**Differences in habitat quality and biodiversity in European grasslands, meadows and farmland: Reviewing the effects of grassland management on arthropod communities**

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Six-spot Burnet moths, a characteristic grassland species.

Source: [Butterfly Conservation Ireland](https://butterflyconservation.ie/wp/report/)

**Abstract**

European grasslands have undergone major changes in recent history. The development of more efficient and productive agricultural practices has intensified land-use and caused changes in the environment. These changes and the effects of climate change have caused plant communities to lose biodiversity as plants with high productivity are enabled to outcompete other species. In this review an overview of the effects that this biodiversity shift have on arthropods is presented. Additionally a meta-analysis was conducted to provide an oversight of studies recording arthropod diversity in grasslands and the differences in diversity between areas of intensive and extensive land-use. This analysis is interpreted as confirming the positive effects of extensive land use on arthropod abundance. Arthropod richness could not be positively associated to extensive land-use.

In light of these results information and theories from articles and papers addressing arthropod diversity and how land use influences the arthropod community is presented. These include the effects of plant diversity, host services of plants, vegetation structure and architecture, vegetation succession and genetic variety of plants on arthropod diversity. Finally I discuss the effect of data analysis and processing of the reviewed papers, differences in methodology and sampling in these studies and analyse the value of using land-use type as an indicator for biodiversity differences.

**Introduction**

In the past century semi-natural grasslands in Western Europe have undergone large changes. Small-scale extensively used lands have been developed into large efficiently producing agricultural fields. The developments in agricultural practices and the re-arrangement of landscape are being recognized as detrimental to biodiversity for the entire grassland ecosystem. Most notable are recent studies finding that arthropod biomass in such grasslands has decreased by as much as 76% ([Hallmann et al., 2017](#_ENREF_23)). This study indicates that changes in land-use and climate change have caused this decline. Arthropods have a valuable role in ecosystems as top-down regulators on i.e. vegetation and micro fauna as well as bottom-up regulation as a food source for a wide array of predators. Furthermore they provide essential ecosystem functions as pollinators and seed-dispersers ([Ollerton et al., 2011](#_ENREF_41), [Lengyel et al., 2010](#_ENREF_35)). Naturally the aforementioned decline in arthropod biomass and diversity is worrying as all these ecosystem functions are threatened to be lost. It is therefore important that the underlying causes for this decline are untangled and countermeasures to improve diversity are assessed. Plants often act as an intermediate between the abiotic environment and the arthropod community. Furthermore plant diversity is often found to correlate to arthropod richness and abundance ([Bennett and Gratton, 2013](#_ENREF_4)). Thus plant communities provide valuable information to assessing land-use effects on arthropod communities.

**Dutch grasslands and trends occurring in North-western Europe regarding grasslands: Land-use changes, climate change, community changes**

To understand the degradation of arthropod communities it is important to provide context by addressing the vegetation changes that form the arthropod habitat. Semi-natural grasslands provide such habitats for many arthropod taxa and via a wide variety in characteristics. Of these characteristics biodiversity, biomass, density, nutrient content and growth timing have been greatly influenced by climate change and other environmental factors ([Thuiller et al., 2005](#_ENREF_52), [Rose et al., 2012](#_ENREF_47), [Cleland et al., 2007](#_ENREF_10)). Generally grasslands in the North-Western Europe are experiencing the same set of changes. Nutrient-poor grasslands which were extensively grazed have been decimated ([Bullock et al., 2011](#_ENREF_8)) and have been replaced by arable or nutrient rich grasslands. Increased Nitrogen, Phosphorous and Potassium from artificial fertilizers and atmospheric deposition have driven the changes in nutrient availability and caused large plant biodiversity losses ([Billeter et al., 2008](#_ENREF_5), [Tilman and Isbell, 2015](#_ENREF_54)). Fertilizers facilitate plants which are able to rapidly process high amounts of nutrients. Coincidentally plants which are unable to do so are being outcompeted in both access to nutrients as well as access to light ([Hautier et al., 2009](#_ENREF_24)).

In addition, climate change has affected grasslands via increased temperatures and increased atmospheric CO2 concentrations ([Menzel, 2003](#_ENREF_39), [Cleland et al., 2006](#_ENREF_9)). A combined effect of these changes causes higher productivity in plants but at the cost of biodiversity ([Ziska et al., 2004](#_ENREF_61), [Thuiller et al., 2005](#_ENREF_52)). Similar to the effect of fertilization, plants which are unable to capitalize on the increased availability of resources are outcompeted ([Yang et al., 2011](#_ENREF_60)). Thus enhancing the competitive advantage gained from eutrophication.

Moreover to accommodate high-yield grass species, land users have drained fields. While low water levels occur frequently in natural grasslands, drained grasslands maintain a stable, low groundwater level. This causes *Carex, Rumex* andother grassland species that have specialized in anoxic, wet environments to disappear since they require high groundwater levels to survive. This then eliminates competition for the targeted crop species and enables high production.

Another land-use change stems from the issue that mass-cultivated crops, such as high-yield grass, are vulnerable to diseases and pests. This vulnerability is enlarged by the genetic homogeneity of the plants that are grown for commercial use. In the past decades, genetic modification of crops has been able to subvert this problem. Via genetically modified resistance crops could be protected from damage by pesticides. These pesticides, however, have caused a direct decline in biodiversity of non-resistant plants. Furthermore non-target arthropods that supplied ecosystem services that benefitted plant diversity are now unable to do so ([Goulson, 2013](#_ENREF_19)). This furthers the negative impact of pesticides on biodiversity.

Essential are the changes in grassland disturbance by grazing and mowing. In traditionally managed extensive grasslands disturbance occurred either annually by haying the fields or by small groups of livestock. This land-use regime allowed plants that are unable to cope with high disturbance to persist ([Marini et al., 2008](#_ENREF_36)). At the same time the grazing and/or haying regime also ensures that there is a constant siphoning of nutrients from the fields. This accommodates plants specialised in low-nutrient environments by preventing a build-up of nutrients by organic material ([Maron and Jefferies, 2001](#_ENREF_37)). In the case of grazing regimes this process is amplified by the food preferences of livestock. Fast-growing plants generally contain higher amounts of nutrients and may encounter trade-offs for their rapid growth in having a decreased resilience to grazing ([Grime and Mackey, 2002](#_ENREF_20)). This makes fast-growing species more attractive for grazers. Similarly, grazing and mowing delays or prevents succession from occurring. Saplings of trees and bushes are being grazed before full development maintaining the dominance of grassland species.

Finally, habitat fragmentation has increased drastically in the past decades ([Tilman et al., 2001](#_ENREF_53)). Reorganisations of land ownership have led to land-users obtaining larger joined pieces of land, instead of the previous smaller and more scattered fields. This resulted in landowners removing the tree-lanes and shrubs that were used to define borders between lands. Furthermore, more semi-natural grasslands were claimed for intensive agricultural use, decreasing the size of extensive grasslands and separating these even further. As a result, plant communities became smaller and more isolated causing extinction risk by stressors to increase ([Kuussaari et al., 2009](#_ENREF_32)), and making it harder for plant communities to recover after a population decrease ([Uematsu et al., 2010](#_ENREF_55)).

In summary, these environmental factors combined are thought to have caused biodiversity shifts from species using stress-tolerant survival strategies towards species using competitive survival strategies (Grime 1988). This has resulted in distinct differences in vegetation types between grasslands that are intensively used for agriculture and grasslands that have been used extensively. Which is affirmed by increasing plant-biodiversity in nature-reserve grasslands while comparable agricultural grasslands have shown no biodiversity improvement ([de Snoo et al., 2012](#_ENREF_12)). Grassland characteristics like biodiversity are found to have significant effect on the quality and diversity of arthropods as a habitat ([Haddad et al., 2009](#_ENREF_22)). It is important that they are taken into account when arthropod communities are studied as they impact results. This paper therefore provides an overview of the effect of changing vegetation characteristics on arthropod communities so they can be taken into consideration when such arthropod communities are studied.

