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Vegetation Characteristics of the Main Grassland Types in China Respond Differently to the Duration of Enclosure: A Meta-Analysis

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Abstract: Enclosure is one of the useful measures to protect and restore degraded grasslands, and it is widely used around the world. The vegetation characteristics of grasslands directly reflect the recovery status of degraded grasslands; however, conflicting results of plant traits were continually achieved in the numerous on-site studies of enclosure in the last two decades. It is necessary to conduct a systematic assessment to find a general conclusion for the effects of enclosure on different grasslands. Studies on the enclosure grasslands in China were taken as the objects to refine the relationships between grassland vegetation characteristics and enclosure measures using meta-analysis. Enclosure had positive effects on the restoration of vegetation coverage, aboveground and belowground biomass, and diversity of degraded grasslands. Different vegetation characteristics and grassland types showed different responses to enclosure duration. The vegetation productivity reached a maximum in the 11–15 years of enclosure for alpine grasslands and typical steppe grasslands, 6–10 years for desert grasslands, and more than 15 years of enclosure for meadow grasslands. Plant species diversity reached the peak values when alpine grasslands and typical steppe grasslands were enclosed approximately 10 years, desert grasslands approximately 11–15 years, and meadow grasslands approximately 5 years. These results indicated that the management strategies of enclosed grasslands should be adjusted reasonably according to the types and the management objectives of grasslands in order to maintain or even improve the condition and services of grassland ecosystems.

Keywords: degraded grassland; coverage; biomass; diversity; growth rate

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1. Introduction

Grasslands, covering approximately 40% of the global terrestrial area [1], not only provide food production but also play essential roles in ecosystem diversity, carbon accumulation, and global climate change [2]. Unfortunately, large-scale climate change and excessive human activity disruption [3], such as livestock overgrazing, lead to severe degradation of grassland ecosystems, even desertification [4–7]. Grasslands in China account for close to 41% of the land area [8], and there are many types of grasslands, including alpine grasslands, desert grasslands, meadow grasslands, and typical steppe grasslands; however, approximately 90% of the grasslands were estimated to be degraded [9], resulting in the decline of grassland vegetation coverage, grassland vegetation productivity, plant diversity, and the deterioration of the entire system structure. For the sake of easing grassland degradation's negative influence and enhancing ecosystem functions and tolerance, many methods have been adopted, including plant rebuilding, reseeding, fertilizing, irrigation, and fencing enclosure [10,11]. Among these methods, enclosure by fence is a relatively low-cost measure and is currently commonly used in the restitution of degraded grasslands [12–14].

Enclosure can protect degraded grasslands from disturbance within a certain period of time and allow the natural restoration of degraded grasslands. Many studies have reported that enclosure has indeed reversed the negative effects and significantly improved vegetation composition, grassland productivity, soil structure, and soil organic matter accumulation [5,15,16]. Enclosing the severely degraded grassland can not only restore the degraded grassland to a certain extent but also avoid the re-degradation caused by non-use during the restoration process [17]. However, some studies have also shown that the enclosure has significant inhibitory effects on plant traits [18,19], as well as a drop in the number of vegetative species and species richness [20]; namely, the species richness of grasslands (5.4 m^{-2}) enclosed for 12 years compared with those grazed (16 m^{-2}) was significantly declined [21]. These controversial results reflect on grassland types and regions [22].

For instance, alpine grasslands' plant species richness and diversity reached the highest value after 5–7 years of enclosure [23,24], and the aboveground biomass (AGB) reached the highest value after 5–6 years of enclosure [25]. For typical steppe grasslands, species diversity decreased significantly in 6 years' enclosure [26], while a study noted that in an enclosure duration of 30 years, plant community diversity was still seen in higher levels [27]. Typical grasslands' vegetation coverage, biomass, and diversity increased significantly from 0 to 15 years and gradually decreased from 16 to 30 years [28]. Five-year duration in meadows, species abundance, and diversity have sustainable benefits [19], but in subalpine meadows of the Qinghai, enclosure had little sustainable benefit after four–five years [29,30]. In addition, others reported that the diversity of alpine meadows gradually decreased in the sixth year [31,32] or in the ninth year [33]. For desert grasslands, this fencing effect occurred only in the first 6 years [8,34]. These contradictory findings from on-site investigations impede our ability to make managerial decisions. Therefore, it is essential to make a comprehensive evaluation of the impact of duration enclosure on vegetation coverage, AGB, and plant diversity of different grassland types in different regions of China. In this study, we focus on the effect of vegetation coverage, biomass, and diversity, which can reflect plant photosynthetic capacity [35,36], energy flow, material circulation [37–41], and ecosystem stability and functions [42–45]. Specifically, we aimed to address the following questions: (1) Whether the enclosure of various types of grasslands resulted in a consistent response from the vegetation characteristics, and (2) How the enclosure duration affected the grassland vegetation characteristics. The policy of grassland enclosure has been implemented in China for several decades, and many scholars have conducted numerous studies related to enclosed grasslands in China, which can be used as good samples to elucidate these questions and achieve a general conclusion. Therefore, we considered the enclosed grasslands in China as the research object, collected the currently published articles on "enclosure" and "plant traits", and used meta-analysis to comprehensively explore the responses to enclosure of plant traits of four main grassland types. Through this study, corresponding theoretical support could be provided for the rational conservation and utilization of enclosed degraded grasslands.

