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Quantifying the effect of ecological restoration on runoff and sediment yields: A meta-analysis for the Loess Plateau of China

Journal:	<i>Progress in Physical Geography</i>
Manuscript ID	PPG-17-018.R2
Manuscript Type:	Main Article
Keywords:	Hydrological monitoring, land degradation, land use transition, plot scale, vegetation recovery
Abstract:	<p>Ecological restoration can result in extensive land use transitions which may directly impact on water runoff and sediment loss and thus influence tradeoffs between multiple hydrological and soil ecosystem services. However, quantifying the effect of these transitions on runoff and sediment yields has been a challenge over large spatial scales. This study integrated and synthesized 43 articles and 331 runoff experimental plots in the Loess Plateau of China under natural rainfall to quantify the impacts of land use transitions on (i) runoff and sediment production, (ii) runoff and soil loss reduction effectiveness, and (iii) the tradeoffs between runoff and soil erosion. The effects of ecological restoration on runoff and sediment yields were quantified using a general mixed linear meta-regression model with a restricted maximum likelihood estimator on overall and individual ecological restoration types. The results showed that artificial grassland, forest, natural grassland, and shrubland had higher runoff and sediment reduction effectiveness. The annual runoff reduction effectiveness of the ecological restoration overall was 72.18% with the effects of artificial grassland, natural grassland, shrubland, and forest at 71.89%, 50.60%, 73.18%, and 73.08%, respectively. The annual sediment reduction effectiveness of the overall ecological restoration was 99.9% without a significant difference among the four land uses associated with ecological recovery. In addition, shrubland and forest significantly reduced sediment yields with relatively high runoff costs. Natural grassland was optimal for balancing water provisioning and soil conservation, and artificial grassland was second to natural grassland in this respect. Meanwhile, newly unmanaged abandoned land and cropland had relative weak functionality with regard to soil and water conservation. The implications of this study's findings are discussed along with their potential to contribute to an improved understanding of the effects of ecological restoration on water supply and soil retention for the water-limited terrestrial ecosystem at a regional scale.</p>

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1 **Running title:**

2 Quantifying the effect of ecological restoration on runoff and sediment yields: A
3 meta-analysis for the Loess Plateau of China

4
5 **Abstract**

6 Ecological restoration can result in extensive land use transitions which may directly impact on water
7 runoff and sediment loss and thus influence tradeoffs between multiple hydrological and soil ecosystem
8 services. However, quantifying the effect of these transitions on runoff and sediment yields has been a
9 challenge over large spatial scales. This study integrated and synthesized 43 articles and 331 runoff
10 experimental plots in the Loess Plateau of China under natural rainfall to quantify the impacts of land use
11 transitions on (i) runoff and sediment production, (ii) runoff and soil loss reduction effectiveness, and (iii)
12 the tradeoffs between runoff and soil erosion. The effects of ecological restoration on runoff and sediment
13 yields were quantified using a general mixed linear meta-regression model with a restricted maximum
14 likelihood estimator on overall and individual ecological restoration types. The results showed that
15 artificial grassland, forest, natural grassland, and shrubland had higher runoff and sediment reduction
16 effectiveness. The annual runoff reduction effectiveness of the ecological restoration overall was 72.18%
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19 restoration was 99.9% without a significant difference among the four land uses associated with
20 ecological recovery. In addition, shrubland and forest significantly reduced sediment yields with
21 relatively high runoff costs. Natural grassland was optimal for balancing water provisioning and soil
22 conservation, and artificial grassland was second to natural grassland in this respect. Meanwhile, newly
23 unmanaged abandoned land and cropland had relative weak functionality with regard to soil and water

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9 24 conservation. The implications of this study's findings are discussed along with their potential to
10 25 contribute to an improved understanding of the effects of ecological restoration on water supply and soil
11
12 26 retention for the water-limited terrestrial ecosystem at a regional scale.

13
14 27 **Keywords**

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16 28 Hydrological monitoring, land degradation, land use transition, plot scale, vegetation recovery
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19
20 30 **I Introduction**

21
22 31 Soil erosion by water has been a serious environmental problem and a threat to the
23
24 32 sustainability and productive capacity of agro-ecosystems (Lal, 1987; Pimentel et al.,
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26 33 1995; Pimentel and Kounang, 1998). Ecological restoration is an important approach for
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28 34 controlling land degradation caused by soil erosion and for improving soil ecological
29
30 35 function. In semi-arid and arid regions, ecosystem services that promote water provision
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32 36 and soil retention by ecological restoration initiatives are critical to ensure the
33
34 37 sustainability of socio-ecological systems. Water provisioning and soil retention
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36 38 services are closely related to water and soil processes, especially runoff and sediment
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38 39 processes which are extremely sensitive to land use and vegetation cover changes
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40 40 arising from ecological restoration initiatives (Brauman et al., 2007; Robinson et al.,
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42 41 2013).

43
44 42 Historically, field observation has been the most commonly used and reliable
45
46 43 method for determining the effect of ecological restoration on runoff and sediment
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48 44 yields. Specifically, runoff experimental plots are used to conduct field observations
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9 45 where vegetation, soil, and topography were considered to be relatively homogeneous
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11 46 (Kinnell, 2016). Studies have revealed that land use types, the magnitude and timing of
12
13 47 rainfall, soil erodibility, and micro-topology can each have important impacts on runoff
14
15 48 and sediment processes at the plot scale (Boix-Fayos et al., 2006). The formation of
16
17 49 vegetation patch patterns, a complex canopy structure, high soil hydraulic conductivity,
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19 50 and increases in plant functional diversity have been found to promote soil and water
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21 51 retention when ecological restoration has altered the bio-physical environment through
22
23 52 natural succession (Imeson and Prinsen, 2004; Hou and Fu, 2014a; Hou et al., 2014a;
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25 53 Zhou et al., 2016). The implementation of ecological restoration interventions can also
26
27 54 incur synergies and tradeoffs among multiple soil- and water-related ecosystem services
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29 55 (Power, 2010; Jia et al., 2014; Fu et al., 2015). Coarse indicator-based methods have
30
31 56 been used to estimate potential tradeoffs between water yield and soil retention, but can
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33 57 suffer from insufficient support from field observations (Dymond et al., 2012; Trabucchi
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35 58 et al., 2013; Zheng et al., 2014; Hao et al., 2017). Observations from field runoff plots
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37 59 on hill-slopes can provide the basis of a more accurate and direct method for choosing
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39 60 optimal land use types for ecological restoration, with the objective of promoting soil
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41 61 and water conservation. Plot scale studies have used runoff cost for sediment control as
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43 62 a simple indicator to quantify the effect of different tillage and biological measures on
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45 63 the tradeoff between runoff yields and soil loss (Yan et al., 2012; Yan et al., 2015).
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47 64 However, it is often difficult to scale up plot or field observations to regional processes,
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9 65 even from multiple field sites, because the sites may not adequately sample (or represent)
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11 66 the region. For example, they may employ different measurement methods, perform
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13 67 experiments over different time periods or have insufficient treatment repetitions
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15 68 (Boix-Fayos et al., 2006; Garcia-Ruiz et al., 2015; Labriere et al., 2015).

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18 69 One way to develop regional-scale understandings of soil and erosion processes
19
20 70 through field scale studies is through a meta-analysis. This approach synthesizes and
21
22 71 analyzes available data from multiple sites and other sources, and attempts to overcome
23
24 72 variations in study contexts and inconsistencies in their conclusions. Meta-analysis is an
25
26 73 effective tool for exploring the regional impacts of local land use change together with
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28 74 soil and water conservation interventions on runoff and soil erosion processes. A
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30 75 meta-analysis approach has been used to investigate the effects of land use types on
31
32 76 annual soil loss, annual runoff, and annual runoff coefficients from field-scale data in
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34 77 Europe and the Mediterranean region (Maetens et al., 2012). It has also been used to
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36 78 study the effectiveness of soil and vegetation management on soil erosion control in the
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38 79 humid tropics where soil erosion was found to be concentrated both spatially (over the
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40 80 landscape elements of bare soil) and temporally (e.g., during crop rotation) (Labriere et
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42 81 al., 2015).

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46 82 Although many descriptive reviews and perspectives on soil erosion and
47
48 83 conservation exist (Chen et al., 2007; Haregeweyn et al., 2015), no quantitative
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50 84 meta-analysis has been done to integrate plot scale data and findings, in support of a
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9 85 broader understanding of land use change and its hydrological and soil erosion impacts
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11 86 for the Loess Plateau in China. The Loess Plateau has a well-known and long history of
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13 87 heavy soil erosion due to an increasing amount of susceptible land use types, such as
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15 88 bare land, sloped cropland, and abandoned land. It has been a research hotspot for soil
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17 89 erosion studies and has been subjected to many soil and water conservation measures
18
19 90 since the early years of New China (Chen et al., 2007; Chen et al., 2015; Zhuang et al.,
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21 91 2015). During the past decades, many soil and water retention and ecological restoration
22
23 92 projects have been implemented to reduce soil erosion and to promote vegetation
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25 93 recovery, especially through the “Grain-for-Green” project launched in 1999 (Chen et
26
27 94 al., 2007). These projects promote the transition from degradation susceptible land to
28
29 95 degradation-resistant land types such as artificial or natural grassland, shrubland, and
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31 96 forest, which has made the Loess Plateau the most significant vegetation greening zone
32
33 97 in China (Lu et al., 2015; Vina et al., 2016). These land use transitions effectively
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35 98 control soil erosion and reduce runoff in this water-limited area (Chen et al., 2015; Feng
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37 99 et al., 2016; Wang et al., 2016). In addition, observations at extensively distributed field
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39 100 plots have been widely used to directly monitor runoff and sediment yields on the Loess
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41 101 Plateau (Chen et al., 2007). Studies have focused primarily on the effect of land use
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43 102 types on runoff and sediment production at the local scale (Kang et al., 2001; Fu et al.,
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45 103 2004; Wang et al., 2011; Zhang et al., 2015; Zhou et al., 2016). However, current studies
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47 104 have paid little attention to the regional effects of ecological restoration on soil and
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9 105 water retention, regardless of sufficient support by observation data.