**Implementing vegetation characteristics to estimate and review developments in arthropod communities**

Since vegetation communities in North-Western Europe are changing drastically, arthropod communities changes are expected to follow. It is therefore necessary to integrate vegetation developments into studies that aim to estimate and review arthropod community developments ([Hutchinson, 1959](#_ENREF_27), [Root, 1973](#_ENREF_46), [Hunter and Price, 1992](#_ENREF_26)). Literature studies summarizing developments of arthropod families in grasslands and local diversity studies of arthropod communities are abundant. It is only recently that a detailed study on arthropod community structure changes as a result of plant biodiversity was made ([Ebeling et al., 2018](#_ENREF_14)). This, and similar other studies, integrate plant biodiversity via generic parameters e.g. species richness, taxonomic diversity and abundance. However, more detailed information about how plant communities are changing is available. This information can be very useful when combined with previously mentioned studies to give precise estimations of how local arthropod communities will develop.

This study aims to present an integrative overview of the current scientific knowledge of plant diversity developments and of local plant habitat effects on arthropods and their communities.

Ideally I would focus on how differences in European grassland land-use translate to diversity differences in arthropods. There is a vast spectrum of factors involved in both the changes that grasslands undergo and how they affect arthropods. As a result this review is limits land-use into an extensive and intensive category. Within this scope I aim to address land-use effects by applying information on vegetation changes as a result of land-use type on comparable grassland communities in Europe. This information is then discussed in light of current scientific knowledge on plant-invertebrate interactions on how to summarize and estimate biodiversity differences between grasslands. In these circumstances I hypothesize that, in accordance to the Resource Specialization Hypothesis ([Southwood et al., 1979](#_ENREF_50), [Strong et al., 1984](#_ENREF_51)), high plant biodiversity creates a high variety in spatial and temporal niches for arthropods. Extensively used grasslands generally have a higher biodiversity ([de Snoo et al., 2012](#_ENREF_12)) and provide more niches for arthropods. Thus, I expect to see higher invertebrate diversity in extensive grasslands compared to intensive grasslands.

**Methods**

**Review methods**

In order to gather data and information for the meta-analysis of arthropod biodiversity I conducted research using databases from Web-of-Knowledge (<http://apps.webofknowledge.com/>). At first the Web of Science Core Collection was used to gather articles. For this search the key words “(plants OR plant) AND (diversity OR richness) AND extensive AND (grasslands OR grassland) AND Europe” and “(arthropod OR arthropoda OR arthropods) AND (diversity OR richness) AND (grasslands OR grassland) Europe” were used. Since the latter search term provided more relevant articles, it was decided that these terms should be studied more elaborately. This was done by including articles from all databases available on Web-of-Knowledge. These search terms provided respectively 58, 38 and 115 search results.

From these results I selected articles that contained information on arthropod diversity developments in European grasslands. I then refined the selection to articles that were digitally available. After this selection procedure a total of 117 articles were found to be relevant. Articles were then summarised in a separate datasheet and biodiversity data from empirical studies were extracted for further analysis. In particular information on species richness and arthropod abundance was selected, since these parameters were commonly measured. The parameters were then adjusted for study duration.

In detail, the articles which were analysed consisted of a variety of studies. Generally these studies covered one or more taxonomic groups of arthropods in local and/or national grasslands. These analyses were aimed at biotic and abiotic effects on arthropod communities e.g. grazing/mowing regimes, habitat diversity and climate change. This analysis resulted in information on characteristics of arthropod communities, data of the developments within these communities and an assessment of the influence of the studied biotic and abiotic factors.

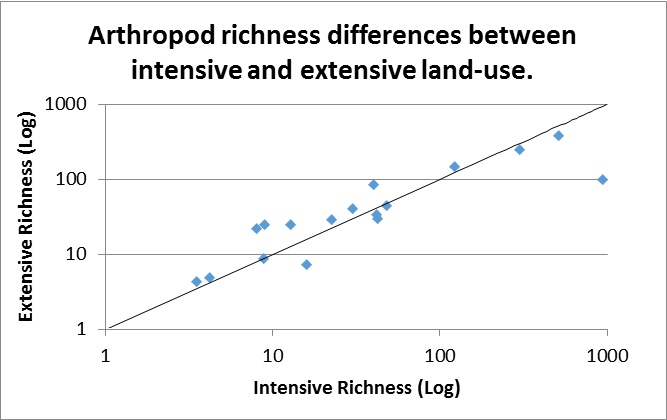
From the gathered data on species richness and abundance an analysis was made to depict differences between extensive and intensive land-use. To do so studies which measured these arthropod community traits in both land-use types were clustered and compared. These measurements where then depicted in two sets of graphs. The first set (Figures 1a & 1b) consist of

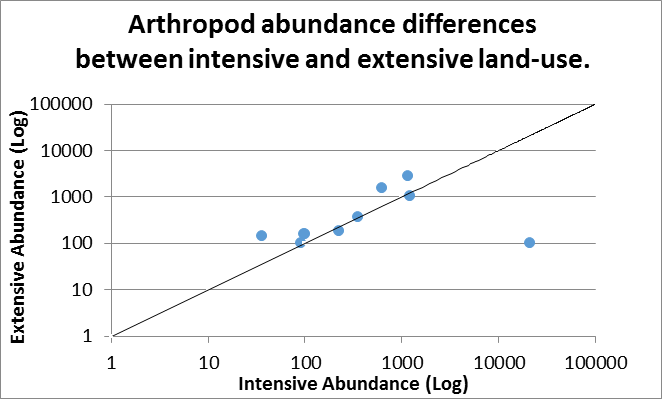
X-Y graphs visualising differences between extensive and intensive land-use for the two biodiversity parameters. Since small-scale arthropod diversity studies were overrepresented in the database it was decided that a Log-transformation would provide a more accurate view of the comparison.

In the second set of graphs I assessed the frequency of arthropod diversity found in the analysed studies. The frequency of the abundance and richness of these communities was then compared between extensively and intensively used land (Figures 2a & 2b).

For all analysis I considered the quantity of studies recording arthropod diversity was low. For the pairwise comparison 10 and 17 datapoints and for the frequency analysis between 13 and 40 datapoints. Therefore I refrained from using a statistical analysis as its results would not provide insightful information. Abundance and richness in the pairwise comparisons were also found to be underrepresented in the higher end of the spectrum. The axis were therefore altered to a logarithmic scale to clarify trends in the dataset.

**Visual representations of meta-data from studies measuring arthropod diversity parameters in fields under different land-use.**

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**Figure 1b**

A pair-wise comparison of arthropod richness

between fields of intensive and extensive use measured in the same study. The line represents values in which X=Y. Points above the line represent studies in which diversity in extensive land-use is higher than intensive land-use while points below represent the opposite.

**Figure 1a**

A pair-wise comparison of arthropod abundance

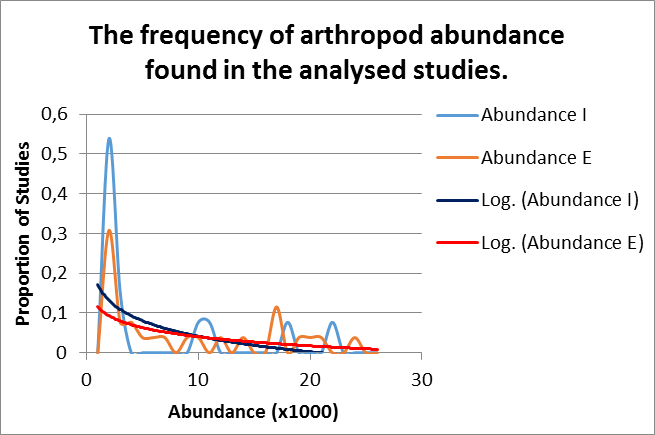
between fields of intensive and extensive use measured

in the same study. The line represents values in which

X=Y. Points above the line represent studies in which

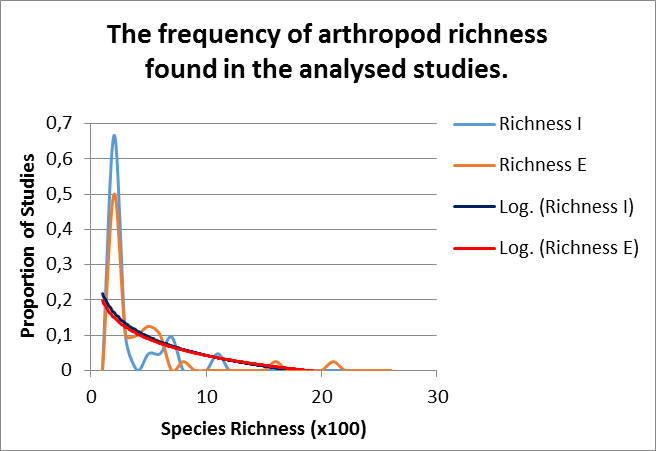
diversity in extensive land-use is higher than intensive

land-use while points below represent the opposite.