2. Materials and Methods

2.1. Data Collection

This research targeted the responses to enclosure effects of four grassland types. To gather records that quantified the results of enclosure, we investigated peer-reviewed journal articles published from 1999 to 2021 using the Web of Science and China National Knowledge Infrastructure (CNKIT). The combinations of the following search term were used, along with "fence enclosure" OR "fence" OR "enclosure" OR "grazing exclusion" OR "grazing removal". Then, articles were refined by countries/regions "PEOPLES R CHINA". Some literature published as dissertations were also collected. More than 240 articles were preliminary obtained. To decrease the bias induced through the display literatures, the following criteria were used for the study selection:

(1) The study sites were grasslands in China, and the types of grassland could be judged through the text of the articles.
(2) The experiment was set up with the enclosure group and the grazing control group at the same time;
(3) There have been no different practices (e.g., fertilization or seeding) performed in the fenced sites;
(4) The grassland type, soil texture, and climate characteristics of the experimental group and the control group were the same;
(5) Each parameter in the chosen article had the records of common values, standard deviations or standard errors, and sample sizes;
(6) The means, standard deviations or standard errors, and pattern sizes of treatment and control have been immediately reported or could, in any other case, be determined from the chosen articles;
(7) Duration of enclosure was at least one year. When more than one article posted data from the same site, the contemporary publication with the most current data was given priority.

Finally, 91 eligible articles from specific study sites were chosen (Figure 1), and a list of date source used in the study are provided in the supplementary material section. The collected data related to vegetation characteristics included plant aboveground biomass (AGB), belowground biomass (BGB), plant coverage, and plant species diversity (Shannon–Wiener index). In addition, the information related to enclosure and grasslands was collected, including grassland types and the duration of enclosure. Data from tables were directly extracted, and data from figures were obtained using GetData Graph Digitizer 2.24. In this database, if the studies were in contrast regarding a number of controls (grazed plots with exceptional stocking rate) in opposition to an equal treatment, we calculated effect sizes for each assessment first and then pooled these effect sizes by using a separate meta-analysis. Furthermore, on the basis of the Chinese vegetation classification system, grassland was divided into four main types, including alpine grassland (MAP 100–500 mm; plants mainly consisting of *Kobresia pygmaea, Potentilla saundersiana, Poa crymophila*, and *Thymelaeaceae*), typical steppe grasslands (MAP 300–400 mm; plants mainly consisting of *Leymus chinesis, Stipa grandis, Artemisia sacrorum, and Thymus mongolicus*), meadow grassland (MAP > 400 mm; plants mainly consisting of *Kobresia humilis, Kobresia pygmaea, Poaceae*, *Asteraceae*, and *Farbaceae*), and desert grassland (MAP $\leq$ 200 mm; plants mainly consisting of *Asteraceae*, *Liliaceae*, and *Polygonaceae*). Duration of grazing exclusion was divided into five time intervals, namely $\leq$5 years, 6–10 years, 11–15 years, 16–20 years, and $\geq$20 years.

2.2. Data Analysis

The AGB effect of enclosure and vegetation coverage was calculated in the entire enclosed grasslands and the same grassland type to evaluate the responses to enclosure measures of plant traits of grassland ecosystems. The growth rate was calculated as follows:

$$\text{Growth rate} = \frac{(\text{values in the enclosed grassland} - \text{values in the control})}{\text{values in the control}}$$

To quantify the distinction of chosen variables between grazed and enclosed grasslands, the herbal log-transformed response ratio (ln*RR*) was used as the effect value to estimate the impact size [46,47]. The formula is as follows:

$$\ln RR = \ln\left(\frac{X_E}{X_C}\right) = \ln(X_E) - \ln(X_C)$$

where X_E and X_C are the average values of the indicators in the treatment (exclusion) and control (grazing) observations, respectively.

The variance (V) of each log response ratio's formula is as follows:

$$V_{\ln RR} = \frac{S_E^2}{N_E (X_E)^2} + \frac{Sc^2}{N_c (X_c)^2}$$

where S_E and S_C are the standard deviations of the treatment and the control, respectively; and N_E and N_C are the sample sizes of the treatment and the control, respectively. The lnRR is a standardized metric that approves assessment of data between treatment (exclusion) and control (grazing) in different units [46].