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11 106 Thus, in this study, we integrated field plot scale monitoring to quantify the effect
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13 107 of ecological restoration on hydrological and soil erosion via a meta-analysis. Our main
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15 108 objectives were to: (a) determine the impact of land use type on runoff and sediment
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17 109 yields across the entire Loess Plateau; (b) identify the tradeoffs and synergies between
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19 110 runoff production and soil erosion under different land use types; and (c) evaluate the
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21 111 overall and land use specific effectiveness of ecological restoration on soil and water
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23 112 retention. Such an approach can inform and support an improved understanding of the
24
25 113 effects of regional-scale land use transitions and can facilitate future large-scale
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27 114 ecological restoration planning and sustainable management. At the same time, this
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29 115 study can complement global-scale studies, especially in other loess regions around the
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31 116 world.
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34 35 117 **II Material and methods**

36 37 118 *I Literature search and data extraction*

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39 119 To collect the meta-analysis data, we searched peer-reviewed journal articles published
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41 120 both in English and in Chinese using the ISI Web of Science and China National
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43 121 Knowledge Infrastructure (CNKI) (from Jan. 1990 to May 2016). We used the
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45 122 following search-term combinations: “runoff” or “streamflow” or “discharge” or “water
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47 123 yield” or “water provision,” and “soil erosion” or “sediment load” or “sediment delivery”
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49 124 or “sediment discharge” or “sediment yield*” or “sediment*”. We then refined our
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9 125 search with keywords “Loess Plateau” or “* middle * Yellow River”. EndNote X7
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11 126 software was used to manage documents, remove duplicates, and screen titles, abstracts
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13 127 and full texts in order to include or exclude studies. Engauge Digitizer software was
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15 128 used to help with extracting numerical data from scatter-plot, box-plot, and bar-plot
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17 129 figures. In addition, we considered further studies cited in the references and studies
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19 130 published as dissertations. A final set of 43 articles and 331 plots were included in our
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21 131 meta-analysis (see Appendices 1 and 2) that met the following criteria for inclusion:
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- 24 132 1. The experiments were conducted in the region of the Loess Plateau and in the
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26 133 middle reach of the Yellow River;
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28 134 2. The experiments were conducted in the field under natural rainfall events;
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30 135 3. The spatial scale of observation was the runoff experimental plot, with relatively
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32 136 homogeneous site conditions and responses to different land cover transitions;
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34 137 4. The study at least partly recorded variables describing runoff or sediment and the
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36 138 following associated factors: land use type, area, slope length, slope steepness, soil
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38 139 properties, and restoration duration;
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40 140 5. Means, standard deviations or standard errors, or sample sizes of treatments and
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42 141 controls were directly reported or could be determined from the main text of the
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44 142 articles.
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48 143 The 43 selected studies were mainly conducted in the hilly-gully region of the Loess
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50 144 Plateau (Figure 1) and were diverse in their specific characteristics: the duration of
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9 145 monitoring, the number of land use types, and site conditions (see Appendix 2).
10 146 Because runoff and erosion events happen mainly during the growing season (from Jun.
11 147 to Sept.) on the Loess Plateau, we focused on the growing season and associated runoff
12 148 events and soil erosion events. Annual runoff and sediment yields were obtained by
13 149 summing rainfall event runoff and sediment yields for the entire growing season. The
14 150 growing season and event rainfall were used to calculate a runoff coefficient to describe
15 151 the likelihood of runoff.
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153 [insert Figure 1.]

30 155 *2 Data characteristics and preprocessing*

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32 156 The first stage of the analysis was to determine the characteristics of the data sources
33 157 and the data. The year of publication indicated that research articles were concentrated
34 158 in 2004, 2006 and the last five years (Figure 2(a)). Although, the duration of the 43
35 159 studies ranged from one to 14 years, most took fewer than five years (Figure 2(b)). The
36 160 number of land use types was generally less than four and all studies examined two
37 161 temporal scales: years and rainfall events (Figure 2(c) and (d)). The research sites were
38 162 distributed across four provinces (Shanxi, Shaanxi, Ningxia, and Gansu) and across 21
39 163 counties (Ansai, Baota, Changwu, Dingxi, Fu, Fugu, Guyuan, Huining, Ji, Lishi,
40 164 Pingshuo, Shenmu, Shouyang, Tianshui, Wuqi, Xifeng, Yanggao, Yichuan, Yongshou,
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9 165 Yulin, and Zizhou) (Figure 2(e)). Using the classification of annual soil erosion rates
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11 166 from Jing (1986), most of the annual soil erosion rates were found to be less than 20
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13 167 t/ha among 7 land use types, but for bare land, abandoned land and cropland, large rates
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15 168 were found at 20-50 t/ha, 50-100 t/ha and more than 100 t/ha. Abandoned land had the
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17 169 highest annual soil loss rate of more than 100 t/ha (Figure 2(f)). The compiled datasets
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19 170 were considered sufficiently rich and representative to be used for a meta-analysis.

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21
22 171 Land use transition types and land use types adopted in our study can be found in
23
24 172 Table 1. Each land use type was occupied by a different dominant plant species. Forage
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26 173 grass species (e.g., *Astragalus adsurgens*, *Medicago sativa*, and *Astragalus*
27
28 174 *complanatus* R. Ex Bge.) was commonly found on artificial grassland plots, whereas
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30 175 natural grassland plots were occupied through natural succession mainly by wild species,
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32 176 including *Agropyron cristatum* (Linn.) Gaertn., *Cleistogenes squarrosa* (Trin.) Keng,
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34 177 *Heteropappus altaicus* (Willd) Novopokr, *Setaria viridis* (L.) Beauv., *Stipa capillata*
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36 178 Linn., *Artemisia scoparia* waldst.et Kit and *Stipa bungeana* Trin. and so on. Forest plots
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38 179 mainly included tall trees, such as *Pinus tabulaeformis* Carr., *Armeniaca sibirica* (L.)
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40 180 Lam., *Populus simonii* Carr., and *Robinia pseudoacacia* Linn.. Shrubland plots mostly
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42 181 contained shorter shrub species such as *Caragana korshinskii* Kom., *Hippophae*
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44 182 *rhamnoides* Linn., *Spiraea pubescens* Turcz., *Lespedeza davurica* (Laxm.) Schindl., and
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46 183 *Amorpha fruticosa* Linn.. Crops such as millet, potato, sorghum, and soybean were
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48 184 cultivated on sloped cropland, and newly abandoned land that was farmland or fallow
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9 185 over a relatively short time period and had relatively low vegetation coverage. Most of
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11 186 the bare land plots had no plant cover and vegetation coverage was approximately zero.
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15 188 [insert Table 1.]
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19 190 [insert Figure 2.]
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23 192 *3 Data analysis*

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25 193 Before conducting a detailed analysis, all data were transformed to uniform units to
26
27 194 make runoff and soil erosion data comparable across all studies. Here, the runoff unit
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29 195 and soil erosion rate were transformed to mm and g/m^2 , respectively. Next, descriptive
30
31 196 statistics were generated to visualize the interactions between land use, runoff and soil
32
33 197 loss, using box-plots grouped by land use type (Figures 3). Then, runoff and soil erosion
34
35 198 rates were \log_{10} transformed to normalize their distribution. One-way analysis of
36
37 199 variance (ANOVA) and Tukey's HSD (honest significant difference) were used to test
38
39 200 for differences (significance level at $p < 0.05$) in runoff and soil loss with land use type
40
41 201 (Figure 3).
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46 202 A range of indicators were used to quantify runoff and soil loss reduction
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48 203 effectiveness and runoff cost of sediment control with land use, with each land use type
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50 204 considered as a separate vegetation management factor, and compared with the case of
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9 205 bare land where plant cover was approximately zero (Figure 4 and Table 2). In order to
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11 206 explore overall and individual soil and water retention effectiveness via a meta-analysis,
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13 207 the land use types were divided into two transition types according to their soil and
14
15 208 water retention measures (Table 1). Firstly, ecological restoration types (ERT) are
16
17 209 essential soil and water conservation measures leading to land use transitions from
18
19 210 cultivated sloping croplands to artificial grassland, natural grassland, shrubland, and
20
21 211 forest in the Loess Plateau. Secondly, land degradation types (LDT) are the main
22
23 212 sources of soil loss and have poor water conservation potential, which included bare
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25 213 land, newly abandoned land, and cropland. Finally, we determined the soil and water
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27 214 retention effectiveness of the four ERTs by contrasting them with the three LDTs via a
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29 215 meta-analysis.
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33 216 Specific criteria were used to expand the datasets and to calculate the effect of
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35 217 runoff and soil erosion rate for the meta-analysis. LDTs were treated as controls or
36
37 218 reference scenarios, whereas ERTs containing artificial grassland, natural grassland,
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39 219 shrubland, and forest were regarded as treatments. We chose the natural log of the
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41 220 response ratio to calculate the effect size, as an alternative to the standardized mean
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43 221 difference (e.g., Hedges' d), which is a more restrictive method (Koricheva J., 2013).
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45 222 Thus, the effect size can be calculated by the natural log of the response ratio ($\ln RR$):
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$$\ln RR = \ln \left(\frac{\bar{Y}_1}{\bar{Y}_2} \right) = \ln \bar{Y}_1 - \ln \bar{Y}_2$$

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223 with variance

$$\vartheta_{\ln RR} = \frac{s_1^2}{n_1 \bar{Y}_1} + \frac{s_2^2}{n_2 \bar{Y}_2}$$

224 where n_1 , \bar{Y}_1 , s_1 were the sample size, mean and standard deviation of the variable
225 related to the ERTs, respectively; n_2 , \bar{Y}_2 , s_2 were the sample size, mean and standard
226 deviation of the variable relevant to the LDTs, respectively. Details on the meta-analysis
227 data are provided in the supplementary material (see Appendix 2).

228 We determined the coarse spatial variability of effect size (lnRR) with longitude,
229 latitude, mean annual precipitation (MAP) and mean annual temperature (MAT) via a
230 regression analysis (see Appendix 3). In the meta-analysis process, model fit statistics
231 (e.g., log-likelihood, deviance, Bayesian information criterion, and Akaike information
232 criterion) were used to evaluate the optimal model. Model availability can be
233 determined by the funnel and Q-Q plot between the standard error and overall effect
234 model residuals, which can be useful for diagnosing the presence of heterogeneity and
235 certain forms of publication bias (Viechtbauer, 2010) (see Appendix 4). The ratio of the
236 runoff plot area, slope length, and slope steepness between ERT and LDT were regarded
237 as continuous (numerical) moderator variables, whereas ERTs were treated as
238 categorical moderator variables. Consequently, a generalized linear mixed
239 meta-regression model was chosen with a restricted maximum likelihood estimator, to
240 evaluate the mean effect size and its 95% confidence intervals (CIs), considering the
241 impact of ERT and topologic characteristics on the effectiveness of soil and water

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9 242 retention (Tables 3 and 4). To characterize soil and water conservation effectiveness
10 243 under different ERTs, the value of the overall mean effect size and the 95% CIs were
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12 244 transformed to estimate the percentage change and other variables relative to the control
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14 245 percentage, using $(e^{\ln RR} - 1) \times 100\%$ (Figure 5). All of the reference lines in Figure
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16 246 5 were at zero referring to a zero effect, and any CI (95%) crossing the reference line
17
18 247 indicates a statistically insignificant result. According to vegetation management factors
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20 248 for the revised universal soil loss equation (RUSLE), we also calculated the ratio of the
21
22 249 annual soil erosion rate per cover-management factor to soil loss on bare land for
23
24 250 temperate, humid tropics, and Loess Plateau regions (Figure 6) (Renard, 1997; Labriere
25
26 251 et al., 2015). Due to the absence of abandoned land in RUSLE's vegetation management
27
28 252 factors, the annual soil erosion ratio of cropland and abandoned land to bare land had
29
30 253 the same relative ratio from the temperate region and the humid tropic region (Figure 6).
31
32 254 Data transformations and statistical analyses were conducted using the R statistical
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34 255 software and the "metafor" R package was used to conduct the meta-analysis
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36 256 (Viechtbauer, 2010; R Core Team, 2013).
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[insert Table 2.]