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**Figure 2a**

*An overview of the amount of arthropod abundance found in each study by proportion of studies. Studies are categorised for land-use and clustered per 1000 individuals found. A Log-adjusted trendline was added for studies measuring abundance in intensively and extensively used lands to more clearly present abundance differences.*

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**Figure 2b**

*An overview of the amount of arthropod richness found in each study by proportion of studies. Studies are categorised for land-use and clustered per 100 species found. A Log-adjusted trendline was added for studies measuring abundance in intensively and extensively used lands to more clearly present richness differences.*

**Findings & Interpretation of the meta-analysis**

**Meta-data findings on land-use and its relation to arthropod diversity parameters**

In the meta-data analysis I found 10 studies measuring arthropod abundance in both types of land-use (Figure 1a). Of these studies one study found a similar arthropod abundance in intensively used land, 4 studies found similar abundances between both land-use types and 5 studies found a higher abundance in extensively used land.

For arthropod richness I found 17 studies presenting arthropod richness in both land-use types (Figure 1b). Of these two studies found arthropod richness to be higher in intensively used land, 11 studies found similar richness and 4 studies found higher richness in extensively used lands.

Furthermore, considering all data, it was found that a high arthropod abundance is more frequently recorded in extensively used lands (Figure 2a). High species richness was reported equally frequent between both land-use types.

Following the findings of the meta-data the next step is to discuss the causes of the higher arthropod abundance and richness in extensively used grasslands (Figures 1a & 1b). This discussion further includes why this increased diversity was more frequently reported in case of increased abundance but not for increased species richness.

**Increased arthropod diversity and its causes in extensively used grasslands.**

Generally, the findings in the meta-analysis support the idea that extensive grasslands support more diverse arthropod communities. There are a multitude of potential causes for a diversity dichotomy between land-use types. These causes and how they affect diversity are discussed in the following paragraphs and aim to aid in interpreting and provide context to the studied dataset.

*Vegetation composition differences between land-use types.*

As discussed in the introduction, plant communities are changing drastically as a result of environmental changes. The pace of these changes differs significantly between extensive and intensive land-use. One of the most striking differences is the difference in plant diversity ([de Snoo et al., 2012](#_ENREF_12)). Multiple studies have shown that high floral and vegetation diversity is associated with high arthropod diversity ([Hegland and Boeke, 2006](#_ENREF_25), [Scherber et al., 2010](#_ENREF_48), [Haddad et al., 2009](#_ENREF_22)). More specifically, common-garden experiments have found that different flowering species attracted different arthropod assemblages. Plots with high biodiversity offer a larger variety of pollen and nectar, through longer periods of time ([Bennett and Gratton, 2013](#_ENREF_4)). For multiple groups of pollinators high plant diversity was also found to have a positive effect on arthropod species richness. Again, this was attributed to increased plant diversity causing a larger variety spatio-temporal niches ([Venjakob et al., 2016](#_ENREF_57)). For herbivorous arthropods a similar pattern of positive correlation with plant biodiversity was found ([Scherber et al., 2010](#_ENREF_48), [Haddad et al., 2009](#_ENREF_22)). Omnivorous and carnivorous arthropods species richness did increase with high plant diversity ([Haddad et al., 2009](#_ENREF_22), [Scherber et al., 2010](#_ENREF_48)). But rather than a direct effect of increased plant species richness predatory arthropod diversity was found to increase with an increase in predator abundance ([Haddad et al., 2009](#_ENREF_22)).

Beside the bottom-up effects of plants, they also provide services as hosts for larvae and eggs of arthropods. In this perspective similar trends occur. Plant biodiversity loss due to eutrophication caused Lepidoptera species with host-plants in eutrophic habitats to sustain a more stable population while species with host-plants in other habitats declined ([Kuussaari et al., 2007](#_ENREF_33)).

Furthermore host plants for Lepidoptera larvae are a primary cause of population thresholds. If host plants are unable to maintain a stable population, due to fluctuating environments, dependent butterfly populations will decline accordingly ([Bubová et al., 2015](#_ENREF_7)).

Furthermore the loss of vegetation richness and high grazing pressure/intensive mowing causes a loss in structural diversity. It is valuable to see vegetation structure as a separate determinant of arthropod biodiversity instead of a component of plant biodiversity. This is because structural diversity is not only affected by the amount of species and their heterogeneity in morphological traits but also by species that have, for example, multiple phenological growth forms or species that are resilient to high grazing pressure or mowing. Considering the effect of vegetation structure it was found that structurally complex habitats could support more diverse arthropod communities ([Reid and Hochuli, 2007](#_ENREF_45), [Nagy and Kisfali, 2007](#_ENREF_40)). In more detail, Orthopteran species richness has benefitted from diverse vegetation structures by extensive land-use. Tall vegetation patches provide refuges for less-mobile species when surrounding patches are being grazed or mown. On the other hand it was found that newly-grazed patches provide suitable habitats for nymphs ([Kenyeres and Szentirmai, 2017](#_ENREF_28)). This was reaffirmed by [Korosi et al. (2012](#_ENREF_31)) and [Pywell et al. (2004](#_ENREF_44)) who also found that arthropods increase in species richness and abundance in complex vegetation structures. They established that heterogeneous vegetation provides a larger potential surface for colonisation and more places to feed, lay eggs, rest and overwinter. Heterogeneous vegetation structure therefore adds spatial niches for arthropods similarly to the way vegetation diversity does ([Woodcock and Pywell, 2010](#_ENREF_59)). This same effect was affirmed by findings of increased functional diversity of Lepidopterans in response to heterogeneous vegetation structure ([Aguirre-Gutierrez et al., 2017](#_ENREF_1)).

Another aspect of vegetation structure lies in successional changes. As grasslands develop bushes and small trees slowly encroach these areas leading to forestation. These forested areas provide new habitats for arthropods but are also causing a negative influence on diversity ([Bubová et al., 2015](#_ENREF_7), [Slancarova et al., 2015](#_ENREF_49)). In Lepidoptera, for example, it was found that diurnal species richness benefitted from the availability of extensive grasslands. But nocturnal Lepidoptera decreased in species richness in the same grasslands ([Baur et al., 2006](#_ENREF_3)). In particular specialist Lepidoptera species are affected by changes in succession and their vegetational compositions ([Poyry et al., 2006](#_ENREF_42)).

Causal to these declines in species diversity is the competitive advantage of tall vegetation. When shrubs encroach grasslands they overgrow shorter grassland species and restrict light availability.

As a result plant diversity decreases and a smaller variety of host-plants becomes available for arthropods ([Koch et al., 2015](#_ENREF_30)). While shrub encroachment is halted by intensive grazing/mowing regimes it can be argued that intensive land-use promotes succession. It does so by negating nutrient limitations that later successional stages have because of their higher primary production ([Menge et al., 2012](#_ENREF_38)).

Finally it is necessary to address the effect of land use on the genetic composition of vegetation.