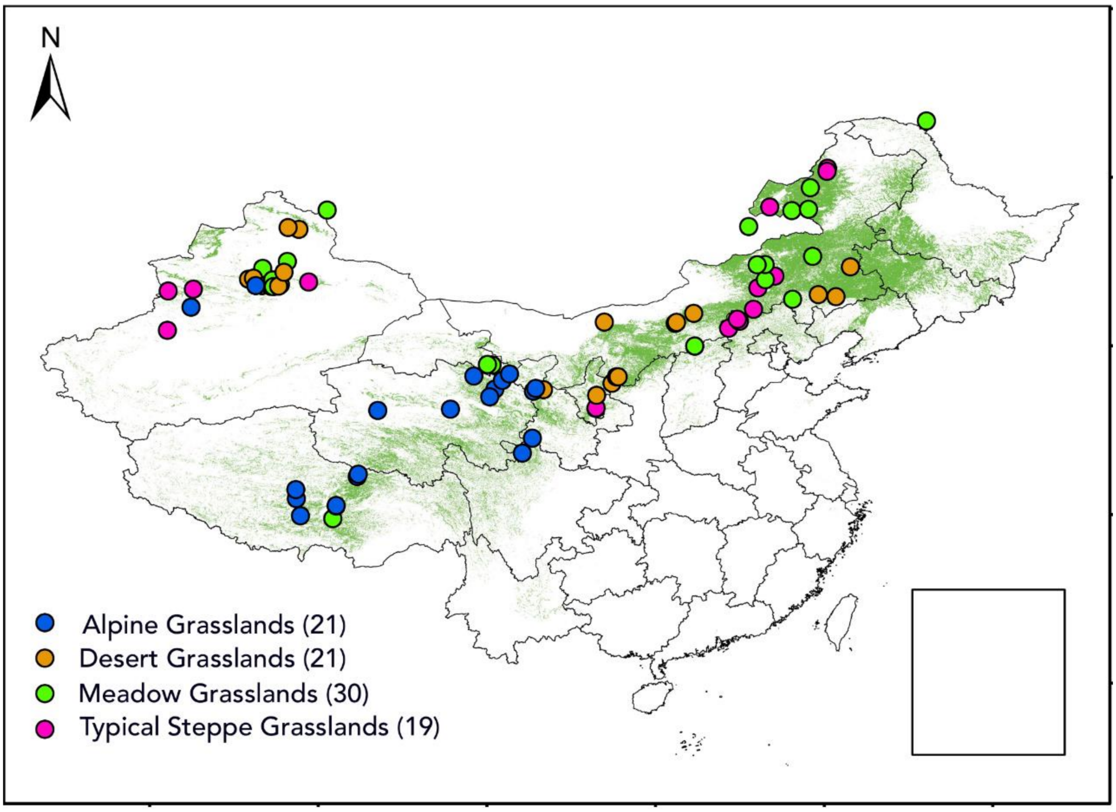

Figure 1. Study sites included in this meta-analysis (colored dots). Numbers represent the number of articles for the grassland types.

To better illustrate the effect of the treatment group on the indicator, the values of lnRR have been modified to estimate the proportion change in treatment and other variables relative to the control (%):

$$E = \left(e^{lnRR} - 1\right) \times 100\%$$

We used a random effect meta-analysis model to test the mean effect size for each study, which assumed that all perceived variation was due not only to sampling error but also to an authentic random error. Mean effect sizes and the 95% confidence intervals (CIs) were generated by a bootstrapping procedure based on 4999 iterations permutations using MetaWin 2.1 [48,49]. Using this method, the effects of vegetation characteristics to enclosures were considered as significant if the 95% CIs did not overlap zero, and significantly different from zero if the 95% CIs did not overlap zero. Microsoft Excel software was used for data processing, ArcGIS 10.2 software was used for data visualization, and figures were plotted in Sigmaplot.

3. Results

3.1. Effects of Enclosure on Vegetation Coverage

The growth rate of vegetation coverage across the enclosed grasslands was greater than 0% (Figure 2a) and showed varied dynamic changes at different enclosure duration. The coverage increased slightly in the short duration of the enclosure (less than five years), then reached a maximum at 10–15 year, approximately 80–100%, and then dropped sharply in the following enclosure years. This implies that the grassland coverage reached saturation in the 10–15 years following the enclosure and that the utilization rate of grassland resources is also the highest. For different types of grasslands (Figure 2b–e), vegetation coverage of alpine grassland did not significantly change in enclosure duration, always approximately 20–40% (Figure 2b). However, growth rate of desert and meadow grasslands both significantly increased with the duration of enclosure, and the growth rate of vegetation coverage after enclosure generally showed an upward trend year after year, with the growth rate being positively correlated with the enclosure period (Figure 2c,d). For typical steppe grasslands, when the enclosure period was less than ten years, the growth rate varied greatly, from 4.63% in the eighth year to 70.42% in the ninth year, but the overall growth rate did not exceed 100%. The highest growth rate occurred at the enclosure duration of 12 to 13 years, approximately 83.60–96.02%. When the enclosure period was more than 20 years, the growth rate of the coverage began to decrease (Figure 2e). This indicated that enclosure increased vegetation coverage regardless of grassland types, and the growth rate fluctuated with the grassland types and the duration of enclosure.