260 **III Results**

261 *1 Impacts of land use type on runoff and soil erosion*

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9 262 Average runoff depths and runoff coefficients among the seven land use types were
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11 263 calculated at the annual and the event scale (Figures 3). Abandoned land, bare land, and
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13 264 cropland had significantly higher annual runoff depths than natural grassland, shrubland,
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15 265 and forest ($p < 0.05$). Abandoned land had the highest annual runoff depth compared to
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17 266 other land cover types, and bare land ranked second for runoff yield. The annual runoff
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19 267 depth of artificial grassland was significantly higher than that of forest and lower than
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21 268 that of abandoned land ($p < 0.05$), whereas those of artificial grassland, natural grassland,
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23 269 and shrubland had no significant difference (Figure 3(a)). On the rainfall event scale,
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25 270 bare land had the highest runoff depth than those of other land use types ($p < 0.05$),
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27 271 whereas the runoff depths of shrubland and forest were significantly lower than those of
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29 272 artificial grassland, bare land, cropland, and natural grassland ($p < 0.05$), with the
30
31 273 exception of abandoned land, which had a higher runoff depth than shrubland and forest
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33 274 (Figure 3(b)). In addition, the annual runoff coefficients of artificial grassland,
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35 275 shrubland, and forest were significantly lower than those of abandoned land, bare land,
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37 276 and cropland ($p < 0.05$), whereas the annual runoff coefficients of abandoned land, bare
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39 277 land, and cropland had no significant difference. Abandoned land also had the highest
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41 278 annual runoff coefficient, whereas the annual runoff coefficients of artificial grassland,
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43 279 natural grassland, shrubland, and forest had no significant difference (Figure 3(c)). Bare
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45 280 land had a significantly higher event runoff coefficient than artificial grassland,
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47 281 cropland, natural grassland, shrubland, and forest ($p < 0.05$), whereas the event runoff
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9 282 coefficients of shrubland and forest were significant lower than those of abandoned land,
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11 283 bare land, and cropland. The event runoff coefficient of shrubland was also significantly
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13 284 lower than that of artificial grassland and forest ($p<0.05$) (Figure 3(d)). These results
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15 285 revealed that abandoned land, bare land, and cropland had relatively higher runoff
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17 286 yields than artificial grassland and natural grassland, whereas shrubland and forest had
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19 287 the lowest runoff yields but high water retention functions.

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22 288 Also presented in Figure 3 are the average soil erosion rates among the seven land
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24 289 use types at the annual and the event scale. Artificial grassland, abandoned land, bare
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26 290 land, and cropland had higher annual soil erosion rates compared to natural grassland,
27
28 291 shrubland, and forest, while those of artificial grassland and cropland were significantly
29
30 292 lower than those of abandoned land ($p<0.05$). Furthermore, the mean annual soil
31
32 293 erosion rate of abandoned land was very close to that of bare land while artificial
33
34 294 grassland, bare land, and cropland had no significant difference in their annual soil
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36 295 erosion rates (Figure 3(e)). In addition, bare land and cropland, had significantly higher
37
38 296 event soil erosion rates than those of abandoned land, artificial grassland, natural
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40 297 grassland, shrubland, and forest. Also, the event soil erosion rate for cropland was the
41
42 298 highest, with bare land second (Figure 3(f)). Although abandoned land had a relatively
43
44 299 low event soil erosion rate, this land use had a higher ability of yielding annual runoff
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46 300 than cropland. At the same time, abandoned land can accumulate more soil loss at the
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48 301 annual scale due to abandoned land that was fallowed from cropland (Figure 3(e) and
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9 302 3(f)). Results showed that natural grassland, shrubland, and forest are preferable land
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11 303 use types for retaining soil and water, and artificial grassland also showed a degree of
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13 304 improved soil and water retention effectiveness, compared to abandoned land, bare land,
14
15 305 and cropland.
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20 307 [insert Figure 3.]
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23
24 309 *2 Soil and water reduction effectiveness and its tradeoff under different land use*
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26 310 *types*
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29 311 Using bare land as a reference, we calculated the runoff and sediment reduction
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31 312 effectiveness on the annual and event scales across six land use types (Table 2; Figure 4).
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33 313 We found that artificial grassland, natural grassland, shrubland, and forest had relatively
34
35 314 high annual effectiveness in retaining water. The annual runoff retention effectiveness of
36
37 315 shrubland and forest was more than 70%, whereas that of cropland and abandoned land
38
39 316 were about 37% and -15%, respectively (Figure 4(a)). All six land use types had
40
41 317 relatively high event effectiveness in retaining water compared to bare land. The event
42
43 318 runoff retention effectiveness of shrubland and forest was more than 70%, and that of
44
45 319 cropland and natural grassland was more than 49% (Figure 4(b)). All six land use types
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47 320 had positive annual soil retention effectiveness compared to bare land. Except for
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49 321 abandoned land, with its low annual soil retention effectiveness (less than 18%), the
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9 322 annual soil erosion reduction effectiveness of artificial grassland, cropland, natural
10 323 grassland, shrubland, and forest was more than 65%. Shrubland had the highest annual
11 324 soil retention effectiveness (96.51%) (Figure 4(c)). In addition, abandoned land, natural
12 325 grassland, and shrubland had relatively high event soil loss retention effectiveness
13 326 (>95%), whereas that of cropland was about -150% (Figure 4(d)). These results
14 327 indicated that artificial grassland, natural grassland, shrubland and forest can be
15 328 considered as effective measures for retaining runoff and sediment, whereas abandoned
16 329 land had low effectiveness in retaining runoff, and cropland was found to weakly
17 330 decrease event sediment yields.

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28 331 The runoff cost of sediment control was used to determine the tradeoffs of different
29 332 land use types at a hillslope scale for soil and water conservation, with reference to bare
30 333 land (Figure 4). On an annual scale, natural grassland, shrubland, and forest had
31 334 relatively high runoff costs, and that of artificial grassland was the highest (4.88 m³/t).
32 335 Abandoned land was associated with greater annual runoff compared to bare land
33 336 (Figure 4(e)). On the event scale, artificial grassland, forest, and shrubland had
34 337 relatively higher water costs, and cropland had lower water costs than abandoned land
35 338 (Figure 4(f)). These results showed that shrubland and forest significantly reduced
36 339 sediment yields with relatively high runoff costs, whereas natural grassland was optimal
37 340 for balancing runoff production and soil conservation and artificial grassland was also
38 341 found to be effective.

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[insert Figure 4.]

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15 345 *3 Evaluation of soil and water retention effectiveness between ERT and LDT*

16 346 Considerable spatial variability in the effect size (i.e. various lnRRs) was found along

17 347 longitudinal and latitudinal gradients (see Appendix 3). Overall annual runoff depth rate

18 348 (lnRR) significantly decreased with an increase in latitude ($p<0.05$), whereas overall19 349 event soil erosion rate (lnRR) increased significantly with both latitude ($p<0.01$) and20 350 longitude ($p<0.001$). This spatial trend was also evident for the event soil erosion rate

21 351 (lnRR). However, both the event runoff depth (lnRR) and the event soil erosion rate

22 352 (lnRR) of artificial grassland significantly decreased with increased longitude ($p<0.01$).

23 353 These results indicated that the effect size of event runoff and soil erosion were more

24 354 sensitive to changes of longitude and latitude, whereas the effect size of annual runoff

25 355 was more limited to variation in latitude, only. In addition, the effect of MAP and MAT

26 356 on the variability of the effect size can be found in Appendix 4. Clearly, it is critical to

27 357 consider spatial heterogeneity when quantifying the overall effect of ecological

28 358 restoration on runoff and soil erosion over large regions.

29 359 Ecological restoration activities had a positive effect on soil and water retention. In

30 360 contrast with LDTs, ERTs significantly reduced annual runoff by 72.18% ($p<0.01$) and31 361 decreased annual soil erosion by 99.9% ($p<0.0001$), whereas the event runoff was

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9 362 reduced by 39.26%, and event soil loss was not significantly decreased (Figure 5 (a) and
10 363 (c)). Moderator variables effectively improved our meta-analysis model, which included
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12 364 the ratios of runoff plot area, slope length, and slope steepness between ERT and LDT
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14 365 (see Appendix 4). The overall event runoff reduction effectiveness was significantly
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16 366 influenced by the ratio of slope steepness and the ratio of area. The ratios of slope
17
18 367 length were more important factors impacting the overall results for event soil erosion
19
20 368 (Table 3). The individual effect of the annual runoff reduction effectiveness of artificial
21
22 369 grassland, natural grassland, shrubland, and forest were 71.89%、 50.60%、 73.18%, and
23
24 370 73.08%, respectively. The combined effect of all the ecological restoration measures
25
26 371 significantly reduced annual soil erosion by about 100% ($p<0.0001$). However, event
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28 372 runoff reduction effectiveness of artificial grassland, natural grassland, shrubland, and
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30 373 forest were 56.41%、 21.97%、 56.97% ($p<0.05$) , and 36.68%, respectively. Event
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32 374 sediments were not significantly reduced (Figure 5 (b) and (d)). In evaluating the
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34 375 individual effects of the ERTs, it was clear that the ratios of runoff plot area, slope
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36 376 length, and slope steepness have significant impacts on annual soil erosion ($p<0.0001$).
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38 377 Annual runoff was obviously influenced by the ratio of the runoff plot area and slope
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40 378 steepness ($p<0.0001$), whereas slope steepness was an important factor for event runoff
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42 379 ($p<0.05$). Event soil erosion was significantly impacted by the ratio of the runoff plot
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44 380 area ($p<0.01$) and slope length ($p<0.05$) (Table 4).
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9 382 [insert Figure 5.]

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13 384 [insert Table 3.]

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17 386 [insert Table 4.]

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21 22 388 **IV Discussion**

23
24 389 *1 The high variability in water and sediment effects of ecological transition types*

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26 390 Land use that includes woody plants (forests and shrubs) and grasses has been shown to
27
28 391 be more effective at decreasing runoff and retaining water than other land use types
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30 392 (Maetens et al., 2012; Garcia-Ruiz et al., 2015; Mutema et al., 2015). At the global scale,
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32 393 the annual mean runoff coefficient of forests has been found to be highest on the
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34 394 micro-plot (Slope length was less than 1 m) and on the plot (Slope length was less than
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36 395 30 m), whereas the land use type with the lowest annual mean runoff coefficient has
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38 396 been found to be grasslands at the micro-plot scale and fallows at the plot scale,
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40 397 regardless of biogeographic context (e.g., climate zone) (Mutema et al., 2015). At the
41
42 398 regional scale, plots with (semi-) natural vegetation cover have been found to have the
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44 399 lowest mean annual runoff coefficients, and the order of low-to-high mean annual
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46 400 runoff coefficients for other land use types has been found to be fallow, cropland and
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48 401 bare soil in Western and Central Europe (Maetens et al., 2012). Our study has also
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9 402 found the annual runoff coefficients of artificial grassland, forest, natural grassland, and
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11 403 shrubland to be significantly lower than those of other land use types in the Loess
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13 404 Plateau. The main reasons for differences in the annual runoff coefficients at the
14
15 405 regional and global scales are related to (i) climate (e.g., mean annual precipitation and
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17 406 mean annual temperature), (ii) the spatial scale of the experiment (e.g., micro-plot, plot
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19 407 and watershed), and (iii) local characteristics (e.g., soil properties, slope gradient, and
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21 408 land use), which vary globally. There are no established protocols for standardizing
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23 409 measurements, and for reporting the results across studies and sites (Garcia-Ruiz et al.,
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25 410 2015; Mutema et al., 2015). Although Western and Central Europe have important loess
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27 411 regions, the Loess Plateau in China is unique in its maximum thick loess distribution
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29 412 area and its soil and water loss regions are wide and intensive. Runoff yields on
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31 413 abandoned land, bare land, and cropland in the Loess Plateau were significantly higher
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33 414 than that in Western and Central Europe. In addition, we found that the annual runoff
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35 415 coefficient on abandoned land in the Loess Plateau was significantly higher than fallow
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37 416 land in Western and Central Europe, and even globally. This result confirmed that
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39 417 unmanaged abandoned land is not beneficial for preserving water, and this land use had
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41 418 higher runoff yields due to the shortage of vegetation cover, loose soil and the absence
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43 419 of mulching practices (Lasanta et al., 2000; Prosdocimi et al., 2016). In addition, we
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45 420 found forest, shrubland, natural grassland, and artificial grassland had higher annual
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47 421 runoff reduction effectiveness than cropland and abandoned land, which had higher
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9 422 annual runoff yields than bare land. Therefore, ecological restoration can effectively
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11 423 conserve water, but with a high variability of effectiveness in different regions due to
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13 424 differences in climate.