The genetic composition of vegetation is closely linked to environmental changes. As a species’ populations shrink so does its genetic variety. As a result the negative effects of intensive land use on plant biodiversity also affect genetic variety negatively. Eutrophication, high disturbance and fragmentation of the landscape as a result of intensive land use have caused a competitive advantage for high productive, durable species. The genetic composition and variety of previously established species is then lost. Fragmentation of natural grasslands isolate plant populations and their genetic pools. High disturbance via intensive grazing/mowing regimes supress plant flowering and genetic recombination ([Last et al., 2014](#_ENREF_34)). Genetic diversity is important to consider since they have a direct effect on arthropod diversity. Multiple studies by [Bailey et al. (2009](#_ENREF_2)), [Ferrier et al. (2012](#_ENREF_16)) and [Brunbjerg et al. (2018](#_ENREF_6)) found that genetic diversity within host plant species positively correlates to arthropod diversity. It should therefore be taken into consideration that arthropod diversity declines before decreases in plant species richness can be determined.

**Land use types and the frequency of studies reporting high biodiversity.**

As mentioned before the vast majority of the articles regarding arthropod diversity conclude that extensive land-use regimes provide benefits on multiple levels. However, the meta-analysis that is conducted in this review did not provide a distinct pattern for these conclusions. In particular the analysis suggests that land-use did not affect species richness significantly (Fig. 2b). On the other hand arthropod abundance was found to be higher in extensive land use (Fig. 2a). Given these results it becomes necessary to evaluate the differences between these articles and this review and to discuss the causes of these discrepancies. The general consensus in these articles support the patterns in the X-Y comparisons and the proportional overrepresentation of high abundance in extensive grasslands. Therefore I focus first on the potential causes of why species richness was not more frequently reported to be higher in extensive grasslands.

*The proportion of articles studying arthropod diversity providing general biodiversity statistics/data.*

The first possible cause lies in the dissonance between the aim of this review and the articles from the library. The aim of many of these articles was to immediately interpret and analyse the found data. While these articles were highly relevant in adding information for this review, many of their results were consisting of more statistically or analytically processed data. This led to large difference in analysis-types for many of the articles and made it difficult to find overlapping, comparable parameters suitable for meta-analysis. In this paper I was able to use between 11% and 35% of the 117 articles for analysis. Most articles did provide appendixes containing a raw lists of fieldwork data citing each individual sample. For a more extensive study on this subject I would therefore recommend that the author calculate these parameters to gain a more complete dataset.

*Sampling method, timeframe and seasonality of sampling in the studied articles.*

Secondly the wide range of methodological approaches in the studies used for meta-analysis stands out. It was the aim of this review to minimise these effects by adjusting the data for duration of the study in which the samples were taken and only selecting papers researching diversity in both land-use types. There were, however, large differences in the methodology of the articles. For the pairwise comparisons these differences were mostly negated but the frequency analyses were particularly affected. Studies ranged from analysing more than 50 years of gathered data ([Franzen and Johannesson, 2007](#_ENREF_18)) to sampling periods of weeks. This adds to a difficulty in comparability between studies since over this timespan arthropod diversity has changed drastically ([van Strien et al., 2019](#_ENREF_56)). There were also differences in the seasonal periods when samples were taken. Measurements taken as early as in March ([Knop et al., 2006](#_ENREF_29)) until as late as November ([Fadda et al., 2008](#_ENREF_15)). At the base of these differences stands the aim of many of such studies. To be able to reasonably measure effects of land use on arthropod diversity, studies have focussed on limited taxonomical groups. Most of these groups have a limited period in which they can be sampled or when diversity is the highest. Therefore comparing such a variety of studies may increase the variety in biodiversity response and decrease the accuracy of the analysis.

It is also valuable to approach the similarities in richness frequency between land use types from another angle. Extensive land use and high plant diversity does not unequivocally lead to high arthropod diversity. This may originate from the fact that this review has aimed to make a dichotomy between intensive and extensive land use that in practise is hard to define. Land usage has been categorised as extensive when grazing or mowing has been reduced to once or twice a year and later in the growing season or because of an absence of fertilisation or water drainage. But the context in which this extensive land use is practised is crucial. The surrounding landscape and activities play a vital role in how vegetation and arthropod communities develop. Atmospheric nitrogen deposition, for example, varies throughout Europe ([Dentener et al., 2006](#_ENREF_13)). On the regional level nitrogen deposition is highest around urban and industrial areas ([Guerreiro et al., 2014](#_ENREF_21)). Since nitrogen oxides have a distribution fall-off when further from the source ([Fournier et al., 2004](#_ENREF_17)) large differences in atmospheric deposition may occur when comparing a variety of grasslands throughout Europe. It could therefore be possible that eutrophication occurs in such quantity that differences in land use may become less important for vegetation composition. Furthermore it is important to consider that the size of the sampled grassland differed considerably. As a result effects of habit fragmentation may vary across the reviewed articles.

Another aspect of the distinction between extensive and intensive land use that is not accurately represented is diversity within these land use types. Spider species were found to be unaffected by extensive grassland use, as certain extensive grasslands still lack the structural diversity required to sustain a diverse population ([Knop et al., 2006](#_ENREF_29)). Furthermore it was found that the regularity of mowing regimes within the context of extensive land use has great impact on vegetation diversity ([Pruchniewicz, 2017](#_ENREF_43)). And a total abandonment of these grasslands proves to have an adverse impact on butterfly, beetle and bumblebee diversity while being beneficial to certain species of heteropterans and grasshoppers ([Walcher et al., 2017](#_ENREF_58), [Slancarova et al., 2015](#_ENREF_49), [Fadda et al., 2008](#_ENREF_15)). Different taxonomical groups of arthropods are thus dependant on different land use aspects and show different biodiversity responses to similar land use types.

Lastly the time it takes to translate improvements in plant biodiversity into arthropod community developments. The vegetation traits that are required to sustain a diverse arthropod assemblage such as diverse architecture may take up to 4-20 years to fully develop ([Davis and Utrup, 2010](#_ENREF_11)).

**Concluding remarks**

Ultimately I have aimed to present a wide variety of explanations for the current decline in arthropod diversity and its relation to vegetation and plant traits and composition. The value of this information now lies into its application to agricultural and land use practices. Therefore I want to address the practical implications and give a brief summary of how arthropod diversity can best be improved via land use changes.

* *Maintain a limited yet constant grazing or mowing regime late in the growing season*

Grasslands need grazing to prevent secondary succession of shrubs and trees and prevents species becoming dominant. Furthermore grazing provides structural diversity that a diverse arthropod community requires.

* *Increase structural diversity of vegetation within grasslands*

Patches of tall vegetation and small shrubs function as refugia for insect during mowing/grazing and allow for plant species less tolerant to disturbance to survive.

Landscape elements alongside grasslands may also provide these services.

* *Increase habitat connectivity*

Habitat fragmentation has harmed the resilience of many grassland ecosystems connecting grasslands of similar land-use increases the genetic diversity of vulnerable plant and arthropod species. Strips of tall vegetation or tree rows with underlying vegetation can provide pathways to connect these habitats and improve biodiversity.