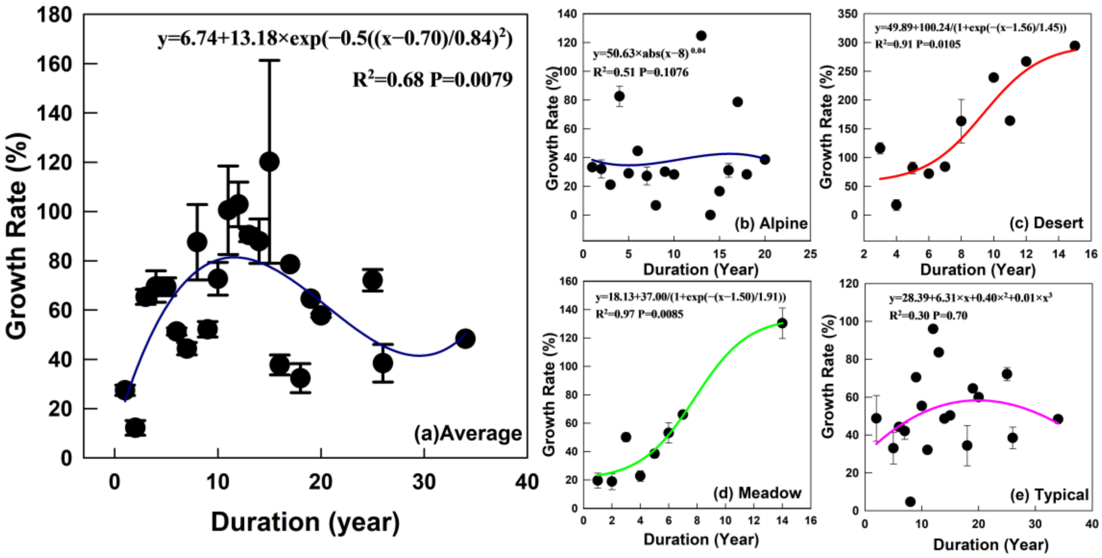

Figure 2. The growth rate of vegetation coverage across the enclosed grasslands (**a**) and in specific grassland types (**b**–**e**). Error bars are 95% bootstrapped confidence intervals.

The meta-analysis showed that the enclosure duration had noticeable effects on coverage of all grasslands (Figure 3). Vegetation coverage significantly increased during 1–15 years, and the highest effect value was 11–15 years; however, the coverage did not significantly change after the enclosure duration was 16–20 years (Figure 3a). To summarize, short-term enclosure can effectively increase vegetation coverage, whereas long-term enclosure is not conducive to increasing vegetation coverage and even has negative effects, and the best enclosure period is 11–15 years. However, regarding different grasslands, vegetation coverage had different responses to enclosure duration. Alpine grasslands' coverage significantly increased with the increase of enclosure duration (Figure 3b). The coverage of desert grasslands continuously increased in the first 1–10 years, then decreased, and the positive effect began to fade after the 15-year enclosure (Figure 3c). The mean effect size of meadow and typical steppe grasslands increased significantly in the enclosure years, and the vegetation coverage reached its highest level in 11–15 years (Figure 3d,e). As a result, it can be assumed that for a typical grassland, the best enclosure period is between 11 and 15 years. After that, as the length of the enclosure time is extended, the vegetation cover of the grassland may exhibit increasingly negative effects.