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15 425 Vegetation recovery can effectively control soil erosion. In our study, we found that
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17 426 land degradation types had significantly higher soil loss than ecological restoration
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19 427 types. The same conclusions have been found in the humid tropics, Western and Central
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21 428 Europe and in global studies (Maetens et al., 2012; Garcia-Ruiz et al., 2015; Labriere et
22
23 429 al., 2015; Mutema et al., 2015). In a global meta-analysis, forests, shrubland, and
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25 430 grassland have been found to have lower annual mean sediment yields than croplands
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27 431 and fallows, where fallows had the highest annual mean sediment yields (Garcia-Ruiz et
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29 432 al., 2015; Mutema et al., 2015). In the humid topics, forest has been found to have the
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31 433 lowest mean annual soil loss, where the low-to-high soil loss order for other land use
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33 434 types were found to be shrubland, grassland, cropland, and bare soil (Labriere et al.,
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35 435 2015). In Western and Central Europe, plots with (semi-)natural vegetation cover have
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37 436 been found to have the lowest mean annual soil loss, where the low-to-high soil loss
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39 437 order of other land use types were found to be fallows, cropland, and bare soil (Maetens
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41 438 et al., 2012). Although grassland, shrubland, and forest can effectively reduce soil loss
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43 439 in the Loess Plateau, for humid tropical areas, Western and Central Europe, and globally,
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45 440 a high variability in the quantity of soil loss at regional and global scales have been
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47 441 observed. Compared to loess regions in Western and Central Europe, the Loess Plateau
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9 442 had the highest soil loss across all land use types, with bare land always having the
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11 443 highest soil loss rate. Although abandoned land (similar to fallows) was an important
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13 444 land use type for re-wilding and for conserving biodiversity, retaining soil, and restoring
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15 445 the ecological function by natural succession (Hou and Fu, 2014b; Queiroz et al., 2014;
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17 446 Corlett, 2016), unmanaged abandoned land in the early stage of ecological restoration
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19 447 has been found to have relatively high annual sediment yields, even exceeding the
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21 448 annual mean soil loss rate of cropland (Lasanta et al., 2000; Maetens et al., 2012;
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23 449 Mutema et al., 2015; Prosdocimi et al., 2016). In our study, the annual reduction
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25 450 sediment effectiveness of shrubland, natural grassland, forest, and artificial grassland
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27 451 was found to be higher than that of cropland and abandoned land, and overall, the
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29 452 effectiveness of ecological restoration land types were approximately two times that of
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31 453 land degradation types. Consequently, ecological restoration had a clear positive
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33 454 effective on decreasing sediment yields than land degradation types. Thus, directly
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35 455 abandoning cropland in the early stage of ecological restoration, meant that bare land
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37 456 and cropland were not always a good choice for mitigating water and sediment
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39 457 production.

44 458 *2 Tradeoffs between water provisioning and soil conservation should be*
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46 459 *considered for ecological restoration in drylands*

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49 460 Soil erosion processes are always associated and coupled with runoff processes with
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51 461 increased runoff transporting more sediments into river courses. The relationships
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9 462 between runoff and sediment yields are complex and operate across extensive
10 463 spatiotemporal scales, especially in water-limited regions (Bloschl, 2006; Boix-Fayos et
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12 464 al., 2006; Mutema et al., 2015; Zheng et al., 2015). In general, the reduction of runoff
13
14 465 causes a synergistic decrease of sediment yields in drylands and many factors can
15
16 466 contribute to reductions in runoff and sediment, such as climate change, land cover
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18 467 change, and ecological restoration (Liang et al., 2015; Gao et al., 2016; Wang et al.,
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20 468 2016; Zhang et al., 2016; Zuo et al., 2016). In our study, ecological restoration had
21
22 469 significant effects on the reduction of water runoff and sediment yields. However,
23
24 470 changes in land use type, as a result of ecological restoration activities, can exert
25
26 471 differing degrees of control on the runoff and sediment yields. Controlling soil loss
27
28 472 usually decreases water provision, particularly in dryland ecosystems (Zheng et al.,
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30 473 2014; Hao et al., 2017). Therefore, the land use type should be chosen to balance water
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32 474 provision and soil conservation from an ecosystem service perspective. Our analysis
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34 475 also revealed that shrubland and forest not only significantly decreased sediment yields,
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36 476 but also had relatively high runoff costs. Furthermore, afforestation had caused severe
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38 477 depletion of soil moisture content and consumed deeper soil moisture than cultivated
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40 478 crops, inducing soil desiccation and a dry soil layer formation in the Loess Plateau,
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42 479 which would be a poor choice for places in arid and semi-arid regions (Deng et al., 2016;
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44 480 Jia et al., 2017). Although abandoned land and cropland had a relatively weak ability to
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46 481 retain soil, they also can significantly increase runoff. Natural grassland was found to be
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9 482 the optimal vegetation type to balance the water requirement and soil conservation
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11 483 objectives, with artificial grassland also found to be effective. Consequently, complete
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13 484 conversion of cropland to forest and shrubland may not be a good strategy, especially in
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15 485 arid and semi-arid regions (Deng et al., 2016; Jia et al., 2017). Although the fallow
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17 486 period was long enough to allow abandoned land to succeed into (semi-) natural
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19 487 vegetation, abandoned land would have better soil and water retention effectiveness in
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21 488 this process (Hou and Fu, 2014a; Hou et al., 2014a; Zhao et al., 2015). Unmanaged
22
23 489 abandoned land in the early fallow stage had high water costs for decreasing sediment
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25 490 and were less effective at retaining water and soil (see also, Lasanta et al., 2000;
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27 491 Maetens et al., 2012). Furthermore, artificial grassland had relatively higher water costs
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29 492 for sediment control than natural grassland and can effectively conserve soil and
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31 493 increase water runoff by different forage managements (Yan et al., 2015). In addition,
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33 494 abandoned land and cropland had the potential to conserve soil and provided water
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35 495 through effective land management and tillage measures (Lasanta et al., 2000;
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37 496 Montgomery, 2007; Yan et al., 2012; Labriere et al., 2015; Prosdocimi et al., 2016).
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39 497 Therefore, these results indicate the need to carefully choose ecological recovery types
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41 498 for soil and water conservation in the context of the tradeoff between water yield and
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43 499 soil conversation.
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500 *3 Regional soil erosion and advice for future research*

501 Although large scale ecological restoration projects have been implemented for at
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9 502 least 15 years and have played a critical role in soil and water conservation, the Loess
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11 503 Plateau has experienced a relatively higher soil loss than the humid tropics and
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13 504 temperate regions of the world (Figure 6). For bare land, specific vegetation
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15 505 management factors in the Loess Plateau have higher ratios of soil loss than in the
16
17 506 humid tropics (Labriere et al., 2015). Ratios between temperate regions and the Loess
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19 507 Plateau for artificial grassland, abandoned land, cropland, forest, natural grassland,
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21 508 shrubland, and bare land have been found to be ca. 4, 2.4, 1, 14, 1.2, and 1.6,
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23 509 respectively (Renard, 1997). For the field plot, the average of annual soil loss of fallows,
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25 510 croplands, grasslands and forests in the Loess Plateau have higher annual soil loss than
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27 511 that of other semi-arid and arid regions from a global analysis (Mutema et al., 2015).

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31 512 Furthermore, there exists a severe conflict between water shortage and soil retention
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33 513 in the Loess Plateau which may be intensified by ecological restoration driven land use
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35 514 change in the context of climate change (Chen et al., 2015; Deng et al., 2016; Maestre et
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37 515 al., 2016). How to better conserve soil and improve water provisioning services are
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39 516 critical science and management problems. We can provide the following advice for
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41 517 future research on soil and water retention in the context of ecological restoration in
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43 518 water-limited environments, as informed by this research:

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46 519 1. Optimal plant species combinations should be identified based on plant
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48 520 functional traits, and their ability to effectively retain soil and balance
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50 521 multi-ecosystem services, from simple species-based vegetation recovery to
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9 522 trait-based community and ecosystem function restoration. For example, improving
10 523 grass community functional diversity can reduce soil erosion in semi-arid land and
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12 524 grasslands which would balance the conflict between water provisioning and soil
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15 525 conservation in semi-arid and arid regions (Zhu et al., 2015; Maestre et al., 2016).
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17 526 2. From the perspective of landscape pattern, process and function, more attention
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19 527 should be paid to the patterns of vegetation change arising from ecological
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21 528 restoration and their effects on soil and water preservation. Physical-based
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23 529 vegetation pattern indicators should be developed to determine the optimal mode of
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25 530 vegetation recovery for the control of soil and water loss. For instance, vegetation
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27 531 patch and landscape connectivity indices can strengthen the understanding of
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29 532 hydrologic and soil erosion process responses to ecological restoration (Imeson and
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31 533 Prinsen, 2004; Liu et al., 2013; Hou and Fu, 2014a; Hou et al., 2014a; Hou et al.,
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33 534 2014b; Maestre et al., 2016).
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37 535 3. To implement future sustainability of vegetation recovery, ecological restoration
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39 536 is not simply concerned with continually increasing the area of afforestation
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41 537 reforestation, returning the cropland to forest and shrubland, and accelerating the
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43 538 rate of plant regeneration. Rather, a series of management strategies are needed to
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45 539 take advantage of emerging technologies to quantify the effects of different land use
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47 540 types and to determine the effect of these management measures on soil loss and
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49 541 water provisioning. This will support transparent decision making and allow the
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9 542 tradeoffs between water yield and soil conservation to be understood. For example,
10 543 no-till agriculture, soil management practices (e.g., mulching) and vegetation
11 544 management (e.g., using local species at suitable coverage level) may be more
12 545 effective for soil loss control and the protection of (semi-) natural vegetation types
13 546 should be advocated (Montgomery, 2007; Chen et al., 2015; Labriere et al., 2015;
14 547 Deng et al., 2016; Prosdocimi et al., 2016).

548

549 [insert Figure 6.]

550

551 **V Conclusions**

552 Ecological restoration projects in the Loess Plateau have increased vegetation cover and
553 have led to land use transitions which have effectively controlled soil and water loss.
554 Our study quantified the effects of ecological restoration on runoff and sediment yields
555 by synthesizing 43 articles at different sites in the Loess Plateau using a meta-analysis.
556 First, the effect of land use type on runoff, sediment yields and soil and water reduction
557 effectiveness were quantified. Artificial grassland, natural grassland, shrubland, and
558 forest were found to be more effective land use types in retaining soil and water than
559 abandoned land, bare land, and cropland. Bare land and cropland were not found to
560 benefit soil and water retention at any time, as was unmanaged abandoned land in the
561 early fallowing stage. Our study found shrubland and forest to have a high runoff cost in

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9 562 controlling sediment. In contrast, natural grassland was found to be the optimal
10 563 vegetation type to balance the water provisioning and soil retention. Artificial grassland
11 564 was also found to be a good land use choice, whereas unmanaged abandoned land and
12 565 cropland were found to have the weakest ability to retain soil, although they can
13 566 significantly increase runoff. Second, ecological restoration effectively controlled soil
14 567 erosion and retained runoff and its effect was comprehensively quantified by this
15 568 meta-analysis. Finally, the Loess Plateau has a relatively high overall soil erosion.
16 569 Future research is needed to examine soil and water retention from an ecological
17 570 recovery perspective, including choosing optimal plant species based on plant
18 571 functional traits, applying physical-based vegetation pattern indicators, and developing
19 572 a range of practical managements and technologies for different land use types.
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574 **Appendices**

575 Appendix 1. Papers included in the meta-analysis.

576 Appendix 2. Data source and datasets for meta-analysis.

577 Appendix 3. Spatial variability of effect size.

578 Appendix 4. Fit statistic of the optimal model and model reliability in meta-analysis.

579

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Figure captions

Figure 1. Location of study sites (N = 43). Some sampling points represent several references, and some references contribute more than one sampling point.

