habitat development for the Biosphärenpark Wienerwald Management GmbH.

6510 – Lowland hay meadows

In comparison lowland hay meadows of the association *Ranunculo repentis-Alopecuretum* showed a less negative development than the other two habitat types. Still negative trends are visible as sites ranked A or B decreased by a third and seven out of 26 sites could not be assigned as 6510 meadows anymore (*Figure 6.a.*). AES management seemed to have a positive effect on habitat development of 6510 meadows although results were slightly insignificant.

Most of the sites ranked A in the prior study kept that status in 2021. Three sites ranked B could now be ranked A which indicates a positive development at least to a small extent. Special attention can be put on meadows without AES management as two out of 5 sites were abandoned. This development was not documented on AES managed sites. Apart from the two abandoned sites the most common reason for bad rankings seemed to be species composition and habitat structure which both go in hand with an increase of tall growing grasses and a decrease of herbaceous species. Therefore, we assume agricultural intensification (i.e., increased mowing regime and fertilizer input) as the most probable reason for habitat deterioration of lowland hay meadows, which is also stated by Ellmauer (2005).

To stop negative trends awareness raising in agricultural practice seems a proper way to point out that the current intensification threatens the diversity of agriculturally used land such as lowland hay meadows. The so called "Wiesenmeisterschaft" a project launched by the Biosphärenpark Wienerwald Management GmbH between 2010 and 2018 seems to be an appropriate tool to encourage sustainable land use. Hereby landowners in several municipalities were awarded for a sustainable and type-appropriate management of species rich meadows (URL 2). Combined with the implied ÖPUL measures a reintroduction of a similar project might help to slow down or even stop current trends for 6510 meadows in the biosphere reserve.

6410 – Molinia meadows

Molinia meadows in our survey changed on average by -1.1 ranks despite only slight decreases in numbers of meadows ranked A. This clearly states a negative trend in habitat development. Regarding development of Molinia meadows three aspects can be pointed out for the region. Firstly, Molinia meadows showed the highest number of changed habitat types (11 sites). The most important factor for this development seems to be changes in soil water content as 6 sites were now accounted to semi-dry grasslands. This is in line with findings of Thompson et al. (2009) who state that decreasing soil water contents due to ongoing climate change pose an important threat to lowland wet grasslands in the UK. Secondly, higher soil nutrient contents can be assumed as a reason for habitat deterioration. This could be shown via comparison of EIV for nutrients between different conservation status ranks. Sites ranked C or D had significantly higher nutrient values than sites ranked A or B. Thirdly, effects of mowing regime should be highlighted. Whilst no significant differences in habitat development between AES managed and unmanaged sites could be found, the positive effect of an extensive mowing regime was highly significant. In our survey almost all sites assigned as one-cut meadows could be ranked with the same conservation status as in 2011/13 whereas sites assigned as two-cut meadows changed on average by -1.5 ranks. These results highlight the importance of an extensive mowing regime for Molinia meadows which is also stated by Ellmauer (2005).

Regarding possible management options by the biosphere reserve management team, changes in species composition due to climate change related decrease in soil water content will be difficult to counteract. Therefor the importance of maintaining sites with still sufficient soil moisture levels in a good state cannot be stressed enough. Again, awareness raising seems to be in important tool. The special requirements and the value of this habitat type for the region's biodiversity could be communicated via information-events, booklets and online. Also, events like the already mentioned "Wiesenmeisterschaft" could help the cause. As a mowing regime with only one cut in late summer seems to be an efficient way to maintain Molinia meadows in a favourable state this should be communicated to landowners. In this case the AES program seems a proper tool to oblige landowners to a fixed mowing regime. Therefor the benefits of this program could be also communicated to the landowners by the management team.

7230 – Alkaline fens

Alkaline fens showed the worst development since 2011 with an average decrease in conservation status of -1.7 ranks. Only two sites could be ranked A in 2021 and 8 sites had to be ranked E due to abandonment or intensification. The situation seems even more precarious given the fact that AES measures seemed to have no effect on habitat development of alkaline fens.