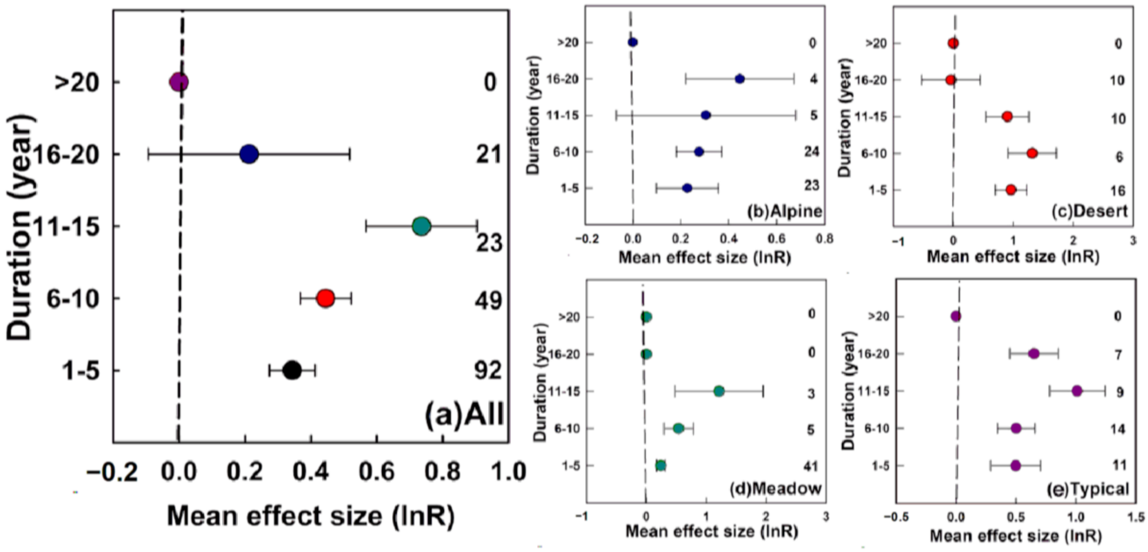

Figure 3. The effect value of vegetation coverage throughout different enclosure years (**a**), as well as the reaction of different types of grassland vegetation coverage to enclosure (**b**–**e**). The values are calculated effect sizes and 95% confidence intervals. Sample sizes are given to the right of the graph.

3.2. Effects of Enclosure on Vegetation Biomass

The average AGB effect of enclosure showed varied dynamic tendencies with enclosed duration, but the value of growth rate was more than 0% regardless of grassland type (Figure 4a). When the enclosure years exceeded 10, the aboveground biomass exhibited a clear upward trend, but as the enclosure time was continuously extended, the growth rate rose. When the years limit was less than 10, the growth rate ranged from 64.58 to 148.31%, with the maximum value emerging in the seventh year. At approximately 20 years of encirclement, it rapidly deteriorated, and the growth rate fell to 34.10%. The AGB effect of enclosure in the alpine grassland increased slightly in the first five years, then reached the maximum value of 376.46% in the 7th year. After the 10-year enclosure, the growth rate steeply decreased. The duration of enclosure increased, although not significantly (Figure 4b). The AGB effect of enclosure in desert grasslands showed some volatility, but the overall trend was upward along with increase of enclosure duration. The growth rate was 29.30% at 15 years of enclosure; it was 271.36% at 26 years (Figure 4c). For meadow grasslands, the AGB effect of enclosure had no obvious changes and retained a higher level when the duration of enclosure was within 10–15 years (Figure 4d). The growth rate of typical steppe grasslands' AGB reached the highest value in the 4th year, up to 249.26%; after that, the growth rate went down year by year, then quickly went up, and in the 15th year, it reached a high of 462.94% (Figure 4e).

AGB and BGB of all grasslands showed different responses to the enclosure effect (Figures 5 and 6). During the enclosure, the AGB increased, while the BGB had no significant change (Figure 6a). Under the enclosure period of 1–15 years, the response of aboveground biomass of vegetation to enclosure kept going up. During the enclosure period of 11–15 years, the effect of aboveground biomass was the largest value, and the positive effect was the strongest. The positive effect of sealing time on aboveground biomass was lessened (Figure 5a). In conclusion, as the enclosure period increased, the overall tendency of the influence on the above-ground biomass of grasslands was to first increase then weaken, and it was estimated that the maximum above-ground biomass of degraded grasslands would be reached in 11 to 15 years. Regarding different grasslands, alpine grasslands reached their peak value in 11–15 years, while the benefits of enclosure on AGB began to decrease in 16–20 years (Figure 5b). In contrast, their BGB had no significant change (Figure 6b). The enclosure of desert grasslands had a significant impact on AGB and BGB (Figures 5c and 6c). Desert grasslands' AGB reached the highest level in the 6–10 years of enclosure duration, then dropped or even returned to its initial level during the following 16–20 years (Figure 5c). The AGB of meadow maintained continuous growth during the 15-year enclosure period (Figure 5c), and the BGB had significant increase in the first 5 years, then decreased (Figure 6d). The AGB of typical steppe grasslands fluctuated during the enclosure years, and the maximum value occurred in the 11–15 years of enclosure (Figure 5e). Nevertheless, the BGB reached the highest value in the 6th to 10th year, then its beneficial effects gradually lessened. (Figure 6e).