Figure 2. Frequency distribution of (a) year of publication of the contributing references (N =43), (b) length of the study, (c) number of land use types investigated per reference, and (d) land use types investigated, (e) the number of case studies located at different counties and provinces, (f) levels of year soil erosion rate under different land use types. Abbreviation of land use types can be found in Table 1.

Event: soil erosion or runoff at an event scale; Year: soil erosion or runoff at a year scale; Event and year: soil erosion or runoff at an event and year scale; AS: Ansai; BT: Baota; CW: Changwu; DX:

Dingxi; F: Fu; FG: Fugu; GY: Guyuan; HN: Huining; J: Ji; LS: Lishi; PS: Pingshuo; SM: Shenmu; SY:

Shouyang; TS: Tianshui; WQ: Wuqi; XF: Xifeng; YG: Yanggao; YC: Yichuan; YS: Yongshou; YL:

Yulin; ZZ: Zizhou.

Figure 3. Boxplots of (a) annual runoff, (b) event runoff, (c) annual runoff coefficient, (d) event runoff coefficient, (e) annual soil loss rate and (f) event soil loss rate among seven land use types. In order to clarify the plot (e) and (f), y-axis breaks were set. The results of ANOVA and Tukey's HSD analysis were added in the figure and the absolutely different lowercase in land use types stand for having a significant difference while just having one same lowercase denotes no significant difference.

Abbreviation of land use types can be found in Table 1.

Figure 4. Runoff and soil loss reduction effectiveness contrasting to the control of bare land and the runoff cost of sediment control at event and annual temporal scale under six land use types.

Abbreviation of land use types can be found in Table 1.

RRE: Runoff reduction effectiveness; SLRE: Soil loss reduction effectiveness; R_{rs} : The runoff cost of

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6 **Figure 5.** The impact of overall and individual ecological restoration types on (a) annual runoff, (b)
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8 annual soil erosion, (c) event runoff and (d) event soil erosion. Significant levels as follows,
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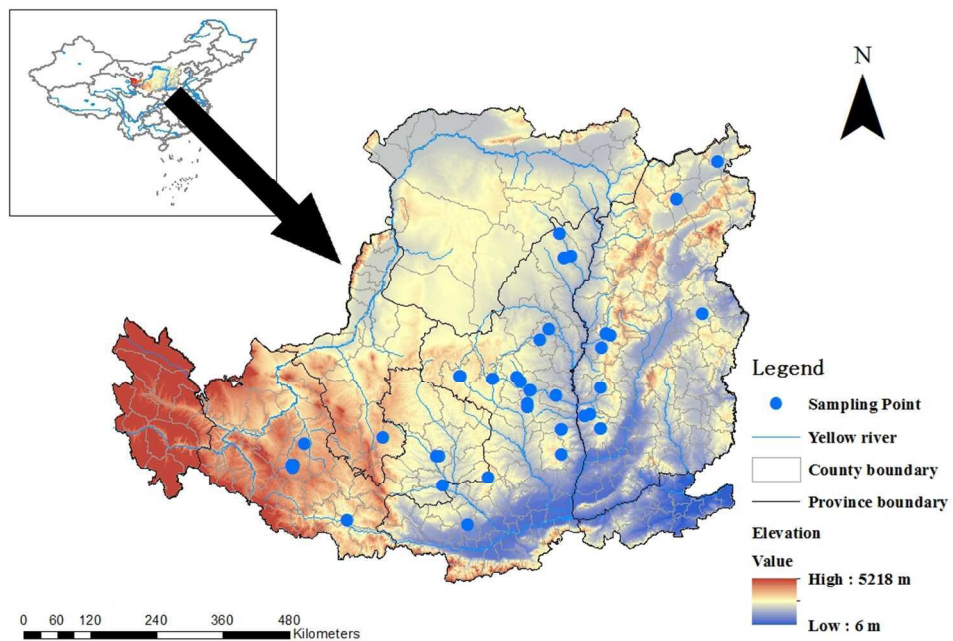
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13 **Figure 6.** Comparison of ratio of annual soil erosion rate per land use type to soil loss on bare land in
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15 three regions. Data on temperate and humid tropic regions were cited from Renard (1997) and Labriere
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17 (2015). Abbreviation of land use types can be found in Table 1.
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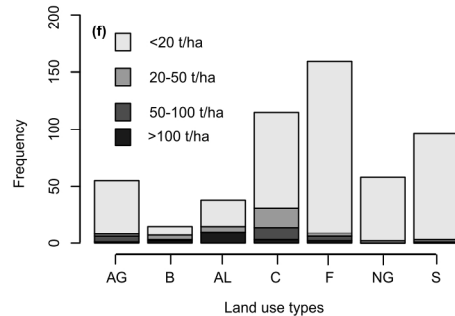
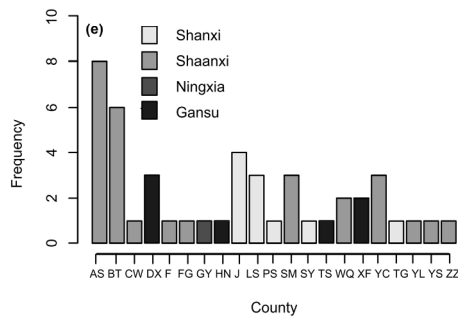
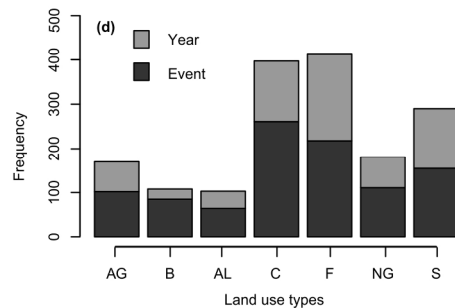
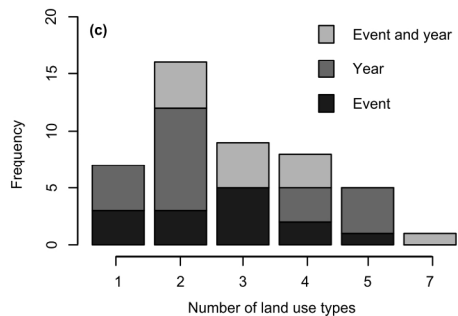
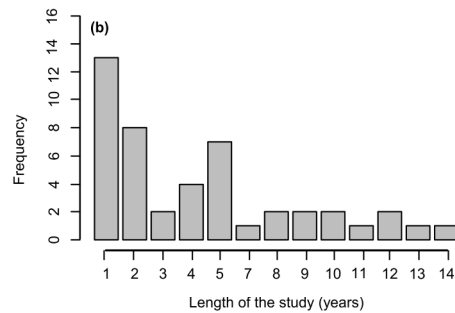
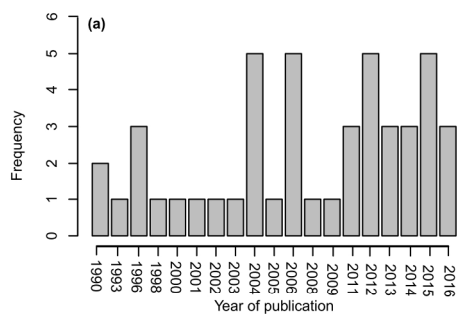
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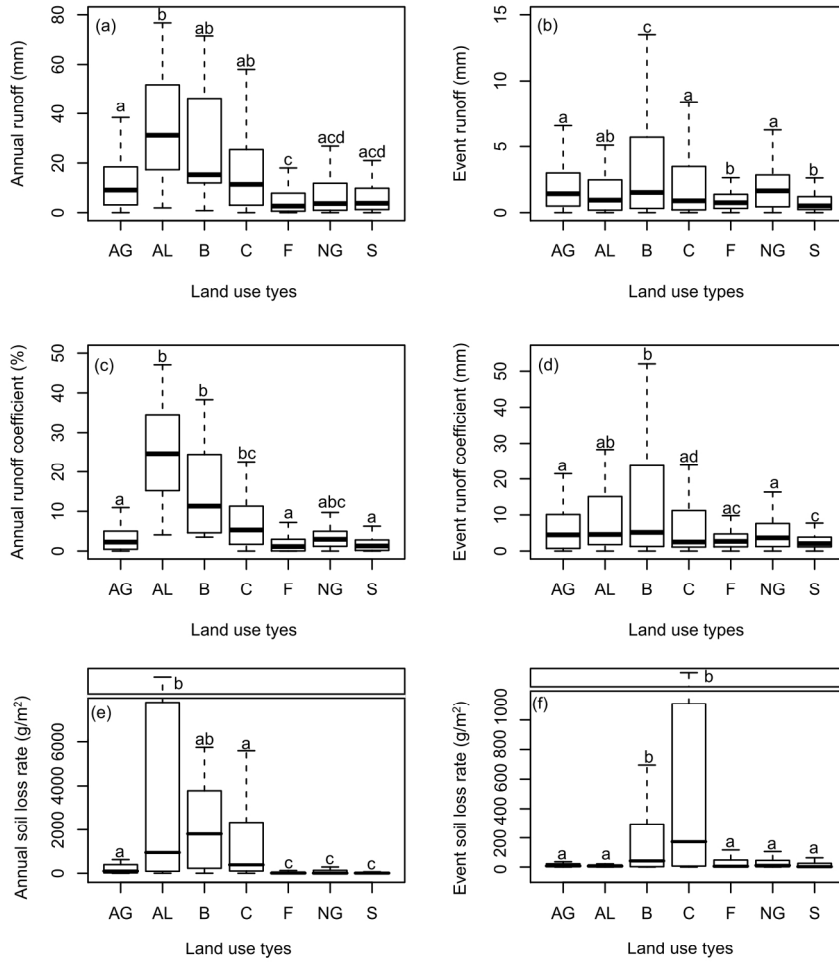
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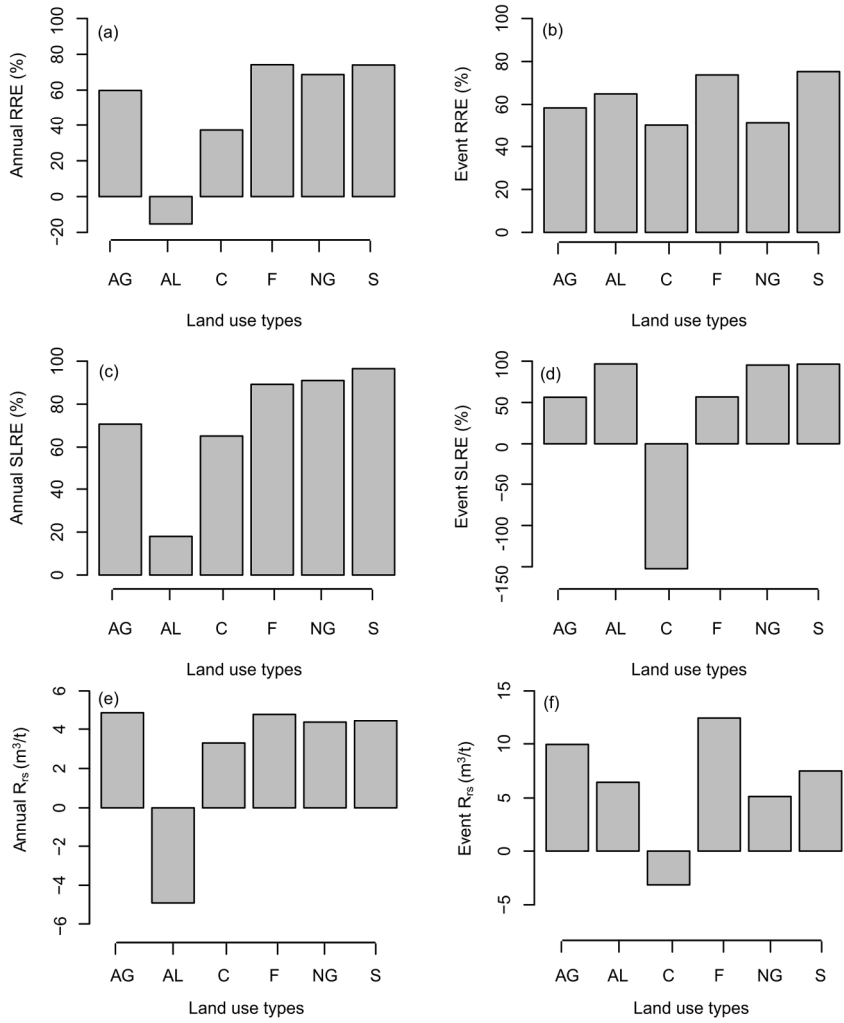
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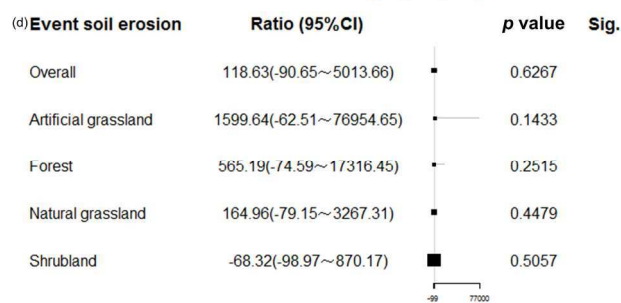
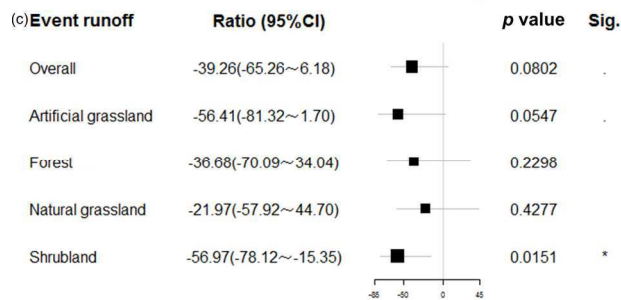
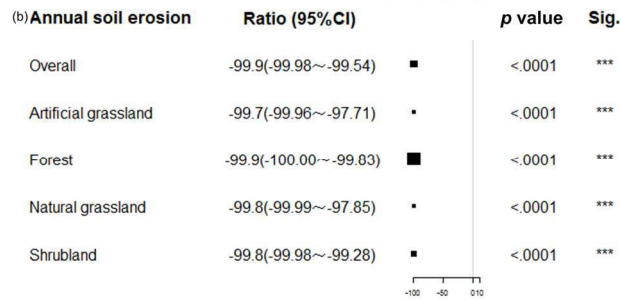
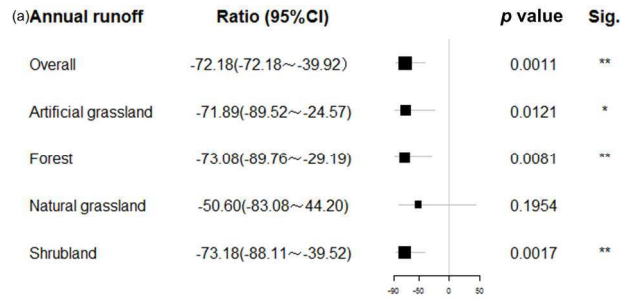
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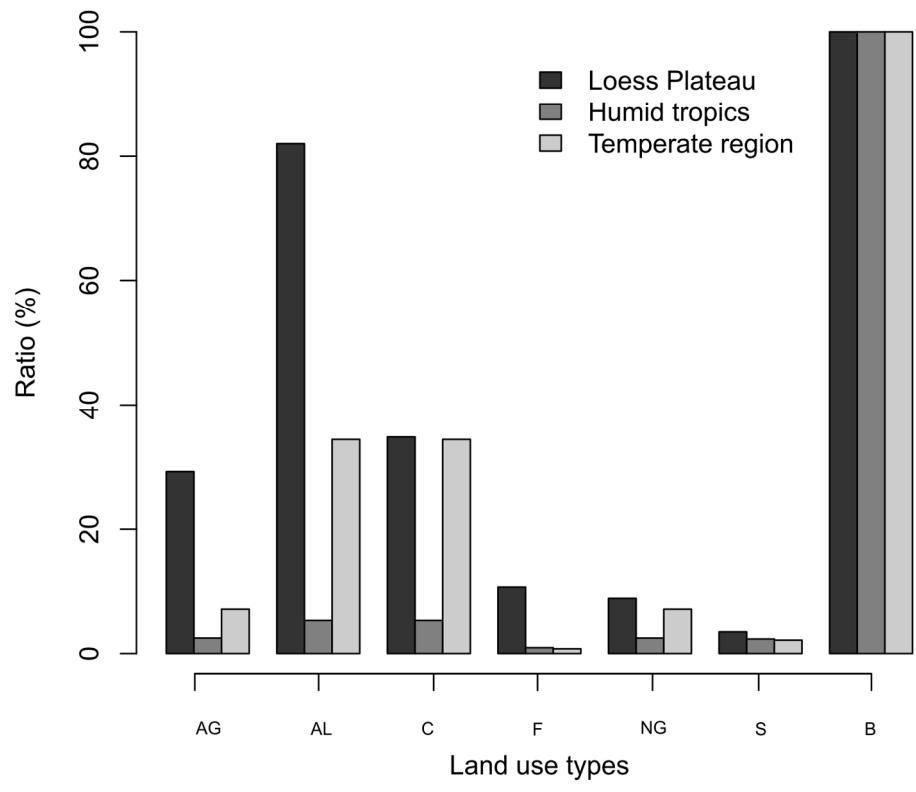
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Tables

