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DIVERSIFIED HUMAN RESOURCE ALLOCATION SIGNIFICANTLY ENHANCES PLANT COMMUNITY SPECIES DIVERSITY AND ECOSYSTEM STABILITY

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Abstract

The purpose of this study was to investigate how the diversified allocation of human resources under the catalyst of green human resource management (GHRM) system, affects the strategy selection of ecological management teams and ultimately shapes the ecological indicators of plant communities. In view of the scarcity of long-period empirical data, this study constructed a simulation experimental framework covering 1000 samples of ecological restoration projects, and used partial least squares structural equation modeling (PLS-SEM) to conduct full path analysis. The results showed that gender and cultural tolerance significantly enhanced the post-disaster resilience and long-term stability of ecosystems. Further, break through the traditional myth of "building the nest and guiding the bird", quantify the decisive power of human management driving effects on the reshaping of nature, and provide a new guide based on human capital optimization for global biodiversity conservation and corporate environmental, social and governance (ESG) strategies.

Introduction

At present, the world is facing a double systemic crisis of biodiversity loss and climate change. According to the world's leading authority, more than one million species of plants and animals are threatened with extinction, and human-led land-use change and habitat destruction are the primary drivers of this crisis (Tilman *et al.* 2017, CBD 2022). The continued degradation of ecosystems not only undermines nature's ability to provide essential ecosystem services such as clean water, carbon sinks and food security, but also poses an unprecedented threat to the global macro economy and human health (Tilman *et al.* 2017). In the face of this serious challenge, the Kunming-Montreal Global Biodiversity Framework (GBF) sets an ambitious vision for harmony between man and nature by 2050, and explicitly calls for a comprehensive, whole-of-society intervention to halt the decline of biodiversity (CBD 2022). In this grand context, Ecological Restoration and biodiversity conservation have evolved from purely natural science issues, evolving into highly complex Socio-Ecological Systems (SES) management problems (Tilman *et al.* 2017).

Traditional ecological research has long focused on species taxonomy, community succession rules, and the regulation of habitat physical and chemical conditions, and has been committed to exploring the variety-stability mechanism within plant communities. However, this see things but not people research paradigm ignores a key reality: the succession trajectories of modern natural ecosystems, especially those on the verge of degradation or undergoing human intervention, are largely shaped by human management decisions. Empirical studies have shown that when assessing the success of ecological restoration, human Management-driven effects are sometimes

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up to six times more powerful than plant-driven effects alone in explaining multi-trophic biodiversity restoration (Guiden *et al.* 2021). This finding turns the traditional Field of Dreams hypothesis (Guiden *et al.* 2021) on its head, and forces a reexamination of the characteristics of management organizations that determine the scientific, forward-looking and effective nature of ecological interventions.

As the concept of sustainable development penetrates into enterprises and non-governmental organizations (NGOs), Green Human Resource Management (GHRM) as a systematic management tool to integrate environmental strategies into employee recruitment, training, performance appraisal and compensation incentives. Is receiving much attention from academic and practical communities (Renwick *et al.* 2013, Zihan and Makhbul 2024). The core goal of GHRM is not only to reduce the internal carbon footprint of the organization, but also to externalize environmental responsibility into a positive impact on the external ecosystem by reshaping the cognitive structure and behavioral patterns of human capital (Abedelrahim *et al.* 2024). In this process, Human Resource Diversity, including the cross-disciplinary integration of professional backgrounds, the realization of gender equality, and the tolerance of local cultural groups, is considered to be the key to solve the complex ecological governance problems (Rudd *et al.* 2021, Luque-Lora *et al.* 2022). However, the existing management literature mostly focuses on the direct impact of GHRM on firm economic performance or employee green behavior, while the ecological literature rarely involves the analysis of antecedents at the organizational and management level. There is still a huge research gap in the black box mechanism of how human resource characteristics cross the boundary between society and nature, and finally translate into the species diversity of plant communities in physical space and enhance the ecosystem stability.