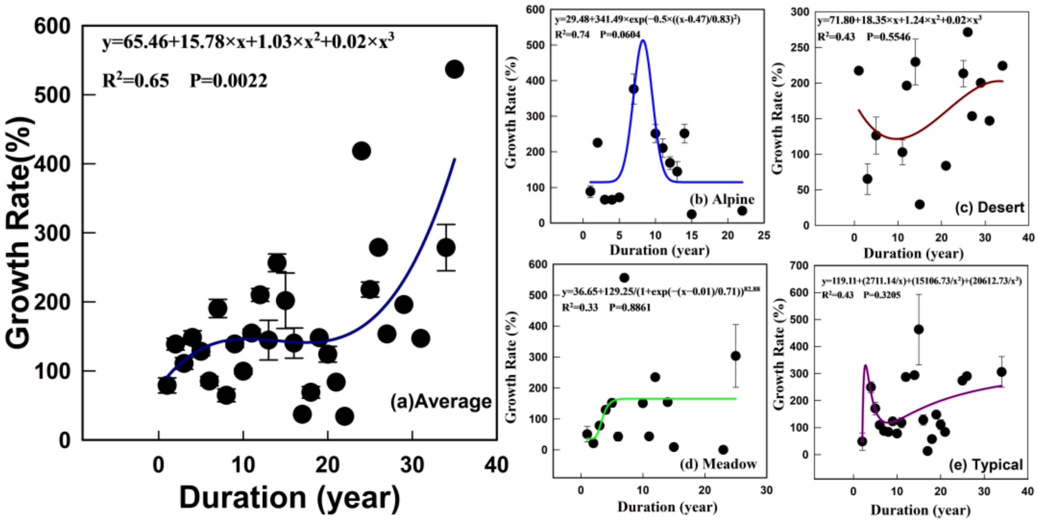

Figure 4. Average growth rate of aboveground biomass **(a)** and growth rate of aboveground biomass in different grassland types (**b**–**e**). Error bars are 95% confidence intervals.

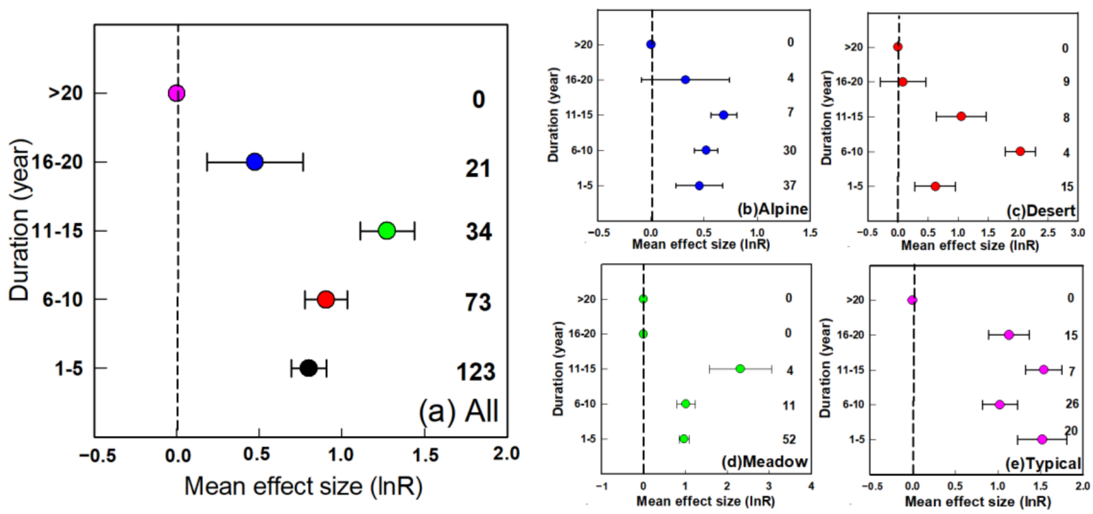

Figure 5. The effect value of aboveground biomass under different enclosure years (**a**), as well as the reaction of different types of grassland aboveground biomass to enclosure, were determined. (**b**–**e**). The values are calculated effect sizes and 95% confidence intervals. Sample sizes are given to the right of the graph.

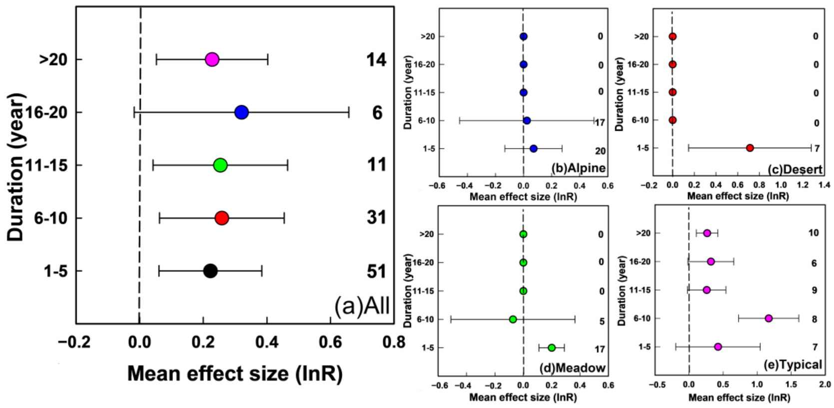

Figure 6. Effect value of underground biomass under different enclosure years (**a**) and response of different grassland underground biomass to enclosure (**b**–**e**). The values are calculated effect sizes and 95% confidence intervals. Sample sizes are given to the right of the graph.