Table 1. The description and relationship between land use transition types and land use types.

Table 2. Indicators of soil and water reduction effectiveness and its tradeoff.

Table 3. Meta-regression results of ratio of runoff plot area, slope length and slope steepness on effect size (lnRR) between ERT and LDT.

Table 4. Meta-regression results of ratio of runoff plot area, slope length and slope steepness and ecological restoration types on effect size (lnRR).

Table 1.

Land use transition types	Land use types	Abbreviation	Definition
Ecological restoration types (ERT)	Artificial grassland	AG	Land is used for grazing and managed through agricultural practices such as seeding, irrigation and use of fertilizer. Main plant species are <i>Medicago sativa</i> and <i>Astragalus adsurgens</i> .
	Natural grassland	NG	Land is unmanaged and has no trees or shrubs. For example, slope wasteland, rangelands.
	Forest	F	Ground is covered with natural vegetation dominated by trees and could also include grasses, herbs and geophytes.
	Shrubland	S	Vegetation is dominated by shrubs but can also include grasses, herbs and geophytes.
Land degradation types (LDT)	Cropland	CL	Crops are sown and harvested within a single agricultural year, sometimes more than once.
	Abandoned land	AL	Farmland was abandoned or fallow at relative short time and have not enough time to succession into grass community because of runoff plot control experiment.
	Bareland	B	Land has been opened and kept bare for various reasons by artificial controlling, which have the lowest coverage approximate at 0.

Table 2.

Indicators	Abbreviation	Equation expression	Parameter meaning	Definition	Sources
Runoff reduction effectiveness	RRE (%)	$RRE = \frac{R_{CK} - R_V}{R_{CK}} \times 100$	R_{CK} (mm); R_V (mm) and SL_{CK} (g/m ²); SL_V (g/m ²) are runoff and soil loss in control (bareland) and treatment (vegetation management factors), respectively.	The effectiveness of water retention in vegetation management factors contrast to reference background such as bare land.	(Sutherland 1998a, b; Zhao et al, 2015; Zhu et al, 2016)
Soil loss reduction effectiveness	SLRE (%)	$SLRE = \frac{SL_{CK} - SL_V}{SL_{CK}} \times 100$	R_d (mm) and S_d (g/m ²) refer to the reduction of runoff and sediment under vegetation management factors as opposed to reference scenario (bareland).	The effectiveness of soil retention in vegetation management factors contrast to reference background such as bare land.	(Yan et al, 2012; Yan et al, 2015)
Ration of detained runoff and sediment	R_{rs} (m ³ /t)	$R_{rs} = \frac{R_d}{S_d} \times 10^3$		Retention of unit slope sediment need to relatively reduce how the amount of runoff at one vegetation management factors due to land use transition.	

Table 3.

Categories	N	Type of evaluation	lnRR	Standard error	Lower limit of CI	Upper limit of CI	Z value	p value	Sig. ^a
Annual runoff	169	Overall effect	-1.28	0.39	-2.05	-0.51	-3.26	0.0011	**
		RA	-0.16	0.03	-0.21	-0.11	-5.88	<.0001	***
		RSL	0.69	0.32	0.05	1.32	2.12	0.0343	*
		RSS	0.03	0.01	0.02	0.04	4.20	<.0001	***
Annual soil erosion	132	Overall effect	-6.93	0.79	-8.49	-5.38	-8.73	<.0001	***
		RA	-4.34	0.85	-6.01	-2.67	-5.09	<.0001	***
		RSL	7.21	1.22	4.81	9.61	5.89	<.0001	***
		RSS	-1.14	0.22	-1.58	-0.70	-5.13	<.0001	***
Event runoff	117	Overall effect	-0.50	0.29	-1.06	0.06	-1.75	0.0802	.
		RA	-0.11	0.62	-1.33	1.11	-0.18	0.8608	
		RSL	-0.15	0.44	-1.01	0.71	-0.35	0.727	
		RSS	0.01	0.01	0.01	0.02	2.29	0.022	*
Event soil erosion	68	Overall effect	1.61	1.27	-0.88	4.10	1.26	0.206	
		RA	-19.26	6.77	-32.54	-5.99	-2.85	0.0044	**
		RSL	15.21	6.19	3.08	27.35	2.46	0.014	*
		RSS	-0.01	0.38	-0.75	0.73	-0.03	0.9784	

Note: a represents significance levels as follows, 0.0001-‘***’, 0.001-‘**’, 0.01-‘*’, 0.05-‘.’, 0.1-‘.’.

ERT: ecological restoration types; LDT: land degradation types; N: sample size; RA: ratio of area; RSL: ratio of slope length; RSS: ratio of slope steepness.

Table 4.