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**Appendix: Literature list used for meta-analysis**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| ID |  | Search Terms | Article Title | | Authors | Year |  |
| 1 |  | plant diversity extensive grasslands europe | Short-term effects of nongrazing on plants, soil biota and aboveground-belowground links in Atlantic mountain grasslands | | Lur Epelde, Anders Lanzén, Iker Mijangos, Estibaliz Sarrionandia, Mikel Anza & Carlos Garbisu | 2017 |  |
| 2 |  | plant diversity extensive grasslands europe | Pervasive early 21st-century vegetation changesacross Danish semi-natural ecosystems: more losersthan winners and a shift towards competitive,tall-growing species | | Allan Timmermann, Christian Damgaard, Morten T. Strandberg and Jens-Christian Svenning | 2015 |  |
| 3 |  | plant diversity extensive grasslands europe | Landscape composition, connectivity and fragment size drive effects of grassland fragmentation on insect communities | | Verena Rösch, Teja Tscharntke, Christoph Scherber and Péter Batáry | 2013 |  |
| 4 |  | plant diversity extensive grasslands europe | Interactive effects of landscape context constrain the effectiveness of local agri-environmental management | | Elena D. Concepción, Mario Díaz, David Kleijn, András Báldi, Péter Batáry,Yann Clough, Doreen Gabriel, Felix Herzog, Andrea Holzschuh, Eva Knop, E. Jon P. Marshall, Teja Tscharntke and Jort Verhulst | 2012 |  |
| 5 |  | plant diversity extensive grasslands europe | Effects of fertilization and cutting frequency on the water balance of a temperate grassland | | Laura Rose, Heinz Coners and Christoph Leuschner | 2012 |  |
| 6 |  | plant diversity extensive grasslands europe | Structure, composition and dynamics of a calcareous grassland metacommunity over a 70-year interval | | Adrian C. Newton, Robin M. Walls, Duncan Golicher, Sally A. Keith, Anita Diaz | 2012 |  |
| 7 |  | plant diversity extensive grasslands europe | Responses of invertebrate trophic level, feeding guild and body size to the management of improved grassland field margins | | Ben A. Woodcock, Simon G. Potts, Thomas Tscheulin, Emma Pilgrim, Alex J. Ramsey, Jennifer Harrison-Cripps, Valerie K. Brown and Jerry R. Tallowin | 2009 |  |
| 8 |  | plant diversity extensive grasslands europe | Effectiveness of the Swiss agri-environment scheme in promoting biodiversity | | EVA KNOP, DAVID KLEIJN, ELIX HERZOG and BERNHARD SCHMID | 2006 |  |
| 9 |  | plant diversity extensive grasslands europe | Relative importance of burning, mowing and species translocation in the restoration of a former boreal hayfield: responses of plant diversity and the microbial community | | HILDE ANTONSEN and PÅL AXEL OLSSON | 2005 |  |
| 10 |  | plant diversity extensive grasslands europe | Are invaders disturbance-limited? Conservation of mountain grasslands in Central Argentina | | Petryna, L.; Moora, M.; Nuñes C.O.; Cantero, J.J.& Zobel, M. | 2002 |  |
| 11 |  | plant diversity extensive grasslands europe | Nutrient status, disturbance and competition: an experimental test of relationships in a wet meadow | | Lepš, Jan | 1999 |  |
| 12 |  | plant diversity extensive grasslands europe | Effects of abandonment of subalpine hay meadows on plant and invertebrate diversity in Transylvania, Romania | | Bruno Baura, Cristina Cremeneb, Gheorghe Grozac, Laszlo Rakosyc, Anatoli A. Schileykod | 2006 |  |
| 13 |  | plant diversity extensive grasslands europe | Restoration of wet grasslands – Effects of seed dispersal, persistence and abundance on plant species recruitment | | Gert Rosenthal | 2006 |  |
| 14 |  | plant diversity extensive grasslands europe | Threatened alvar grasslands in NW Russia and their relationship to alvars in Estonia | | SERGEY ZNAMENSKIY1, AVELIINA HELM and MEELIS PÄRTEL | 2004 |  |
| 15 |  | plant diversity extensive grasslands europe | Grazing management impacts on the viability of the threatened bog fritillary butterfly Proclossiana eunomia | | Nicolas Schtickzelle, Camille Turlure, Michel Baguette | 2007 |  |
| 16 |  | plant diversity extensive grasslands europe | Relative importance of habitat area, connectivity, management and local factors for vascular plants: spring ephemerals in boreal semi-natural grasslands | | Katja M. Raatikainen, Risto K. Heikkinen, Miska Luoto | 2008 |  |
| 17 |  | plant diversity extensive grasslands europe | Management effects on the vegetation and soil seed bank of calcareous grasslands: An 11-year experiment | | Hans Jacquemyn, Carmen Van Mechelen, Rein Brys, Olivier Honnay | 2010 |  |
| 18 |  | plant diversity extensive grasslands europe | River Dikes in Agricultural Landscapes: The Importance of Secondary Habitats in Maintaining Landscape-Scale Diversity | | Zoltán Bátori & László Körmöczi & Márta Zalatnai & László Erdős & Péter Ódor & Csaba Tölgyesi & Katalin Margóczi & Attila Torma & Róbert Gallé & Viktória Cseh & Péter Török | 2016 |  |
| 19 |  | plant diversity extensive grasslands europe | Contrasting effects of irrigation and fertilization on plantdiversity in hay meadows | | Isabell B. Müller∗, Constanze Buhk, Dagmar Lange, Martin H. Entling,Jens Schirmel | 2016 |  |
| 20 |  | plant diversity extensive grasslands europe | Abandonment of traditionally managed mesic mountainmeadows affects plant species composition and diversity | | Daniel Pruchniewicz | 2017 |  |
| 21 |  | plant diversity extensive grasslands europe | The association of windmills with conservation of pollinating insects and wild plants in homogeneous farmland of western Poland | | Sylwia Pustkowiak & Weronika Banaszak-Cibicka & Łukasz Emil Mielczarek & Piotr Tryjanowski & Piotr Skórka | 2017 |  |
| 22 |  | plant diversity extensive grasslands europe | Flowering Farmland Competitions in Europe: History, facts and potential interactions with agri-environmental measures | | Andreas Hilpolda, Erich Tassera, Ulrike Tappeinera, Georg Niedrista | 2018 |  |
| 23 |  | plant diversity extensive grasslands europe | Spider assemblage structure and functional diversity patterns of natural forest steppes and exotic forest plantations | | Róbert Galléa, Ágota Szabóa, Péter Császára, Attila Tormaa | 2018 |  |
| 24 |  | plant diversity extensive grasslands europe | Assessing the impact of land abandonment, nitrogen enrichment and fairy-ring fungi on plant diversity of Mediterranean grasslands | | Giuliano Bonanomi, Guido Incerti, Marina Allegrezza | 2013 |  |
| 25 |  | plant diversity extensive grasslands europe | The conservation of ground layer lichen communities in alvar grasslands and the relevance of substitution habitats | | Ede Leppik, Inga Ju¨riado, Ave Suija, Jaan Liira | 2013 |  |
| 26 |  | plant diversity extensive grasslands europe | Modelling the spatial distribution of species-rich farmland to identify priority areas for conservation actions | | Sebastian Klimek, Gabriele Lohss, Doreen Gabriel | 2014 |  |
| 27 |  | plant diversity extensive grasslands europe | Hydroperiod and Traditional Farming Practices Drive Plant Community Composition on Unregulated Atlantic Floodplain Meadows | | Caitriona Maher & Micheline Sheehy Skeffington & Michael Gormally | 2014 |  |
| 28 |  | plant diversity extensive grasslands europe | Effects of grazing and biogeographic regions on grassland biodiversity in Hungary – analysing assemblages of 1200 species | | A. Báldia, P. Batáryc, D. Kleijn | 2012 |  |
| 29 |  | plant diversity extensive grasslands europe | Threatened inland sand vegetation in the temperate zone under different types of abiotic and biotic disturbances during a ten-year period | | Christopher Faust, Karin Süss, Christian Storm, Angelika Schwabe | 2010 |  |
| 30 |  | arthropod richness grasslands europe | Intensive agriculture reduces soil biodiversity across Europe | | MARIA A. TSIAFOULI1 , ELISA THEBAULT, STEFANOS P. SGARDELIS, PETER C . DE RUITER, WIM H. VAN DER PUTTEN, KLAUS BIRKHOFER, LIA HEMERIK, FRANCISKA T . DE VRIES, RICHARD D. BARDGETT, MARK VINCENT BRADY, LISA BJORNLUND, HELENE BRACHT JØRGENSEN, S € OREN CHRISTENSEN, TINA D’ HERTEFELDT, STEFAN HOTES, W.H. GERAHOL, JAN FROUZ, MIRA LIIRI, SIMON R . MORTIMER, HEIKKI SETÄLÄ, JOSEPH TZANOPOULOS, KAROLINE UTESENY, VACLAV PIZL, JOSEF STARY, VOLKMAR WOLTERS and KATARINA HEDLUND | 2015 |  |