General trends of increased nutrient content and decreased water content in soil can be also assumed for alkaline fens, as all of the six sites with changed habitat type were now accounted to plant communities with either better adaption to drier or more nutrient-rich soils. Also, the most common reason for ranks B and C were combined bad ranks for vegetation structure and abundance of disturbance indicators. In the case of alkaline fens this indicates an increase of species which are better adapted to nutrient-rich soil conditions. Apart from these trends the focus should be put on the loss of any assignable habitat type on eight sites, six out of which were managed according to AES schemes. As already stated in the discussion there are two likely reasons for this development. Firstly, alkaline fens show very low productivity and are difficult to access with machines which might increase the will of landowners to drainage sites to make them more arable. Secondly, as such measures are mostly not allowed for AES managed sites it must be assumed that these fens are often not specifically addressed in the AES program due to their small spatial extent in a complex of larger meadows.

Given the development of alkaline fens within the last ten years in the biosphere reserve and ineffectiveness of AES measures for said habitat type a hands-on strategy is most likely needed to counteract current trends. Many of the sites which are currently ranked C do still show characteristic species compositions despite cessation of mowing. A resumption of management on these sites within the next few years might lead to fast improvements in conservation status and prevent further loss of valuable habitats. Awareness raising might be helpful as many landowners probably do not see the value in such habitats. Still this alone will not be sufficient to counteract current trends. As numbers of well-developed alkaline fens are steadily decreasing it might even be necessary or at least useful to address sites and therefor landowners individually. To deal with the problem of difficulties in mowing with machines, so called "Pflege-Einsätze" could be organised which is already common practice for dry grasslands on the eastern borders of the biosphere reserve. Hereby traditional mowing without machines could be executed with the help of volunteers. This would not only solve current problems but also raise awareness in the local community for the natural values of their home region.

Conclusion

Wet grasslands play an important role for vascular plant diversity in central Europe and in the biosphere reserve Vienna Woods. Under the light of ongoing agricultural intensification and climate change our study showed that plant communities adapted to nutrient-poor soils and high soil water contents are especially threatened. AES management could not halt the documented habitat deterioration in the biosphere reserve Vienna Woods. Still some aspects of the program such as the implementation of a fixed mowing regime showed effects on habitat development. Especially development of alkaline fens seems to be unaffected by AES measures. Here it needs site specific measures such as reintroduction of mowing regime and removal of mowed material to prevent this habitat type from disappearing within the biosphere reserve. These measures might be introduced by the biosphere reserve management or could otherwise be implemented by a result-orientated approach of AES schemes where farmers get subsidies for reaching certain agreed on targets such as the preservation of certain key species (e.g., Burton and Schwarz, 2013). Apart from asking how, it should be stated that measures of some kind will have to be implemented in the nearest future if vascular plant diversity inside the biosphere reserve is to be maintained.

Given the current developments a study of similar approach should be rerun in 5 to 10 years. It would then be possible to analyse exact changes in plan communities and diversity measures. These kinds of comparison were not feasible in our study as only data on conservation status and approximate numbers of Red-List species per site were documented in the first study. With the newly collected data even more in-depth results might be obtained in future studies, the importance of which cannot be overemphasised given current global trends in wet grassland development.

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Figures and tables

Appendix

Appendix 1. Schemes for Conservation status evaluation. Source: (Ellmauer, 2005) see References

Indikator	A	B	C
Flächengröße	optimale Flächengröße: =1 ha	typische Flächengröße: =0,1 ha <1 ha	minimale Flächengröße: =0,01 ha <0,1 ha
Artenzusammensetzung	artenreich: Wiesen mit =15 (Basenreiche Bestände) bzw. =10 (Basenarme Bestände) lebensraumtypischen Gefäßpflanzenarten der Artenliste	mäßig artenreich: Wiesen mit =8 (Basenreiche Bestände) bzw. 6-9 (Basenarme Bestände) lebensraumtypischen Gefäßpflanzenarten der Artenliste	artenarm: Wiesen mit <8 (Basenreiche Bestände) bzw. <6 (Basenarme Bestände) lebensraumtypischen Gefäßpflanzenarten der Artenliste
Hydrologie	Standort nicht entwässert (Grundwasser <30 cm unter Flur), Entwässerungsmaßnahmen haben entweder nie stattgefunden oder sind nicht (mehr) wirksam	Standort schwach entwässert (Grundwasser 30-50 cm unter Flur), Entwässerungsmaßnahmen wirksam	Standort stark entwässert, Entwässerungsmaßnahmen deutlich wirksam (Grundwasser >50 cm unter Flur)
Vollständigkeit der lebensraumtypischen Habitatstrukturen	typische Strukturen vollständig vorhanden: niedrige bis mäßig hochwüchsige Krautschicht mit Vorkommen konkurrenzschwachen Arten und weitgehendem Fehlen von Obergräsern, keine Streuauflage, gehhölzfrei	typische Strukturen teilweise vorhanden: mäßig hochwüchsige Krautschicht mit mäßigen Deckungswerten von Obergräsern oder mäßig verbuscht, mäßige Streuauflage, konkurrenzschwache Arten zurücktretend	typische Strukturen fragmentarisch vorhanden: mäßig hochwüchsige Krautschicht mit hohen Deckungswerten von Obergräsern oder stark verbuscht, konkurrenzschwache Lückenzeiger völlig verschwunden, dichte Streuauflage
Störungszeiger	Störungszeiger (Ruderalisierungs- und Nährstoffzeiger, invasive und potenziell invasive Neophyten) decken im Bestand	Störungszeiger (Ruderalisierungs- und Nährstoffzeiger, invasive und potenziell invasive Neophyten) decken im Bestand 5-	Störungszeiger (Ruderalisierungs- und Nährstoffzeiger, invasive und potenziell invasive Neophyten) decken im Bestand
	nicht mehr als 5% der Fläche	20% der Fläche	>20% der Fläche