Categories	N	Type of evaluation	lnRR	Standard error	Lower limit of CI	Upper limit of CI	Z value	p value	Sig. ^a
Annual runoff	169	Artificial grassland	-1.27	0.50	-2.26	-0.28	-2.54	0.0121	*
		Forest	-1.31	0.49	-2.28	-0.35	-2.68	0.0081	**
		Natural grassland	-0.71	0.54	-1.78	0.37	-1.30	0.1954	
		Shrubland	-1.32	0.41	-2.13	-0.50	-3.20	0.0017	**
		RA	-0.15	0.03	-0.21	-0.10	-5.54	<.0001	***
		RSL	0.62	0.33	-0.04	1.27	1.87	0.0635	.
		RSS	0.03	0.01	0.01	0.04	3.83	0.0002	***
Annual soil erosion	132	Artificial grassland	-5.81	1.03	-7.83	-3.77	-5.66	<.0001	***
		Forest	-8.22	0.94	-10.08	-6.37	-8.76	<.0001	***
		Natural grassland	-6.51	1.35	-9.18	-3.84	-4.83	<.0001	***
		Shrubland	-6.66	0.87	-8.39	-4.94	-7.63	<.0001	***
		RA	-3.71	0.93	-5.55	-1.86	-3.98	0.0001	***
		RSL	6.56	1.37	3.86	9.26	4.80	<.0001	***
		RSS	-1.04	0.24	-1.51	-0.57	-4.40	<.0001	***
Event runoff	117	Artificial grassland	-0.83	0.43	-1.68	0.02	-1.94	0.0547	.
		Forest	-0.46	0.38	-1.21	0.29	-1.21	0.2298	
		Natural grassland	-0.25	0.31	-0.87	0.37	-0.80	0.4277	
		Shrubland	-0.84	0.34	-1.52	-0.17	-2.47	0.0151	*
		RA	0.53	0.82	-1.10	2.15	0.64	0.5244	
		RSL	-0.61	0.56	-1.73	0.51	-1.08	0.2839	
		RSS	0.01	0.01	0	0.02	2.12	0.0365	*
Event soil erosion	68	Artificial grassland	1.99	1.51	-1.02	5.01	1.32	0.1907	
		Forest	2.05	1.37	-0.69	4.78	1.50	0.1400	
		Natural grassland	1.60	1.26	-0.92	4.12	1.27	0.2085	
		Shrubland	0.64	1.40	-2.15	3.43	0.46	0.6502	
		RA	-18.46	6.80	-32.06	-4.86	-2.71	0.0086	**
		RSL	14.64	6.16	2.32	26.96	2.38	0.0207	*

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RSS	-0.06	0.37	-0.80	0.68	-0.16	0.8737
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Note: a represents significance levels as follows, 0.0001-‘***’, 0.001-‘**’, 0.01-‘*’, 0.05-‘.’, 0.1-‘ ’.

N: sample size; RA: ratio of area; RSL: ratio of slope length; RSS: ratio of slope steepness.

For Peer Review

Appendix 1. Papers included in the meta-analysis*1. Web of science core database*

- Feng, Q., X. D. Guo, W. W. Zhao, Y. Qiu, and X. Zhang. 2015. A comparative analysis of runoff and soil loss characteristics between "extreme precipitation year" and "normal precipitation year" at the plot scale: A case study in the Loess Plateau in China. *Water* 7:3343-3366.
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- Wang, X. Y., H. W. Gao, J. N. Tullberg, H. W. Li, N. Kuhn, A. D. McHugh, and Y. X. Li. 2008. Traffic and tillage effects on runoff and soil loss on the Loess Plateau of northern China. *Australian Journal of Soil Research* 46:667-675.
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Appendix 2. Data source and datasets for meta-analysis

Table 5. Data source included in our meta-analysis (details about references can be founded in Appendix 1).

Number	Reference	Publication year	Longitude (°)	Latitude (°)	MAT (°C)	MAP (mm)	Land use type(s)	Case time frame(s)	Study length (year)	Number of plots	Area (m ²)	Slope length (mm)	Slope steepness (°)
1	Luo, W. X., et al.	1990	108.14	34.58	10.8	601.1	2	Event	1	12	100	20	18
2	Hou, X. L., et al.	1990	108.77	36.92	8.8	549.1	5	Year	10	14	100	20	27
3	Zhang, J. T., et al.	1993	110.61	36.24	10.0	579.0	3	Event	1	3	100	20	26.6, 28.5, 28.7
4	Yu, X. X., et al.	1996	110.93	36.04	10.0	579.0	4	Year	5	6	100	20	22, 24, 27, 28
5	Hou, X. L., et al.	1996	108.77	36.92	8.8	549.1	5	Year	8	18	100	20	27
6	Zhang, J. J., et al.	1996	110.93	36.04	10.0	579.0	3	Event	1	13	100	20	26, 28
7	Zhang, Q. M., et al.	1998	111.25	37.53	8.9	500.0	2	Event and Year	1	8	59	13.34	28
8	Chen, Y. M., et al.	2000	108.77	36.92	8.8	579.0	4	Year	1	7	100	20	23, 27
9	Wu, Q. X., et al.	2002	110.12	36.05	9.7	574.0	2	Year	7	2	100	20	25, 27
10	Hu, M. J., et al.	2003	109.32	36.86	8.8	500.0	3	Event and Year	10	6	100	20	27, 23
11	Pan, C. Z., et al.	2005	110.12	36.05	9.7	574.0	2	Event	1	3	100	20	
12	Shen, Z. Z., et al.	2006	110.04	36.61	9.9	572.0	3	Event	2	3	32	16	21
13	Zhao, H. B., et al.	2006	109.32	36.86	8.8	500.0	5	Event	1	11	100	20	24
14	Li, M., et al.	2006	107.62	35.70	10.0	500.0	4	Year	12	4	30.5, 164, 187, 695		8, 22, 24, 27.5
15	Liu, X. F., et al.	2009	104.62	35.59	6.3	427.0	2	Year	1	7	140	20	13
16	Zhou, Y., et al.	2011	108.08	36.98	7.8	478.3	2	Year	2	5	100	20	12
17	Jiang, N., et al.	2011	110.37	38.81	8.4	437.4	3	Event and Year	1	5	100	20	11, 12, 15, 17
18	Yan, X. L., et al.	2012	107.56	35.71	10.0	500.0	2	Event	2	3	100	20	5
19	Wang, Q. C., et al.	2012	113.79	40.18	6.9	425.0	5	Year	5	6	100	20	8
20	Xu, J., et al.	2012	109.46	36.43	9.9	572.0	4	Event and Year	5	4	32	16	21

21	Zhang, X. S., et al.	2012	104.88	35.93	6.4	373.8	1	Event	1	1	60	12	22
22	Ai, N., et al.	2013	108.10	36.98	7.8	478.3	2	Event and Year	4	5	100	20	12, 17, 28, 29
23	Lv, Y.Z., et al.	2015	105.72	34.71	11.0	533.7	2	Event and Year	2	4	100	20	23, 24, 25
24	Wang, X. Y., et al.	2014	110.73	36.27	10.3	575.9	3	Event	11	7	100	20	16, 20, 22, 23, 29, 30
25	Zhou, J., et al.	2016	109.52	36.70	9.9	535.0	3	Event	5	18	30	10	
26	Zhu, T. X.	2016	111.05	37.33	8.9	479.0	4	Event	12	4	100, 200, 399	20, 23	30, 31, 37
27	Yi, C. Q. and J. Fan	2016	110.52	38.83	8.4	437.4	1	Event	4	3	60	12	15
28	Zheng, M. and X. Chen	2015	109.97	37.68	10.7	440.0	1	Event	9	5	300	20	22
29	Zhang, L., et al.	2015	112.84	39.62	9.6	426.7	4	Event and Year	1	8	100, 161.8, 206.83	20, 40, 54	4, 38
30	Jian, S. Q., et al.	2015	104.65	35.58	6.3	420.0	2	Year	5	12	100	10	15
31	Feng, Q., et al.	2015	109.32	36.86	8.8	539.0	3	Event and Year	4	9	40	10	23
32	Ma, L., et al.	2014	110.10	35.65	9.7	574.0	2	Year	13	6	100	20	23
33	Hou, J., et al.	2014	109.52	36.70	9.9	531.0	1	Year	2	3	10	5	23, 24, 25
34	Jiang, N., et al.	2013	110.37	38.81	8.4	437.4	4	Event and Year	1	5	100	20	11, 12, 15, 17
35	Guo, Z. and M. Shao	2013	106.47	36.02	7.0	416.0	1	Year	2	5	100	20	7, 7.7, 7.8, 7.9, 8.5
36	Gao, G. Y., et al.	2012	109.52	36.70	9.8	535.0	3	Event and Year	4	9	18	9	19
37	Wang, L., et al.	2011	109.46	36.50	9.8	537.0	1	Year	2	12	400	20	23
38	Wang, X. Y., et al.	2008	113.20	37.75	7.3	518.3	1	Year	5	6	100	20	2.9
39	Fu, B. J., et al.	2004	110.97	36.68	8.8	473.9	4	Event	2	17	100	20	10, 15, 20, 24, 25, 30
40	Zheng, F. L.	2006	108.58	35.33	8.0	560.0	2	Event and Year	1	8	243.8, 253.5,	38.2, 41	39

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41	Huang, Z. L., et al.	2006	104.64	35.55	6.3	420.0	5	Year	14	15	50, 100	10	23
42	Zhang, K., et al.	2004	109.27	36.93	8.8	541.0	2	Year	5	6	100	20	5, 10, 15, 20, 25, 28
	Zhang, K., et al.	2004	110.30	39.20	9.1	400.0	2	Year	3	1	100	20	6
	Zhang, K., et al.	2004	111.15	37.55	8.9	506.0	2	Year	8	6	100	20	5, 10, 15, 20, 25, 30
	Zhang, K., et al.	2004	109.78	37.52	9.2	420.0	2	Year	9	4	100	20	22, 31
43	Kang, S. Z., et al.	2001	107.68	35.23	9.1	541.9	7	Event and Year	3	12	27, 100, 250	9, 20, 50	0.5, 1, 3, 30, 32, 36

Note: MAT: mean annual temperature. MAP: mean annual precipitation.

Table 6. Event runoff (lnRR) and ratio of plot characteristics between ERT and LDT for meta-analysis.