| 31 |  | arthropod richness grasslands europe | The influence of conservation field margins in intensively managed grazing land on communities of five arthropod trophic groups | | ANNETTE ANDERSON, TIM CARNUS, ALVIN J. HELDEN, HELEN SHERIDAN and GORDON PURVIS | 2013 |  |
| 32 |  | arthropod richness grasslands europe | Riparian field margins: can they enhance the functional structure of ground beetle (Coleoptera: Carabidae) assemblages in intensively managed grassland landscapes? | | Lorna J. Cole, Sarah Brocklehurst, David A. Elston and David I. McCracken | 2012 |  |
| 33 |  | arthropod richness grasslands europe | Ecosystem engineering and predation: the multi-trophic impact of two ant species | | Dirk Sanders and F. J. Frank van Veen | 2011 |  |
| 34 |  | arthropod richness grasslands europe | Spontaneous succession in limestone quarries as an effective restoration tool for endangered arthropods and plants | | Robert Tropek, Tomas Kadlec, Petra Karesova, Lukas Spitzer, Petr Kocarek, Igor Malenovsky, Petr Banar, Ivan H. Tuf, Martin Hejda and Martin Konvicka | 2010 |  |
| 35 |  | arthropod richness grasslands europe | The classification of insect communities: Lessons from orthopteran assemblages of semi-dry calcareous grasslands in central Germany | | DOMINIK PONIATOWSKI and THOMAS FARTMANN | 2008 |  |
| 36 |  | arthropod richness grasslands europe | The potential of grass field margin management for enhancing beetle diversity in intensive livestock farms | | B. A. WOODCOCK, S. G. POTTS, E. PILGRIM, A. J. RAMSAY, T. TSCHEULIN, A. PARKINSON, R. E. N. SMITH, A. L. GUNDREY, V. K. BROWN and J. R. TALLOWIN | 2007 |  |
| 37 |  | arthropod richness grasslands europe | Plants, insects and birds in semi-natural pastures in relation to local habitat and landscape factors | | BO SÖDERSTRÖM, BIRGITTA SVENSSON, KAROLINA VESSBY and ANDERS GLIMSKÄR | 2000 |  |
| 38 |  | arthropod richness grasslands europe | Biodiversity and agri-environmental indicators—general scopes and skills with special reference to the habitat level | | Wolfgang Büchs | 2003 |  |
| 39 |  | arthropod richness grasslands europe | Effects of vegetation structure and floristic diversity on detritivore, herbivore and predatory invertebrates within calcareous grasslands | | Ben A. Woodcock  Richard F. Pywell | 2010 |  |
| 40 |  | arthropod richness grasslands europe | Ground spider assemblages as indicators for habitat structure in inland sand ecosystems | | Sascha Buchholz | 2010 |  |
| 41 |  | arthropod richness grasslands europe | Set-aside promotes insect and plant diversity in a Central European country | | Anikó Kovács-Hostyánszki, Ádám Körösi, Kirill Márk Orcib, Péter Batáryc, András Báldib | 2011 |  |
| 42 |  | arthropod richness grasslands europe | Biodiversity in low-intensity pastures, straw meadows, and fallows of a fen area–A multitrophic comparison | | Roman Buchera, Christian Andresc, Martin F. Wedelb, Martin H. Entlingb, Herbert Nickeld | 2015 |  |
| 43 |  | arthropod richness grasslands europe | Optimizing arthropod predator conservation in permanent grasslands by considering diversity components beyond species richness | | K. Birkhofera, T. Dieköttera, C. Meuba, K. Stötzela, V. Woltersa | 2015 |  |
| 44 |  | arthropod richness grasslands europe | Set-aside promotes insect and plant diversity in a Central European country | | Anikó Kovács-Hostyánszki, Ádám Körösi, Kirill Márk Orcib, Péter Batáryc, András Báldib | 2011 |  |
| 45 |  | arthropod richness grasslands europe | The importance of viticultural landscape features and ecosystem service enhancement for native butterflies in New Zealand vineyards | | Mark Gillespie, Steve D. Wratten | 2010 |  |
| 46 |  | arthropod richness grasslands europe | Shrub encroachment alters composition and diversity of ant communities in abandoned grasslands of western Carpathians | | Michal Wiezik, Marek Svitok, Adela Wieziková, Martin Dovčiak | 2012 |  |
| 47 |  | arthropod richness grasslands europe | Biodiversity responses to land use in traditional fruit orchards of arural agricultural landscape | | Jakub Horaka, Alena Peltanovab, Andrea Podavkovac, Lenka Safarovad, Petr Boguschf, Dusan Romportlb, Petr Zasadilca | 2013 |  |
| 48 |  | arthropod richness grasslands europe | Restoration management of fly ash deposits crucially influence their conservation potential for terrestrial arthropods | | Robert Tropek, Ilona Cerna, Jakub Straka, Tomas Kadlec, Pavel Pech, Filip Tichanek, Pavel Sebek | 2014 |  |
| 49 |  | arthropod richness grasslands europe | Asymmetrical responses of forest and ‘‘beyond edge’’ arthropod communities across a forest–grassland ecotone | | Federica Lacasella, Claudio Gratton, Stefano De Felici, Marco Isaia, Marzio Zapparoli, Silvio Marta, Valerio Sbordoni | 2014 |  |
| 50 |  | arthropod richness grasslands europe | Carabid beetles as indicators for shrub encroachment in dry grasslands | | Jens Schirmel, Jasmin Mantilla-Contreras, Dorothea Gauger, Irmgard Blindowa | 2014 |  |
| 51 |  | ((arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe) | Diversity of bumblebees, heteropteran bugs and grasshoppers maintained by both: abandonment and extensive management of mountain meadows in three regions across the Austrian and Swiss Alps | | Ronnie Walcher | 2017 |  |
| 52 |  | ((arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe) | Effects of different mowing regimes on orthopterans of Central-European mesic hay meadows | | Zoltán Kenyeres, István Szentirmai | 2017 |  |
| 53 |  | ((arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe) | Impact of floral nectar limitation on life-history traits in a grassland butterfly relative to nectar supply in different agricultural landscapes | | Julie Le beau, Renate A. Wesselingh, Hans Van Dyck | 2018 |  |
| 54 |  | ((arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe) | Grassland management in agricultural vs. forested landscapes drives butterfly and bird diversity | | Lunja M.Ernsta Teja Tscharntkea Péter Batáry | 2017 |  |
| 55 |  | ((arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe) | Spatial structure of traditional land organization allows long-term persistence of large Formica exsecta supercolony in actively managed agricultural landscape | | Michal Wiezik, Igor Gallay, Adela Wieziková, Marek Čiliak, Martin Dovciak | 2017 |  |
| 56 |  | ((arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe) | Scale-dependent effects of grazing on the species richness of alkaline and sand grasslands | | Laura Godó, Orsolya Valkó, Béla Tóthmérész, Péter Török, András Kelemen & Balázs Deák | 2017 |  |
| 57 |  | ((arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe) | Restoration of semi-natural grasslands, a success for phytophagous beetles (Curculionidae) | | Steiner, M (Steiner, Magdalena); Ockinger, E (Ockinger, Erik); Karrer, G (Karrer, Gerhard); Winsa, M (Winsa, Marie); Jonsell, M (Jonsell, Mats) | 2016 |  |
| 58 |  | ((arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe) | From Landsat to leafhoppers: A multidisciplinary approach for sustainable stocking assessment and ecological monitoring in mountain grasslands | | Riccardo Primi | 2016 |  |
| 59 |  | ((arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe) | Microhabitat heterogeneity promotes soil fertility and ground-dwelling arthropod diversity in Mediterranean wood-pastures | | Sergio García-Tejeroa, Ángela Taboada | 2016 |  |
| 60 |  | ((arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe) | The role of ecological infrastructure on beneficial arthropods in vineyards | | Kristijan Franin, Božena Barić and Gabrijela Kuštera | 2016 |  |