3.3. The Impact of Enclosure on Plant Species Diversity

The grassland plant species diversity increased firstly and then decreased, and the effect value of plant species diversity reached the highest in the 11–15 years of enclosure (Figure 7a), indicating that the positive effect on grassland plant species diversity is the greatest between 11 and 15 years after enclosure. There is a certain degree of detrimental influence on the diversity of grassland vegetation when the enclosure duration reaches 15 years, and it may be increased as the enclosure term is continuously extended. This negative effect will become increasingly more substantial. As for specific grassland types, plant species diversity in the alpine grasslands increased significantly in the first 1–5 years and then decreased after 6–10 years of enclosure. When the enclosure was more than 20 years, the positive effects on plant species diversity ceased to be significant (Figure 7b). Plant species diversity in the enclosed desert grasslands generally increased within 15 years of enclosure—specifically, the enclosure raised diversity over 1–5 years, then it fell for 6–10 years and reached a peak during the 11th–15th year, and at 16 to 20 years, it started to decline once more, but not considerably (Figure 7c). Within the 10 years of enclosed, the plant species diversity in the meadow grasslands showed an increase in the first 1–5 years and then decreased (Figure 7d). The plant species diversity of typical steppe grasslands peaked in the 6th–10th year, then decreased after 11–15 years or even more than 20 years of enclosure. It showed negative effect values when the enclosure duration was more than 20 years, revealing that after more than ten years of enclosure, the variety of typical steppe grasslands started to steadily decline (Figure 7e).

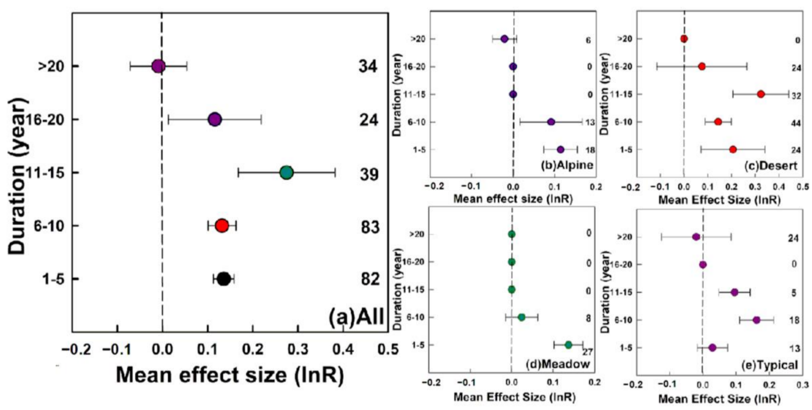

Figure 7. The effect value of plant species diversity under different enclosure years (**a**) and the response of different grassland plant species diversity to enclosure (**b**–**e**). The values are calculated effect sizes and 95% confidence intervals. Sample sizes are given to the right.

4. Discussion

Vegetation biomass and plant species diversity are the main indicators reflecting community structure characteristics and growth status of vegetation [50]. AGB can reflect the status of grassland restorations, and BGB has a central impact on the steadiness of grassland ecosystems [51]. Plant species diversity reflects the persistence and stability of grassland ecosystems [52]. Enclosure has a direct impact on vegetation coverage, biomass, and diversity [25,53]. Our meta-analysis showed a significantly positive effect of short-term enclosure on grassland coverage, biomass, and species diversity. Furthermore, vegetation coverage and biomass of enclosed grasslands to the enclosure years were essentially comparable, and after the duration of enclosure, all types of grasslands had a similar increased tendency in vegetation coverage, AGB, and BGB. It was well observed that the vegetation coverage, AGB, and BGB of different grasslands significantly increased in a certain enclosure period. These results are in accord with previous studies [54–57] which have verified that enclosure plays a positive role in restoration of degraded grasslands, and the accumulation of litter due to enclosure increases the organic matter into soil and promotes the growth of vegetation [58–60]. On the basis of the data analysis of coverage and biomass of all grasslands, it was indicated that the 11–15 years of enclosure duration had the strongest positive effects. However, specific to different types of grassland, their coverage and plant biomass reached peak values after different numbers of enclosure years. The desert grasslands required 6–10 years, the typical steppe grasslands required 11–15 years, and the AGB of alpine grasslands reached the highest value after 15 years, with their coverage continuing to increase within 20 years. The coverage and biomass of meadow grasslands showed a trend growth within the 15 years. The above results were in line with some on-site studies. For example, Yang et al. [61] found that the coverage and biomass of grassland enclosed for 15 years were greater than in non-enclosed grassland. Enclosing for 6–8 years significantly improved the vegetation coverage and AGB of alpine grasslands [37]. In less than 10 years of enclosed desert grasslands, significant increases in grassland coverage and biomass have been reported with the increase of enclosure duration [62–64]. However, the coverage and biomass of grassland generally changed from an increasing to decreasing trend after a certain enclosure period, likely because the increase of enclosure duration caused the habitats to become gradually homogenized; the diversity decreased, finally resulting in neither increase nor decrease in biomass [65]. Jin et al. [66] found that after the desert grasslands were enclosed more than 10 years, the structure of the plant community began to change, and perennial herbs and small shrubs gradually replaced the previously vigorous dominant species, resulting in a decrease in grassland coverage and biomass. Shan et al. [67] found that the vegetation coverage and biomass of typical steppe grasslands reached a maximum after the 11–15 years of enclosure and then decreased. All of these results elucidated that the types of grasslands should be considered when considering the optimal duration of enclosure through plant traits.