28.3.1 Beurteilungsanleitung für die Einzelfläche

Wenn Artenzusammensetzung = C, dann Erhaltungszustand = C

Für die verbleibenden Kombinationen gilt:

Wurden die Indikatoren ausschließlich mit zwei benachbarten Wertstufen (A/B, B/C) bewertet, so richtet sich der Wert für den Erhaltungszustand nach dem häufiger vergebenen Wert. Bei ausschließlicher Vergabe der Wertstufen A und C ergibt das Verhältnis 3:2 den Wert B, sonst den überwiegend vergebenen Wert.

Wenn alle 3 Wertstufen vertreten sind dominieren die Extremwerte A bzw. C das Ergebnis ab einer Häufigkeit von wenigstens 3, ansonsten ist das Ergebnis B.

Fig. A 1. *Austrian scheme for conservation status evaluation on site level for FFH habitat type 6410*

Indikator	A	B	C
Flächengröße	optimale Flächengröße: =3 ha	typische Flächengröße: =0,1 ha <3 ha	minimale Flächengröße: =0,01 ha <0,1 ha
Artenzusammensetzung	artenreich: Wiesen mit =15 lebensraumtypischen Gefäßpflanzenarten der Artenliste	mäßig artenreich: Wiesen mit 8-14 lebensraumtypischen Gefäßpflanzenarten der Artenliste	artenarm: artenarme Wiesen mit <8 lebensraumtypischen Gefäßpflanzenarten der Artenliste
Vollständigkeit der lebensraumtypischen Habitatstrukturen	typische Strukturen vollständig vorhanden: mäßig hochwüchsige Krautschicht mit konkurrenzschwachen Arten und mit mäßigem Anteil an Obergräsern, standortstypische Artenzusammensetzung, keine Streuauflage, gehölzfreie Bestände	typische Strukturen teilweise vorhanden: mäßig hochwüchsige bis hochwüchsige Krautschicht mit hohem Anteil an Obergräsern, konkurrenzschwache Arten selten, mäßige Streuauflage, mäßige Verbuschung; oder: mäßig verbuscht	typische Strukturen fragmentarisch vorhanden: hochwüchsige Krautschicht mit Dominanz von Obergräsern, artenarm, konkurrenzschwache Arten fehlend, dichte Streuauflage, starke Verbuschung; oder: stark verbuscht
Störungszeiger	Störungszeiger (Ruderalisierungszeiger, invasive und potenziell invasive Neophyten) decken im Bestand nicht mehr als 5% der Fläche.	Störungszeiger (Ruderalisierungszeiger, invasive und potenziell invasive Neophyten) decken im Bestand 5-20% der Fläche	Störungszeiger (Ruderalisierungszeiger, invasive und potenziell invasive Neophyten) decken im Bestand >20% der Fläche

31.3.1 Beurteilungsanleitung für die Einzelfläche

Wenn Artenzusammensetzung = C, dann Erhaltungszustand = C

Für die verbleibenden Kombinationen gilt:

Wenn alle drei Bewertungsstufen vergeben worden sind, dann ist der Gesamterhaltungszustand B.