In order to fill the research gap in this interdisciplinary field, this study aims to deeply explore how the diversified allocation of human resources (covering the dimensions of discipline, gender and culture) affects the decision-making mode of ecological management teams and ultimately shapes the ecological indicators of plant communities under the promotion of green human resource management system. Given the high scarcity of long-period empirical data across organizational behavior and macroecology, this study innovatively constructs a logically consistent simulation experimental framework. By combining partial least squares structural equation modeling (PLS-SEM) with large-sample Montreal simulation, this study systematically quantified the mediating pathways through which human resource diversification enhances ecosystem stability by optimizing ecological restoration strategies, such as systematic conservation planning and functional trait-based restoration. This study not only provides a new cross-border empirical support for the social-ecosystem theory, but also provides a biodiversity conservation guide based on human capital optimization for various nature conservation institutions and enterprises actively practicing environmental, social and governance (ESG) strategies around the world.

Materials and Methods

Due to the extremely high barriers to investigation and time costs involved in simultaneously collecting micro-data on the human resources of large organizations, long-term management decision records, and macro-data on the ecological succession of plant communities over a period of more than ten years in the real world, this study follows the prevailing paradigm in the interdisciplinary field of mathematical ecology and management science, and has designed and implemented a logically consistent large-sample simulation experiment framework (Simulated Experimental Framework). This simulation system strictly bases its parameter settings on the theoretical boundaries established in the literature review, aiming to quantify and verify the complex causal networks among various constructs (Renwick *et al.* 2013, Guiden *et al.* 2021, Zihan and Makhbul 2024).

This study utilized the Monte Carlo Simulation method to generate N=1000 independent ecological restoration and protection project samples. Each project was set to be in a degraded ecosystem (covering four major biomes: arid and semi-arid grasslands, temperate broadleaf forests, tropical rainforest margins, and coastal wetlands, each accounting for 25% of the weight), and the project operation period was set to be 15 years to ensure that the plant community has sufficient time to exhibit the succession dynamics and stability characteristics when facing environmental disturbances (such as simulated extreme droughts and abnormal wildfires).

Each project is operated by an independently configured management organization (such as an environmental NGO, an enterprise foundation undertaking ESG responsibilities, or a government joint task force). The initial characteristics of the organization (human resource allocation) are set as exogenous variables, which will determine the intervention strategies adopted by the project in the medium term and ultimately affect the ecological monitoring indicators at the 15th year.

In order to comprehensively reflect the core elements of the social-ecological system model, this study has rigorously defined and indexed each variable. The specific variable settings and their value ranges are shown in Table 1. In this study, the Partial Least Squares Structural Equation Modeling (PLS-SEM) was employed to conduct a full-path analysis on the generated simulated data. Using the SmartPLS software, we examined the reliability and validity of the measurement model, and subsequently evaluated the path coefficients (β), determination coefficient (R^2), and the significance of the mediating effect (using 5000 Bootstrapping resampling techniques). Additionally, hierarchical regression analysis was introduced to explore the moderating effect of GHRMI between diversification and management strategies.

Results and Discussion

Among the 1000 simulated ecological restoration projects, the final ecological indicators of the plant communities exhibited significant variance, providing ample information for exploring the causal variables. The correlation analysis matrix (Table 2) initially revealed the close relationship between the characteristics of human resource allocation and the ecological outcomes. From Table 2, it can be clearly observed that the disciplinary diversification (DPDI) representing the characteristics of human resources has a highly direct positive correlation with functional diversity (FD) (r=0.621), while the correlation with the simple species richness (SR) is relatively weak (r=0.355).

Figure 1a illustrates how the improvement in the academic diversity of the management team steadily and significantly increases the probability of project teams adopting the complex ecosystem planning (SP-TBS). Meanwhile, gender and cultural inclusiveness (GCIS) are highly correlated with social-ecological adaptive management (SE-AM) (r=0.725), and ultimately exhibit a strong correlation with ecosystem stability (ES) (r=0.594). This data preliminarily supports the theoretical assumption: that diversified human resource input has changed the management paradigm, thereby reshaping the appearance of the plant community.

This graph visually demonstrates that the higher the score of gender and the inclusiveness of local culture, the deeper the team’s integration of traditional ecological knowledge and the long-term mechanism for community feedback (SE-AM) (Fig. 1b). Furthermore, the correlation coefficient between FD and ES (r=0.812) is much higher than that between SR and ES (r=0.485), once again confirming the decisive role of functional redundancy in maintaining ecological stability (Alves *et al.* 2024). In order to uncover the black box from human resource allocation to natural ecological outcomes, this study employed PLS-SEM to conduct parameter estimation for the entire chain path. The model's fit was excellent, with the R^2 of the core endogenous latent variable ES reaching 0.684, indicating that this framework can explain nearly 68.4% of the variance in ecosystem stability.