| 61 |  | ((arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe) | Exploring the causes of high biodiversity of Iberian dehesas: the importance of wood pastures and marginal habitats | | Gerardo Moreno, Guillermo Gonzalez-Bornay, Fernando Pulido, María Lourdes Lopez-Diaz, Manuel Bertomeu, Enrique Juárez, Mario Diaz | 2016 |  |
| 62 |  | ((arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe) | Land management impacts on European butterflies of conservation concern: a review | | Terezie Bubova, Vladimı´r Vrabec, Martin Kulma  , Piotr Nowicki | 2015 |  |
| 63 |  | ((arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe) | Butterflies in Portuguese ‘montados’: relationships between climate, land use and life-history traits | | Jana Slancarova, Patricia Garcia-Pereira, Zdenek Faltynek, FricHelena Romo, Enrique Garcia-Barros | 2015 |  |
| 64 |  | ((arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe) | Fragmentation genetics of the grassland butterfly Polyommatus coridon: Stable genetic diversity or extinction debt? | | Jan Christian Habel Sabrina V. Jochen Krauss Julia SchwarzerAlfons WeigMartin HusemannIngolf Steffan-Dewenter | 2015 |  |
| 65 |  | ((arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe) | Shrub encroachment affects the diversity of plants,  butterflies, and grasshoppers on two Swiss subalpine  pastures | | Bärbel Koch, Peter J. Edwards, Wolf U. Blanckenhorn, Thomas Walter and Gabriela Hofer | 2015 |  |
| 66 |  | ((arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe) | Metapopulations of endangered Maculinea butterflies are resilient to large-scale fire | | Piotr Nowicki | 2015 |  |
| 67 |  | ((arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe) | Hydroperiod and Traditional Farming Practices Drive Plant Community Composition on Unregulated Atlantic Floodplain Meadows | | Caitriona Maher, Micheline Sheehy Skeffington, Michael Gormally | 2015 |  |
| 68 |  | ((arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe) | Intensive agriculture reduces soil biodiversity across Europe | | Maria A. Tsiafouli Elisa Thébault Stefanos P. Sgardelis Peter C. de Ruiter Wim H. van der Putten Klaus Birkhofer Lia Hemerik Franciska T. de Vries Richard D. Bardgett | 2014 |  |
| 69 |  | ((arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe) | Effects of habitat and landscape characteristics on the arthropod assemblages (Araneae, Orthoptera, Heteroptera) of sand grassland remnants in Southern Hungary | | Attila Torma , Róbert Gallé , Miklós Bozsó | 2014 |  |
| 70 |  | ((arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe) | The impact of grazing management on Orthoptera abundance varies over the season in Mediterranean steppe-like grassland | | Jocelyn Fonderflick, Aurelien Besnard, Aurore Beuret, Mathieux Dalmais, Bertrand Schatz | 2014 |  |
| 71 |  | ((arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe) | Pastoral Practices to Reverse Shrub Encroachment of Sub-Alpine Grasslands: Dung Beetles (Coleoptera, Scarabaeoidea) Respond More Quickly Than Vegetation | | Claudia Tocco, Massimiliano Probo, Michele Lonati , Giampiero Lombardi, Matteo Negro, Beatrice Nervo, Antonio Rolando, Claudia Palestrini | 2013 |  |
| 72 |  | ((arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe) | Earthworms, spiders and bees as indicators of habitat quality and management in a low-input farming region—A whole farm approach | | Anikó Kovács-Hostyánszki, Zoltán Elek, Katalin Balázs, Csaba Centeri, Eszter Falusi, Philippe Jeanneret, Károly Penksza, László Podmaniczky, Ottó Szalkovszki, András Báldi | 2013 |  |
| 73 |  | ((arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe) | Soil food web properties explain ecosystem services across European land use systems | | Franciska T. de Vries, Elisa Thébault, Mira Liirie, Klaus Birkhoferf, Maria A. Tsiafoulig, Lisa Bjørnlundh, Helene Bracht Jørgensen, Mark Vincent Bradyi, Søren Christensenh, Peter C. de Ruiter, Tina d’Hertefeldt, Jan Frouzj, Katarina Hedlundf, Lia Hemerik, W. H. Gera Holk, Stefan Hotesl, Simon R. Mortimern, Heikki Setäläe, Stefanos P. Sgardelisg, Karoline Utesenyo, Wim H. van der Puttenk,p, Volkmar Wolters, and Richard D. Bardgett | 2013 |  |
| 74 |  | ((arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe) | Land use changes and ground dwelling beetle conservation in extensive grazing dehesa systems of north-west Spain | | Sergio García-Tejero, Ángela Taboada, Reyes Tárrega, José M. Salgado | 2013 |  |
| 75 |  | ((arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe) | Cross-taxa congruence, indicators and environmental gradients in soils under agricultural and extensive land management | | Aidan. M. Keitha, Bas Bootsa, Christina Hazarda, Robin Niechojd, Julio Arroyoa, Gary D. Bendinge, Tom Bolgera, John Breend, Nicholas Clipsona, Fiona M. Doohana, Christine T. Griffinb, Olaf Schmidt | 2011 |  |
| 76 |  | ((arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe) | Science into practice – how can fundamental science contribute to better management of grasslands for invertebrates? | | NICK A. LITTLEWOOD, ALAN J. A. STEWART and BEN A. WOODCOCK | 2012 |  |
| 77 |  | ((arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe) | High mobility reduces beta-diversity among orthopteran communities - implications for conservation | | LORENZO MARINI, ERIK ÖCKINGER, ANDREA BATTISTI and RICCARDO BOMMARCO | 2012 |  |
| 78 |  | ((arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe) | Effects of grazing, vegetation structure and landscape complexity on grassland leafhoppers (Hemiptera: Auchenorrhyncha) and true bugs (Hemiptera: Heteroptera) in Hungary | | ÁDÁM KOROSI, PETER BATARY, ANDRAS OROSZ, DAVID REDEI and ANDRA SBALDI | 2012 |  |
| 79 |  | ((arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe) | Population isolation rather than ecological variation explains the genetic structure of endangered myrmecophilous butterfly Phengaris (=Maculinea) arion | | Marcin Sielezniew, Robert Rutkowski | 2012 |  |
| 80 |  | ((arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe) | How can we preserve and restore species richness of pollinating insects on agricultural land? | | Markus Franzén and Sven G. Nilsson | 2008 |  |
| 81 |  | ((arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe) | Relative efficiency of extensive grazing vs. wild ungulates management for dung beetle conservation in a heterogeneous landscape from Southern Europe (Scarabaeinae, Aphodiinae, Geotrupinae) | | Pierre Jay-Roberta, Jérome Niogreta, Faïek Errouissia, Maureen Labarussiasa, Éléonore Paolettia, Maite Vázquez Luisa, Jean-Pierre Lumareta | 2008 |  |
| 82 |  | ((arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe) | Are spiders reacting to local or landscape scale effects in Hungarian pastures? | | Péter Batárya, András Báldib, Ferenc Samuc, Tamás Szutsd, Sarolta Erdosa | 2008 |  |
| 83 |  | ((arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe) | Consequences of the cessation of 3000 years of grazing on dry Mediterranean grassland ground-active beetle assemblages | | Sylvain Fadda, Frédéric Henry, Jérôme Orgeas, Philippe Ponel, Élise Buisson | 2008 |  |
| 84 |  | ((arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe) | From multi-criteria approach to simple protocol: Assessing habitat patches for conservation value using species rarity | | Ferenc Samua, Peter Csontosb, Csaba Szinetarc | 2008 |  |
| 85 |  | ((arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe) | Vascular plant and Orthoptera diversity in relation to grassland management and landscape composition in the European Alps | |  | 2008 |  |
| 86 |  | ((arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe) | HABITAT PREFERENCE IN TERRITORIES OF THE RED-BACKED SHRIKE *LANIUS OLLURIO* AND THEIR FOOD RICHNESS IN AN EXTENSIVE AGRICULTURE LANDSCAPE | | A. GOŁAWSKI and S. GOŁAWSKA | 2008 |  |
| 87 |  | ((arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe) | Contrasting trends of butterfly species preferring semi-natural grasslands, field margins and forest edges in northern Europe | | Mikko Kuussaari, Janne Heliola & Juha Poyry | 2007 |  |