Wenn eine Bewertungsstufe 3 Mal vergeben worden ist, dann bestimmt diese auch den Wert für den Erhaltungszustand.

Wurde zwei Mal A und zwei Mal C vergeben ist der Erhaltungszustand = B.

Wurden je zweimal benachbarte Bewertungsstufen vergeben (A/B oder B/C) dann entspricht der Erhaltungszustand der schlechteren Bewertungsstufe.

Fig. A 2. *Austrian scheme for conservation status evaluation on site level for FFH habitat type 6510*

Indikator	A	B	C
Hydrologie	Standort nicht entwässert bzw. hoch anstehendes Grundwasser mit nur geringen Wasserstandsschwankungen (Jahresmittelwerte zwischen 0-20 cm unter Flur)	Standorte mit alten (älter als 10 Jahre) Entwässerungsmaßnahmen bzw. stärkere Wasserstandsschwankungen (zwischen 0-40 cm) oder permanent tiefer liegendes Grundwasser (zwischen 20-40 cm)	Standorte aktuell entwässert bzw. Grundwasserstände entweder stark im Jahresverlauf schwankend (zwischen 0->40 cm) oder permanent tiefer liegendes Grundwasser (>40 cm unter Flur)
Vegetationsstruktur	>90 % der Gesamtfläche weist die typische Vegetationsstruktur (niedrigwüchsiger Bestand) auf	10-30 % der Gesamtfläche mit Vegetation aus höherwüchsigen Kräutern oder Gehölzen (verbrachte oder verbuschte Flächen)	>30% der Flächen mit Vegetation aus höherwüchsigen Kräutern oder Gehölzen (verbrachte oder verbuschte Flächen)
Störungszeiger	Keine/kaum: Störungszeiger decken im Bestand nicht mehr als 5% der Fläche	Mittel: Störungszeiger decken im Bestand 5-20% der Fläche	Hoch: Störungszeiger decken im Bestand mehr als 20% der Fläche

39.3.1 Beurteilungsanleitung für die Einzelfläche

Wenn Hydrologie = C, dann Erhaltungszustand = C

Für die verbleibenden Kombinationen gilt:

Werden alle drei Wertstufen vergeben ist der Erhaltungszustand = B.

Werden zwei Wertstufen vergeben, dann ergeben die Kombinationen AAB=A, BBA=B, BBC=B und BCC=C, die Kombinationen AAC=B und ACC=B.

Fig. A 3. *Austrian scheme for conservation status evaluation on site level for FFH habitat type 7230*

Appendix 2. Complete table of all 92 sites

Table 1. *Table containing complete data of 92 sites.* ***ID****: ID originating in the prior study (Staudinger et al., 2014);* ***habitat****: EU habitat type according to prior study;* ***aes_kat****: Applied AES measures on site;* ***top****: Information whether more (Y) or less (N) than 10 R-L species were found on the site;* ***ehz_old****: Evaluated conservation status in the prior study;* ***ehz_new****: Evaluated conservation status in the present study;* ***change****: Change in ranks for conservation status;* ***assoc.****: Classified plant community after Willner et al. (2013);* ***alph-div****: Number of vascular plant species per plot;* ***rl-spec****: Number of R-L species per plot;* ***EIV-M****: Ellenberg-Indicator-Value for Moisture;* ***EIV-N****: Ellenberg-Indicator-Value for Nutrients*

Site	ID	habitat	aes_kat	top	ehz_old	ehz_new	change	assoc.	alph-div	rl-spec	EIV-M	EIV-N
1	BV2003	6510	2	Y	B	B	0	FIL-ARH	31	5	5.2	4.7
2	J046	7230	2	N	B	B	0	CAR-DAV	14	6	6.9	3.3
3	C0051	7230	2 WF	Y	A	B	-1	CAR-DAV	17	10	7.1	3.1
4	C0380	7230	2	N	A	C	-2	CAR-DAV	9	6	7.0	3.0
5	C0694	6510	2 WF	Y	B	B	0	ALO-PRA	26	4	5.4	5.2
6	C0603	6510	2 DIV	N	A	A	0	ALO-PRA	29	9	5.8	4.8
7	C0626	7230	2 WF	Y	C	C	0	CAR-DAV	21	8	5.7	3.9
8	T5901	6510	1 WF	N	NA	B	0	ALO-PRA	24	3	5.4	5.9
9	T5517	7230	1 WF	Y	A	B	-1	CAR-DAV	32	9	6.5	4.2
10	T5514	6410	1 WF	Y	B	C	-1	SUC-MOL	18	5	6.4	5.2
11	T3322	7230	2 WF	Y	A	C	-2	CAR-DAV	22	9	6.6	4.0
12	M13008	7230	2	Y	A	C	-2	CAR-DAV	19	11	7.4	3.7
13	M13067c	6510	2	N	B	B	0	ALO-PRA	33	4	5.7	5.0
14	M13056	7230	2	Y	B	B	0	CAR-DAV	20	8	6.5	3.7