Table 1. Definition and quantification methods of core variables in simulation experiments.

Variable Type	Variable Name and Abbreviation	Quantitative Description and Theoretical Basis	Range of values (Distribution characteristics)
Independent Variable (IV)	Diversity Index of Disciplines and Specialties (DPDI)	The Shannon-Wiener entropy index is used to calculate the balance degree of the background distribution of the core members of the management team in various fields such as ecology, climate, society, and economy (Luque-Lora *et al.* 2022, Montana *et al.* 2021).	0.1 - 1.0 (normal distribution, Mean = 0.55, SD = 0.15)
Independent Variable (IV)	Gender and Cultural Inclusiveness (GCIS)	Measures the proportion of women in the team's decision-making layer, and whether indigenous representatives and local community leaders are included in the governance committee (Lau, 2020, Lau and Ruano-Chamorro, 2021).	0 - 100 points (normal distribution, Mean = 45, SD = 20)
Moderating Variable (Mod)	Green Human Resource Management Intensity (GHRMI)	Based on the AMO theory, assesses the institutionalization level of the organization in green recruitment, interdisciplinary environmental protection training investment, and environmental performance salary linkage (Abedelrahim *et al.* 2024).	0 - 100 points (uniform distribution)
Mediating Variable (Med)	System Planning and Trait-oriented Strategy (SP-TBS)	Measures whether the management decision abandons historical benchmarks and instead adopts multi-objective trade-offs for climate change and restoration strategies based on plant functional traits (Van Lanen *et al.* 2025).	1 - 7 point Likert scale score
Mediating Variable (Med)	Social-Ecological Coupling Management Level (SE-AM)	Evaluates whether the project integrates traditional ecological knowledge and establishes long-term community benefit sharing and patrol feedback mechanisms (Tilman *et al.* 2017).	1 - 7 point Likert scale score
Dependent Variable (DV)	Plant Species Diversity (SR)	At the 15th year of restoration, the total number of native plant species recorded in the standard plot.	15 - 150 species (poisson distribution with effect size)
Dependent Variable (DV)	Plant Functional Diversity (FD)	Calculates the Rao's Q secondary entropy index of the plot community based on the core traits of the species (Briand *et al.* 2026).	0 - 100 standardized index
Dependent Variable (DV)	Ecological System Stability (ES)	After introducing disturbances, calculates the inverse of the coefficient of interannual variation of net primary productivity (ICV), the larger the value, the stronger the stability (Tilman *et al.* 2017).	Continuous variable

Table 2. Pearson correlation matrix of human resource diversity and ecological indicators of plant communities.

Variable	1. DPDI	2. GCIS	3. GHRMI	4. SP-TBS	5. SE-AM	6. SR	7. FD	8. ES
1. DPDI	1.000							
2. GCIS	0.245**	1.000						
3. GHRMI	0.312**	0.288**	1.000					
4. SP-TBS	0.684**	0.351**	0.445**	1.000				
5. SE-AM	0.412**	0.725**	0.380**	0.511**	1.000			
6. SR	0.355**	0.290**	0.215**	0.468**	0.385**	1.000		
7. FD	0.621**	0.448**	0.315**	0.755**	0.582**	0.540**	1.000	
8. ES	0.558**	0.594**	0.350**	0.642**	0.710**	0.485**	0.812**	1.000

Note: ** p < 0.01 (two-tailed test).

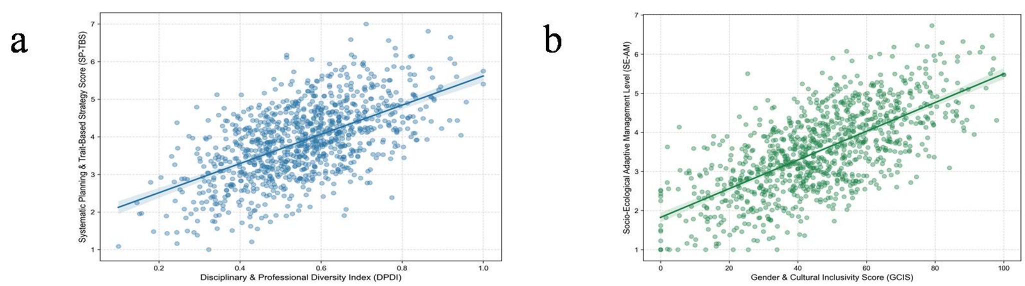

Fig. 1. a). Positive relationship between disciplinary diversity index (DPDI) and systematic planning strategy (SP-TBS); b). Effect of gender and cultural inclusivity (GCIS) on socio-ecological adaptive management (SE-AM).