| 88 |  | ((arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe) | Predicting extinction risk of butterflies and moths (Macrolepidoptera) from distribution patterns and species characteristics | | Markus Franzén & Mikael Johannesson | 2007 |  |
| 89 |  | ((arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe) | Grazing management impacts on the viability of the threatened bog fritillary butterfly Proclossiana eunomia | | Nicolas Schtickzelle, Camille Turlure, Michel Baguette | 2007 |  |
| 90 |  | ((arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe) | Factors influencing bug diversity (Insecta: Heteroptera) in semi-natural habitats | | CORINNE ZURBRUGG and THOMAS FRANK | 2004 |  |
| 91 |  | ((arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe) | Species composition, feeding specificity and larval trophic level of flower-visiting insects in fragmented versus continuous heathlands in Denmark | | Y.L. Dupont, B. Overgaard Nielsen | 2005 |  |
| 92 |  | ((arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe) | Differences in the diversity of oribatid mite communities in forests and agrosystems lands | | Julio Arroyo, Juan Carlos Iturrondobeitia | 2005 |  |
| 93 |  | ((arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe) | Resumed forest grazing restored a population of Euphydryas aurinia (Lepidoptera: Nymphalidae) in SE Finland | | KIMMO SAARINEN, JUHA JANTUNEN and ANU VALTONEN | 2005 |  |
| 94 |  | ((arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe) | The influence of grassland management on ground beetles (Carabidae, Coleoptera) in Swiss montane meadows | | Anne-Catherine Grandchamp, Ariel Bergamini, Silvia Stofer, Jari Niemela, Peter Duelli, Christoph Scheidegger | 2005 |  |
| 95 |  | ((arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe) | Habitat-based models for predicting the occurrence of ground-beetles in arable landscapes: two alternative approaches | | Sandrine Petit, Karen Haysom, Richard Pywell, Liz Warman, David Allen, Roger Booth, Les Firbank | 2002 |  |
| 96 |  | ((arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe) | Estimating the biodiversity of hay meadows in north-eastern Switzerland on the basis of vegetation structure | | Andrea Schwab, David Dubois, Padruot M. Fried, Peter J. Edwards | 2001 |  |
| 97 |  | ((arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe) | Does Extensive Grazing Benefit Butterflies in Coastal Dunes? | | Michiel F. Wallis De Vries, Ivo Raemakers | 2001 |  |
| 98 |  | ((arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe) | Enhancing insect diversity in agricultural grasslands: the roles of management and landscape structure | | MANUELA DI GIULIO, PETER J. EDWARDS and ERHARD MEISTER | 2001 |  |
| 99 |  | ((arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe) | The impact of grazing on spider communities in a mesophytic calcareous dune grassland | | Bonte, D; Maelfait, J.-P. & Hoffmann, M. | 2000 |  |
| 100 |  | ((arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe) | Modelling populations of Erigone atra and E. dentipalpis (Araneae: Linyphiidae) across an agricultural gradient in Scotland | | I.S. Downie, I. Ribera, D.I. McCracken; W.L. Wilson, G.N. Foster, A. Waterhouse | 1999 |  |
| 101 |  | ((arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe) | Consequences of Succession on Extensively Grazed Grasslands for Central European Butterfly Communities: Rethinking Conservation Practices | | OLIVER BALMER AND ANDREAS ERHARDT | 2000 |  |
| 102 |  | ((arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe) | The impact of different agricultural land-uses on epigeal spider diversity in Scotland | | I.S. Downie, W.L. Wilson, V.J. Abernethy, D.I. McCracken, G.N. Foster, I. Ribera, K.J. Murphy | 1999 |  |
| 103 |  | ((arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe) | The Hemiptera of Two Sown Calcareous Grasslands. III. Comparisons with theAuchenorhyncha Faunas of Other Grasslands | | M. G. Morris | 1990 |  |
| 104 |  | (plants OR plant) AND (arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe | Taxonomic and Behavioral Composition of an Island Fauna: A Survey of Bees (Hymenoptera: Apoidea: Anthophila) on Martha's Vineyard, Massachusetts | | Paul Z. Goldstein and John S. Ascher | 2016 |  |
| 105 |  | (plants OR plant) AND (arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe | Determinants of parasitoid communities of willow-galling sawflies: habitat overrides physiology, host plant and space | | TOMMI NYMAN, SANNA A. LEPPANEN, GERGELY V ARKONYI, MARK R. SHAW | 2015 |  |
| 106 |  | (plants OR plant) AND (arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe | RECOVERY OF SPIDER COMMUNITIES AFTER A SPONTANEOUS SUMMER FIRE IN THE FORB-BUNCHGRASS STEPPE OF EASTERN UKRAINE | | Nina PolchaninovA | 2015 |  |
| 107 |  | (plants OR plant) AND (arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe | Life history traits, but not phylogeny, drive compositional patterns in a butterfly metacommunity | | SANDRINE PAVOINE, MICHEL BAGUETTE, VIRGINIE M. STEVENS, MATHEW A. LEIBOLD, CAMILLE TURLURE | 2014 |  |
| 108 |  | (plants OR plant) AND (arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe | Grazing history influences biodiversity: a case study on ground-dwelling arachnids (Arachnida: Araneae, Opiliones) in the Natural Park of Alpi Marittime (NW Italy) | | Mauro Paschetta, Valentina La Morgia | 2012 |  |
| 109 |  | (plants OR plant) AND (arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe | Landscape context and elevation affect pollinator communities in intensive apple orchards | | Lorenzo Marinia, Marino Quarantac, Paolo Fontanad, Jacobus C. Biesmeijer | 2012 |  |
| 110 |  | (plants OR plant) AND (arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe | The Impact of Overgrazing on Dung Beetle Diversity in the Italian Maritime Alps | | Matteo Negro, Antonio Rolando and Claudia Palestrini | 2011 |  |
| 111 |  | (plants OR plant) AND (arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe | Time budget, social and ingestive behaviours expressed by native beef cows in Mediterranean conditions | | A. Braghieri, C. Pacelli, A. Girolami, F. Napolitano | 2011 |  |
| 112 |  | (plants OR plant) AND (arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe | Land-use, environment, and their impact on butterfly populations in a mountainous pastoral landscape: species richness and family-level abundance | | J. W. Dover A. Rescia S. Fungariño J. Fairburn P. Carey P. Lunt C. Arnot R. L. H. Dennis C. J. Dover | 2010 |  |
| 113 |  | (plants OR plant) AND (arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe | Habitat preferences of Maculinea arion and its Myrmica host ants: implications for habitat management in Italian Alps | | Luca Pietro Casacci, Magdalena Witek, Francesca Barbero, Dario Patricelli, Gaetano Solazzo, Emilio Balletto, Simona Bonelli | 2010 |  |
| 114 |  | (plants OR plant) AND (arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe | Recent records of steppe species in Belarus, first indications of a steppe species invasion? | | Oleg Aleksandrowicz | 2011 |  |
| 115 |  | (plants OR plant) AND (arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe | Disentangling effects of habitat diversity and area on orthopteran species with contrasting mobility | | Lorenzo Marini, Riccardo Bommarco, Paolo Fontana, Andrea Battisti | 2010 |  |
| 116 |  | (plants OR plant) AND (arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe | Effects of vineyard management on biodiversity at three trophic levels | | Odile T. Bruggisser, Martin H. Schmidt-Entling, Sven Bacher | 2010 |  |
| 117 |  | (plants OR plant) AND (arthropod OR arthropoda OR arthropods) AND extensive AND (diversity OR richness) AND (grasslands OR grassland) Europe | Response of orthopteran diversity to abandonment of semi-natural meadows | Lorenzo Marini, Paolo Fontana, Andrea Battisti, Kevin J. Gaston | | 2009 |  |