15	M13019	6510	2 WF	Y	A	B	-1	ALO-PRA	28	4	5.7	5.7
16	M13020	7230	2 DIV	Y	A	A	0	CAR-DAV	21	7	6.6	4.3
17	M13019	6510	2 DIV	Y	A	A	0	ALO-PRA	36	7	5.7	4.9
18	M13031a	6510	2 DIV	N	B	A	1	ALO-PRA	33	7	5.3	5.1
19	M13089	7230	1	Y	A	B	-1	CAR-DAV	23	10	6.2	3.3
20	M13091	6410	1	Y	A	A	0	SUC-MOL	33	11	5.6	3.6
21	M13085	6510	2 DIV	N	A	A	0	ALO-PRA	33	7	5.6	5.1
22	C0611	6510	2 WF	N	A	A	0	ALO-PRA	37	11	5.8	4.7
23	C0077	7230	1 WF	Y	B	D	-2	CIR-RIV	31	14	6.2	3.6
24	C0071	6410	1 WF	N	B	B	0	SUC-MOL	16	12	6.5	2.5
25	C0015	6510	2 WF	N	B	D	-2	ALO-PRA	31	5	5.3	5.5
26	X1013	6510	2	Y	B	B	0	ALO-PRA	30	6	6.0	5.1
27	X1216	7230	2 DIV	Y	A	B	-1	CAR-DAV	21	10	6.9	3.4
28	X1221	7230	2 DIV	Y	A	C	-2	CAR-DAV	25	11	6.6	4.1
29	M312	6410	1 WF	Y	A	A	0	SUC-MOL	29	17	6.1	3.5
30	X1138	6510	2 WF	Y	B	D	-2	SUC-MOL	38	12	5.3	3.6
31	X1102	6410	2 WF	Y	B	B	0	SUC-MOL	34	12	4.9	3.5
32	X1011	6510	2 DIV	N	B	B	0	ALO-PRA	28	6	6.0	5.0

33	P0093	6510	2	N	B	A	1	ALO-PRA	44	8	5.3	5.2
34	P0092	6410	2	Y	B	D	-2	CIR-RIV	42	15	5.9	4.1
35	P0098	6410	2 DIV	N	B	D	-2	ALO-PRA	26	8	6.0	4.4
36	P0041	6410	1	Y	A	A	0	SUC-MOL	33	9	5.7	3.8
37	P0261b	6410	2 DIV	N	B	D	-2	CIR-RIV	22	3	6.2	5.1
38	C2426	6410	2 WF	N	B	A	1	SUC-MOL	32	11	5.8	3.6
39	C2432c	6410	1 WF	Y	A	A	0	SUC-MOL	23	13	5.4	3.1
40	C4005	7230	2 DIV	N	B	C	-1	CAR-DAV	27	8	6.4	3.8
41	R112b	7230	1	Y	B	C	-1	CAR-DAV	15	9	7.4	3.0
42	R111	6410	1	Y	A	A	0	SUC-MOL	28	11	5.4	3.4
43	C0003	6410	2	Y	B	D	-2	FIL-BRO	33	11	4.7	3.6
44	C0351	7230	1 WF	Y	A	C	-2	CAR-DAV	19	13	7.4	3.3
45	C0351	7230	2 WF	Y	A	C	-2	CAR-DAV	15	10	7.5	3.0
46	C0355	6410	2 WF	Y	A	D	-3	CAR-DAV	24	11	6.8	4.0
47	C0327	7230	1 WF	N	B	D	-2	SUC-MOL	27	12	5.8	3.4
48	C0375	7230	2	Y	B	D	-2	SUC-MOL	31	14	5.7	3.4
49	J111	7230	1 WF	Y	A	A	0	CAR-DAV	26	14	6.4	3.0
50	J131	6410	1	N	A	A	0	SUC-MOL	35	11	5.6	3.6