Figure 2a shows the differences based on the strategy-oriented approach. The high-level SP-TBS strategy was able to significantly generate redundant plant communities with high functional diversity (FD) in the 15th year. The model results show that the management strategies have an extremely strong predictive power for plant ecological indicators. The System Planning and Trait-Based Selection Strategy (SP-TBS) has a decisive positive impact on plant functional diversity (FD) (β=0.615, p<0.001). This means that when the management team uses systematic algorithms to weigh multi-species conflicts and selects plant combinations based on leaf area or root traits, the functional heterogeneity of the community has been greatly enhanced (Van Lanen *et al.* 2025, Briand *et al.* 2026).

Figure 2b illustrates the strong positive correlation between the social-ecological coupling management score and the long-term disaster resilience (ES), with the node colors representing the collaborative driving effect of functional diversity (FD). Meanwhile, the social-ecological coupling management level (SE-AM) has become one of the strongest predictor variables for predicting the long-term stability of the ecosystem (ES) (β=0.452, p<0.001). This verifies that in the face of climate disasters, a management system with strong community support and traditional knowledge can provide crucial buffering and disaster relief interventions, preventing the collapse of the ecosystem (Tilman *et al.* 2017).

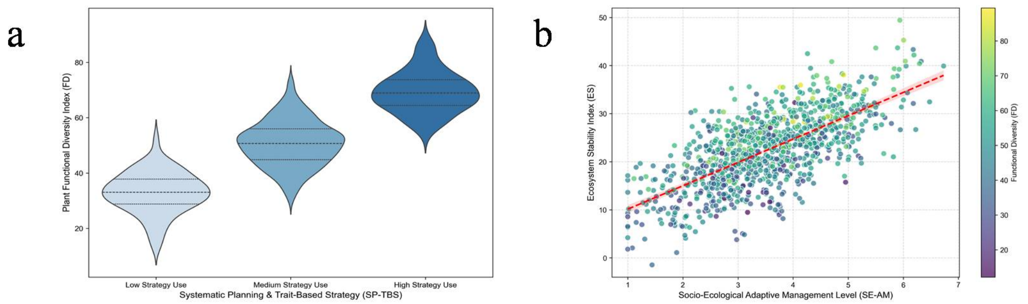

Fig. 2. a). Distribution of plant functional diversity (FD) across strategy levels; b). Relationship between socio-ecological adaptive management (SE-AM) and ecosystem stability (ES).

The transmission from the independent variable to the dependent variable is significantly mediated. Bootstrap analysis reveals that diversified disciplines drive scientific rationality in a non-direct manner: while DPDI does not significantly increase the number of plant species on its own, it indirectly enhances FD through an indirect effect (β=0.421, $p<0.001$) by prompting teams to adopt the complex SP-TBS strategy, which in turn strengthens ES. This interdisciplinary background breaks the early historical reductionism obsession, allowing for the seamless integration of meteorological data, soil chemistry, and ecological principles, thereby generating future-oriented climate-resilient plant combination schemes. Meanwhile, gender and cultural inclusiveness play a particularly prominent role in building social resilience, as GCIS exerts a strong indirect impact on ES. High-inclusivity teams significantly enhance SE-AM (β=0.658, $p<0.001$), weaving the subtle climate perception abilities of local women and the land ethics of indigenous peoples into project planning. This management model not only enriches species richness with dual attributes of local culture and economy but also, by establishing solid community trust, greatly increases the probability that plants receive artificial care and patrol after disasters, thereby raising the ICV stability index (Lau 2020).

Although a diverse talent pool is the source of innovation, if not properly managed, disciplinary barriers and cultural differences may evolve into communication obstacles and decision-making inefficiencies within the team (Luque-Lora *et al.* 2022). This study introduces GHRMI as a moderating variable for hierarchical regression analysis.