Values of effect size in our meta-analysis revealed that plant diversity of different grasslands had varied responses to the enclosure. The highest diversity of alpine grasslands appeared within 5 years of enclosure, in accordance with other studies which showed that enclosures of 6 years [25] or 4 years [39,68] in the alpine grasslands is the optimal duration. Longer enclosure duration marked decreases in alpine grasslands' species richness and diversity [11,33,69,70]. Nine-year enclosures have been noted to exhibit obvious reduction of plant diversity [71–73]. Desert grassland ecosystems are fragile and vulnerable, vegetation depends mainly on plant propagation and establishment [74,75]. Yang et al. [76] observed the species diversity of enclosed desert grasslands in 3, 5, and 8 years and found that diversity obviously increased with the duration of enclosure. Pan et al. [77] suggested that desert grasslands in short-term enclosure (less than 5 years) and long-term enclosure (lasting 15 years) both can allow species diversity to maintain a high level. The positive effects of enclosure on species diversity were the most significant in the 11–15 years, followed by enclosure for 1–5 years, and our results are in agreement with finding of Wu et al. [8] that 16-year enclosed desert grasslands had more plant species and greater stable ecosystems than 6-year enclosed desert grasslands. Although species diversity data of enclosed meadow grasslands was available only for enclosures of up to 10 years, our meta-analysis found that 1–5 years of enclosure had a significant positive effect on its diversity, which is consistent with the findings of Huang et al. [78], who noted that the species diversity increased within 5 years of enclosure in the meadow grasslands. This meta-analysis showed that species diversity of typical steppe grasslands reached a maximum after enclosure of 6–10 years, and the result is in line with Wu et al. [71], who found that species diversity reached a peak value after enclosure of 9 years, whereas the negative impact occurred when the enclosure duration was prolonged. However, there are also some reports that it takes 14 years [79] or 15 years for the diversity of typical steppe grasslands to reach its peak [80]. This difference could be due to the type and condition of the typical steppe grasslands at the time of enclosure. A natural succession process also includes enclosure and disturbing the grassland. The plant species diversity usually goes up as time passes, peaks in the middle, and then goes down. The inflection point will be different for different types of grassland and the conditions of each typical grassland at the start [68,81,82]. After the plant diversity increases significantly, the competition among species will increase, and the competitive exclusion effect will lead to the decline of community diversity [83], which will decrease the coverage or biomass of grasslands, and ultimately affect the stability of the system [23,84]. Therefore, we propose that the optimal enclosure period is vital and necessary for reestablishing degraded grasslands and is determined by the grassland types.

5. Conclusions

Enclosure had positive effects on vegetation restoration in degraded grassland ecosystems. The coverage of alpine grassland maintained continuous growth within 20-year enclosure, the AGB decreased after 15 years, and the species diversity began to decline after 10 years. If the objective is to increase alpine grassland yield to its maximum potential, the fence should be removed for approximately 15 years. On the other hand, if the objective is to restore the stability of the alpine grassland ecosystem, enclosure should be discontinued approximately 10 years after it has been established. The coverage and AGB of meadow grasslands continued to increase within 15 years, while BGB and plant species diversity declined after 5 years. Within 15 years, when grassland yields are at their optimum, fencing in meadows should be removed. In addition, at approximately the 5th year, plant species variety should be at its peak. Desert grasslands' coverage and AGB decreased after 10 years, while the species diversity decreased after 15 years. Removal of the fence at approximately 15 years after enclosure has begun for stabilizing the desert grassland ecosystem; when desert grassland production is at its peak, there must be no fence after the 10th year of enclosure. For typical steppe grasslands, the vegetation coverage and AGB decreased after 15 years, and the BGB and diversity decreased after 10 years. To maximize typical steppe grassland productivity, the fence should be removed after roughly 15 years of enclosure, and optimal plant species diversity of typical steppe grassland should be required after the 10th year of enclosure. These results showed that it is necessary to adjust the enclosure management strategies reasonably according to the grassland types and the management objectives of grassland vegetation to ensure the plant traits' health of grassland ecosystems.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/agronomy13030854/s1, Data sources.

Author Contributions: C.L., H.L., J.H., M.S., C.F. and X.Y., data curation, methodology, formal analysis, and writing—original draft preparation; C.L., manuscript writing; K.L. and X.S., conceptualization, methodology, validation, supervision, funding acquisition, and writing—review and editing. All authors discussed the results and contributed to the final manuscript. All authors have read and agreed to the published version of the manuscript.

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Data Availability Statement: The data sources presented in this study are available in supplementary material here.

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Conflicts of Interest: The authors declare that they have no known competing financial interest or personal relationship that could have appeared to influence the work reported in this paper.

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