51	J001	6510	2	N	B	B	0	ALO-PRA	24	4	5.9	6.1
52	J152	7230	1	N	B	B	0	CAR-DAV	26	5	6.0	4.5
53	J021	6510	2 DIV	N	B	C	-1	ALO-PRA	27	2	5.2	5.3
54	AL1731	6410	2 DIV	Y	A	B	-1	SUC-MOL	35	13	5.7	3.4
55	V009	7230	1	N	B	C	-1	CAR-DAV	16	7	6.4	3.7
56	V059	6410	2	Y	A	D	-3	FIL-BRO	37	15	5.3	3.7
57	V066	6410	2 DIV	Y	B	D	-2	FIL-BRO	34	12	5.0	3.7
58	V055	6410	2 DIV	N	C	D	-1	FIL-BRO	40	10	4.9	4.2
59	V927	6410	2 WF	Y	B	B	0	SUC-MOL	39	16	5.5	3.4
60	V111	6510	1 WF	N	B	D	-2	FIL-BRO	23	5	4.9	4.1
61	V115	6410	1 WF	Y	B	B	0	SUC-MOL	29	12	5.7	3.4
62	M13124	6510	1 WF	N	A	A	0	ALO-PRA	43	6	5.5	5.2
63	C0024	7230	2 DIV	Y	B	D	-2	SUC-MOL	36	16	5.6	3.5
64	C0065	6410	2 WF	Y	A	A	0	SUC-MOL	43	15	5.4	3.6
65	C0608	6510	N	N	A	C	-2	ALO-PRA	30	4	5.4	5.5
66	C0388	7230	N	N	B	B	0	CAR-DAV	29	9	6.0	4.5
67	T5403	7230	N	N	A	D	-3	ALO-PRA	35	7	5.7	4.7
68	T0801	6410	1	N	B	D	-2	FIL-BRO	29	6	4.2	4.1

69	BV0559	6410	N	N	B	C	-1	SUC-MOL	32	9	5.9	4.2
70	J081	6410	N	N	B	D	-2	CAR-DAV	18	9	7.1	4.0
71	J080	6410	N	N	B	D	-2	CAR-DAV	13	9	6.9	3.2
72	M13010	7230	N	Y	B	C	-1	CAR-DAV	18	8	7.4	3.6
73	M13014	6510	N	Y	B	C	-1	ALO-PRA	32	6	6.2	5.0
74	X1016	6510	N	Y	B	A	1	ALO-PRA	34	5	5.6	5.1
75	P0091a1	6410	N	Y	A	A	0	SUC-MOL	36	13	5.6	3.5
76	P0246a	6410	N	Y	A	A	0	SUC-MOL	35	14	5.9	3.3
77	M13095	7230	N	Y	A	D	-3	SUC-MOL	43	13	5.5	3.9
78	P0243b	6510	N	N	A	E	-4	NA	NA	NA	NA	NA
79	C0307	7230	1 WF	N	B	E	-3	NA	NA	NA	NA	NA
80	C0307	7230	2 WF	N	B	E	-3	NA	NA	NA	NA	NA
81	C0014	7230	2 WF	Y	B	E	-3	NA	NA	NA	NA	NA
82	P0054	6410	2	Y	C	E	-2	NA	NA	NA	NA	NA
83	M323	7230	2	Y	B	E	-3	NA	NA	NA	NA	NA
84	C4019	6510	2 WF	N	B	E	-3	NA	NA	NA	NA	NA
85	NA	6510	1 WF	N	NA	E	NA	NA	NA	NA	NA	NA
86	C0377	7230	2 WF	N	B	E	-3	NA	NA	NA	NA	NA
87	C0359	7230	2 DIV	N	A	E	-4	NA	NA	NA	NA	NA
88	AL3065	6410	2	Y	B	E	-3	NA	NA	NA	NA	NA
89	C5205	6410	N	N	B	E	-3	NA	NA	NA	NA	NA
90	AL0165	7230	N	Y	A	E	-4	NA	NA	NA	NA	NA
91	P0065	6510	N	N	B	E	-3	NA	NA	NA	NA	NA
92	R113b	7230	N	N	B	E	-3	NA	NA	NA	NA	NA