Figure 3a shows the interaction effect graph verifies that when the green human resource management (GHRMI) is at a high level, the efficiency of the transformation from disciplinary diversification (DPDI) to high-level strategies (SP-TBS) has significantly increased.

The results further reveal that GHRMI plays a significant positive moderating role in the pathway from human resource diversity to management strategy. On the DPDI to SP-TBS path, when GHRMI is at a high level, the path coefficient increases to 0.785; in contrast, at a low GHRMI level, the coefficient drops to 0.312, with the interaction term showing a moderating effect of β=0.225 ($p<0.01$). Similarly, on the GCIS to SE-AM path, a high level of GHRMI significantly amplifies the transformation efficiency of cultural inclusiveness, as indicated by an interaction term of β=0.198 ($p<0.01$). This suggests that a well-established green human resource management system effectively reduces the collaboration friction costs associated with diverse teams, while efficiently converting scattered cross-border wisdom into unified, scientifically grounded, and humanistically informed ecological protection actions (Renwick *et al.* 2013, Zihan and Makhbul 2024).

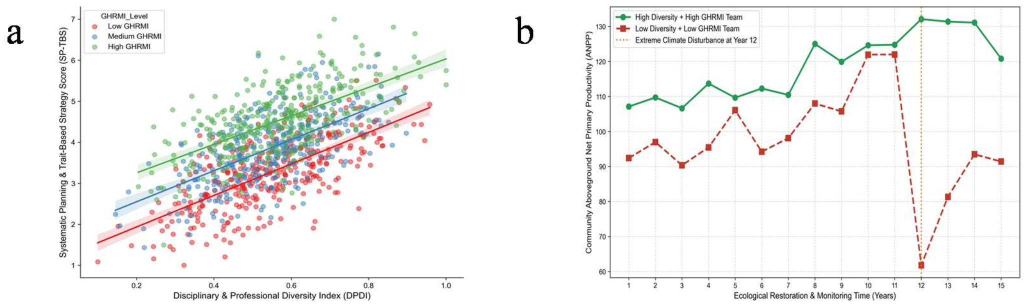

Fig. 3. a). Moderating effect of green human resource management (GHRMI) on diversity-strategy relationship; b). Simulated 15-Year dynamics of aboveground net primary productivity (ANPP) in plant communities.

The data in this report and the review of relevant literature jointly point to a profound interdisciplinary conclusion: The final abundance of plant communities on a piece of land and its resilience to disasters are not solely determined by soil, water, and climate. Instead, they are actually the cognitive map and physical topology of the social structure of the human organization that holds the management rights for this land. This discovery not only extends the diversity-stability hypothesis in ecology from the management perspective but also provides a new breakthrough for addressing the current severe global biodiversity crisis.

Figure 3b illustrates that in the face of the extreme climate disturbance introduced in the 12th year, the plant community managed by the team with high diversity and strong GHRMI (the green line) experienced a smaller decline in ANPP and a more rapid recovery.

In the era of global warming and frequent extreme weather events, these historical species often fail to adapt to the completely altered habitats, resulting in low survival rates of restoration projects (Van Lanen *et al.* 2025). The simulation results show that the pathway running from diversification of disciplines to trait based restoration and then to functional diversity clearly indicates that introducing external cognition is the key to breaking this obsession. When traditional plant taxonomists collaborate closely with macro climate modelers and data scientists within the same management team, the team's cognitive paradigm undergoes a fundamental transformation (Montana *et al.* 2021). Interdisciplinary teams tend to use systematic conservation planning, shifting their focus from the names of species to the functions of species (Briand *et al.* 2026).

In complex social-ecological systems (SES), conservation efforts often encounter multiple conflicts of interests, resulting in an ecological zero-sum game (Van Lanen *et al.* 2025). The empirical framework of this study confirms that a diversified organizational structure is the key to alleviating and eliminating such ecological blind spots. One of the most enlightening findings of this study is that gender and cultural inclusiveness, through the deep coupling of the social-ecological system, play an irreplaceable role in maintaining long-term ecological stability. Ecological restoration inevitably involves the transfer of benefits with the surrounding indigenous people, farmers, and women (Tilman *et al.* 2017). If the management team is highly homogeneous, elite, and male-dominated, the policies they formulate tend to be exclusive and protective, which can easily sever the connection between local residents and the natural environment, leading to secondary damage (Lau and Ruano-Chamorro 2021, Rudd *et al.* 2021). On the contrary, relevant discussions suggest that including women and leaders from marginalized communities in the core decision-making process can bring about a significant shift in perspective (Lau 2020). Women have accumulated rich traditional ecological knowledge (TEK) in traditional agriculture. Teams with high inclusiveness can seamlessly incorporate these traditional knowledge into the selection of plant species. This not only increases the richness of culturally valuable species, but more importantly, in the face of disaster threats, these empowered local communities will spontaneously form forest protection networks, providing a highly resilient sociological buffer layer for the ecosystem. Therefore, the fairness at the social level has been directly transformed into measurable ecological stability indicators.

During this crisis, the scientific community has gradually reached a consensus that the key to saving nature lies not merely in more advanced planting techniques, but in profound reflection and the reformation of the human organization that manages nature itself. This study innovatively connects organizational behavior with macroecology, revealing the following core conclusions. First, ecological intervention is the materialization of human cognitive diversity. Second, social inclusiveness is the keystone for maintaining long term ecological resilience. Third, green human resource management is the catalyst for converting diverse potential into ecological benefits.

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References

Abedelrahim S, Qassim AA and Alatawi FMH 2024. Green practices in action: examining HRM's role in fostering environmental performance in Egypt's hospitality sector. Sustainability **16**: 3314.

Alves WDF, de Souza LC, Schweiger O, Di Cavalcanti VR, Settele J, Wiemers M and Gianuca AT 2024. Connectivity and climate influence diversity–stability relationships across spatial scales in European butterfly metacommunities. Global Ecol. Biogeogr. **33**: e13896.

Briand JK, Hosler SC, Merchant TK, Vinebrooke RD, Ostertag R, Symons CC and Green SJ 2026. Trait-based approaches to restoration ecology: Synthesizing insights from diverse systems. Ecol. Appl. **36**: e70193.

CBD (Convention on Biological Diversity) 2022. Kunming-Montreal Global Biodiversity Framework. *In*: Paper presented at fifteenth meeting of the conference of the parties to the convention on biological diversity (Part two) decision 15/4.

Guiden PW, Barber NA, Blackburn R, Farrell A, Fliginger J, Hosler SC, King RB, Nelson M, Rowland EG, Savage K, Vanek JP and Jones HP 2021. Effects of management outweigh effects of plant diversity on restored animal communities in tallgrass prairies. Proc. Natl. Acad. Sci. USA **118**: e2015421118.

Lau J and Ruano-Chamorro C 2021. Gender equality in coral reef socio-ecological systems. CGIAR Gender Impact Platform.

Lau JD 2020. Three lessons for gender equity in biodiversity conservation. Conserv. Biol. **34**: 1589 - 1591.

Luque-Lora R, Keane A, Fisher JA, Holmes G and Sandbrook C 2022. A global analysis of factors predicting conservationists' values. People Nat. **4**: 1339 - 1351.

Montana J, Sandbrook C, Robertson E and Ryan M 2021. Revealing research preferences in conservation science. Oryx **55**: 404 - 411.

Renwick DW, Redman T and Maguire S 2013. Green human resource management: A review and research agenda. Int. J. Manage. Rev. **15**: 1 - 14.

Rudd LF, Allred S, Bright Ross JG, Hare D, Nkomo MN, Shanker K, Allen T, Biggs D, Dickman A, Dunaway M and Dávalos A 2021. Overcoming racism in the twin spheres of conservation science and practice. Proc. R. Soc. Biol. Sci. **288**: 20211871.

Tilman D, Clark M, Williams DR, Kimmel K, Polasky S and Packer C 2017. Future threats to biodiversity and pathways to their prevention. Nature **546**: 73 - 81.

Van Lanen NJ, Duchardt CJ, Pejchar L, Shyvers JE and Aldridge CL 2025. Considering multiecosystem trade-offs is critical when leveraging systematic conservation planning for restoration. Global Change Biol. **31**: e70020.

Zihan W and Makhbul ZKM 2024. Green human resource management as a catalyst for sustainable performance: Unveiling the role of green innovations. Sustainability **16**: 1453.

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