ERT	LDT	lnRR	VlnRR	Ratio of area	Ratio of slope length	Ratio of slope steepness
Artificial grassland	Cropland	-0.738636	0.1197305	1	1	1
Natural grassland	Cropland	-1.204353	0.1210358	1	1	1
Shrubland	Cropland	-0.70876	0.200023	1	1	1
Shrubland	Cropland	-0.811576	0.2218719	1	1	1
Forest	Cropland	-0.263294	0.1948783	1	1	1
Shrubland	Cropland	-1.976622	0.2788845	1	1	1
Shrubland	Bareland	-0.104221	0.0742817	1	1	1
Shrubland	Bareland	-0.207037	0.0961305	1	1	1
Forest	Bareland	0.3412446	0.069137	1	1	1
Shrubland	Bareland	-1.372083	0.1531431	1	1	1
Shrubland	Cropland	-0.507343	0.2981979	1	1	2.4
Shrubland	Cropland	-0.610159	0.3200467	1	1	2.4
Forest	Cropland	-0.061877	0.2930532	1	1	2.4
Shrubland	Cropland	-1.775205	0.3770593	1	1	2.4
Shrubland	Cropland	-0.745975	0.2523903	1	1	1.6
Shrubland	Cropland	-0.848792	0.2742392	1	1	1.6
Forest	Cropland	-0.30051	0.2472456	1	1	1.6
Shrubland	Cropland	-2.013837	0.3312517	1	1	1.6
Shrubland	Cropland	-0.724858	0.2706714	1	1	1.2
Shrubland	Cropland	-0.827675	0.2925202	1	1	1.2
Forest	Cropland	-0.279393	0.2655267	1	1	1.2
Shrubland	Cropland	-1.992721	0.3495328	1	1	1.2
Shrubland	Cropland	-0.664107	0.3637007	1	1	0.96
Shrubland	Cropland	-0.766923	0.3855495	1	1	0.96
Forest	Cropland	-0.218641	0.358556	1	1	0.96
Shrubland	Cropland	-1.931969	0.4425621	1	1	0.96
Shrubland	Cropland	-0.220473	0.3901691	1	1	0.8
Shrubland	Cropland	-0.323289	0.412018	1	1	0.8
Forest	Cropland	0.224993	0.3850244	1	1	0.8
Shrubland	Cropland	-1.488335	0.4690306	1	1	0.8
Shrubland	Abandoned land	1.907595	0.469395	1	1	1.17
Shrubland	Abandoned land	1.5099182	0.5013298	1	1	1
Shrubland	Abandoned land	-1.968115	0.1793395	1	1	1
Natural grassland	Abandoned land	-0.678528	0.2995557	1	1	1
Artificial grassland	Abandoned land	-0.818321	0.1968642	1	1	1
Forest	Abandoned land	-0.052836	0.1504617	1	1	1
Shrubland	Abandoned land	-0.358751	0.1374865	1	1	1
Forest	Abandoned land	0.0778106	0.1846949	1	1	1
Shrubland	Abandoned land	-0.738224	0.1852974	1	1	1
Forest	Abandoned land	0.5865544	0.1972324	1	1	1

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3	Forest	Abandoned land	-0.693199	0.2500938	1	1	1
4	Shrubland	Cropland	-3.68249	0.4519361	1	1	1
5	Natural grassland	Cropland	-2.392904	0.5721523	1	1	1
6	Artificial grassland	Cropland	-2.532697	0.4694607	1	1	1
7	Forest	Cropland	-1.767212	0.4230582	1	1	1
8	Shrubland	Cropland	-2.073127	0.410083	1	1	1
9	Forest	Cropland	-1.636565	0.4572914	1	1	1
10	Shrubland	Cropland	-2.452599	0.4578939	1	1	1
11	Forest	Cropland	-1.127821	0.4698289	1	1	1
12	Forest	Cropland	-2.407575	0.5226904	1	1	1
13	Forest	Abandoned land	-0.241758	0.1320939	0.56	0.56	0.9
14	Shrubland	Abandoned land	0.1634898	0.1173833	0.56	0.56	0.9
15	Natural grassland	Abandoned land	0.1556922	0.1091718	0.56	0.56	0.9
16	Forest	Cropland	-1.066885	0.134514	0.56	0.56	0.9
17	Shrubland	Cropland	-0.661637	0.1198034	0.56	0.56	0.9
18	Natural grassland	Cropland	-0.669434	0.1115919	0.56	0.56	0.9
19	Forest	Bareland	-0.780803	0.1274506	0.56	0.56	0.9
20	Shrubland	Bareland	-0.375554	0.1127399	0.56	0.56	0.9
21	Natural grassland	Bareland	-0.383352	0.1045285	0.56	0.56	0.9
22	Forest	Abandoned land	-0.351365	0.2071701	0.56	0.56	
23	Shrubland	Abandoned land	0.053883	0.1924595	0.56	0.56	
24	Natural grassland	Abandoned land	0.0460854	0.184248	0.56	0.56	
25	Forest	Abandoned land	-4.093317	0.083449	0.94	0.63	
26	Shrubland	Abandoned land	-3.587767	0.083073	0.94	0.63	
27	Natural grassland	Abandoned land	-3.058074	0.0868869	0.94	0.63	
28	Natural grassland	Abandoned land	-2.766294	0.1007778	0.94	0.63	
29	Natural grassland	Abandoned land	-2.556572	0.1204393	0.94	0.63	
30	Natural grassland	Abandoned land	-2.722808	0.0989565	0.94	0.63	
31	Forest	Bareland	-4.632361	0.0788056	0.94	0.63	
32	Shrubland	Bareland	-4.126811	0.0784296	0.94	0.63	
33	Natural grassland	Bareland	-3.597118	0.0822436	0.94	0.63	
34	Natural grassland	Bareland	-3.305338	0.0961344	0.94	0.63	
35	Natural grassland	Bareland	-3.095616	0.115796	0.94	0.63	
36	Natural grassland	Bareland	-3.261852	0.0943131	0.94	0.63	
37	Forest	Cropland	-4.918443	0.085869	0.94	0.63	
38	Shrubland	Cropland	-4.412893	0.0854931	0.94	0.63	
39	Natural grassland	Cropland	-3.883201	0.089307	0.94	0.63	
40	Natural grassland	Cropland	-3.59142	0.1031978	0.94	0.63	
41	Natural grassland	Cropland	-3.381698	0.1228594	0.94	0.63	
42	Natural grassland	Cropland	-3.547934	0.1013766	0.94	0.63	
43	Forest	Abandoned land	-4.202924	0.1585252	0.94	0.63	
44	Shrubland	Abandoned land	-3.697374	0.1581492	0.94	0.63	
45	Natural grassland	Abandoned land	-3.167681	0.1619631	0.94	0.63	
46	Natural grassland	Abandoned land	-2.8759	0.175854	0.94	0.63	
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3	Natural grassland	Abandoned land	-2.666179	0.1955156	0.94	0.63	
4	Natural grassland	Abandoned land	-2.832415	0.1740327	0.94	0.63	
5	Shrubland	Abandoned land	-0.676553	0.0920319	1	1	1
6	Shrubland	Bareland	-1.215597	0.0873885	1	1	1
7	Shrubland	Cropland	-1.285368	0.1641295	1	1	1
8	Forest	Cropland	-2.352482	0.080316	1	1	1
9	Shrubland	Abandoned land	-0.569849	0.2367856	1	1	1
10	Forest	Abandoned land	-1.636963	0.1529721	1	1	1
11	Forest	Cropland	1.3913983	0.9495158	1	1	60
12	Forest	Cropland	1.9928003	0.9539391	1	1	64
13	Shrubland	Cropland	0.5444034	0.9639288	0.18	0.45	72
14	Natural grassland	Cropland	1.5613054	0.7267734	0.18	0.45	72
15	Forest	Bareland	-0.324227	0.5553121	1	1	30
16	Forest	Bareland	0.2771752	0.5597354	1	1	32
17	Shrubland	Bareland	-1.171222	0.5697251	0.18	0.45	36
18	Natural grassland	Bareland	-0.15432	0.3325697	0.18	0.45	36
19	Forest	Bareland	-0.630332	0.4893193	1	1	10
20	Forest	Bareland	-0.02893	0.4937426	1	1	10.67
21	Shrubland	Bareland	-1.477327	0.5037323	0.18	0.45	12
22	Natural grassland	Bareland	-0.460425	0.2665769	0.18	0.45	12
23	Forest	Bareland	-0.348936	0.5287184	1	1	60
24	Forest	Bareland	0.2524661	0.5331417	1	1	64
25	Shrubland	Bareland	-1.195931	0.5431315	0.18	0.45	72
26	Natural grassland	Bareland	-0.179029	0.305976	0.18	0.45	72
27	Forest	Cropland	0.7269667	0.9647656	1	1	1.09
28	Forest	Cropland	0.0774408	0.967794	1	1	0.86
29	Forest	Cropland	0.5063859	0.9664828	1	1	1.13
30	Forest	Cropland	0.3907228	0.97455	1	1	0.6
31	Forest	Cropland	0.9450145	0.96633	1	1	0.83
32	Shrubland	Cropland	-0.479832	0.9736005	1	1	0.75
33	Natural grassland	Cropland	1.3770713	0.9732783	1	1	0.83
34	Natural grassland	Cropland	0.6973305	1.0765146	1	1	
35	Forest	Cropland	0.0565513	1.0560205	1	1	
36	Forest	Cropland	-0.186905	1.0561837	1	1	
37	Forest	Cropland	-0.687068	1.133319	1	1	
38	Shrubland	Cropland	-0.439971	1.067138	1	1	
39	Shrubland	Cropland	-0.397494	1.0681651	1	1	
40	Natural grassland	Cropland	0.2736744	1.6565007	1	1	1.07
41	Shrubland	Cropland	-1.67805	1.9547895	1	1	1.08
42	Artificial grassland	Bareland	-0.846102	0.1164515	1	1	1
43	Artificial grassland	Bareland	-0.579562	0.1740925	1	1	1
44	Forest	Bareland	-0.495125	0.7944386	1	1	1
45	Artificial grassland	Bareland	-2.265232	0.9392279	1	1	1
46	Forest	Bareland	-1.736227	0.8407046	1.62	2	9.75
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Artificial grassland	Bareland	-1.062254	0.8477191	2.07	2.7	9.75
Forest	Bareland	-0.949913	0.9317708	2.07	2.7	9.75
Forest	Bareland	-0.714355	0.6952504	1	1	1
Artificial grassland	Bareland	-2.484462	0.8400396	1	1	1
Forest	Bareland	-1.955457	0.7415163	1.62	2	9.75
Artificial grassland	Bareland	-1.281484	0.7485308	2.07	2.7	9.75
Forest	Bareland	-1.169143	0.8325825	2.07	2.7	9.75
Forest	Bareland	0.2861498	0.9035884	0.48	0.37	0.1
Artificial grassland	Bareland	-1.483958	1.0483777	0.48	0.37	0.1
Forest	Bareland	-0.954952	0.9498544	0.78	0.74	1
Artificial grassland	Bareland	-0.280979	0.9568688	1	1	1
Forest	Bareland	-0.168638	1.0409205	1	1	1
Forest	Bareland	0.2861498	0.9035884	0.48	0.37	0.1
Shrubland	Cropland	-0.843974	0.2337925	1	1	0.71
Artificial grassland	Cropland	-0.625658	0.2790812	1	1	0.71
Shrubland	Cropland	-0.772791	0.246391	1	1	0.8
Artificial grassland	Cropland	-0.554475	0.2916797	1	1	0.8
Shrubland	Abandoned land	-0.385211	0.2923681	1	1	1.09
Artificial grassland	Abandoned land	-0.166895	0.3376568	1	1	1.09
Shrubland	Abandoned land	-0.570545	6.91E-06	1	1	
Natural grassland	Abandoned land	0.0529224	3.44E-06	1	1	
Shrubland	Cropland	-0.624939	6.56E-06	1	1	
Natural grassland	Cropland	-0.001472	1.43E-07	1	1	
Shrubland	Cropland	-0.559616	1.32E-07	1	1	
Natural grassland	Cropland	0.0638515	2.54E-06	1	1	
Forest	Abandoned land	-8.699515	0.1522264	1	1	
Forest	Abandoned land	-2.090166	4.03E-07	1	1	

Note: ERT: ecological restoration types; LDT: land degradation types

Table 7. Annual runoff (lnRR) ratio of plot characteristics between ERT and LDT for meta-analysis.

ERT	LDT	lnRR	VlnRR	Ratio of area	Ratio of slope length	Ratio of slope steepness
Artificial grassland	Bareland	-0.680299	5.74E-09	1	1	1
Artificial grassland	Bareland	-0.975099	7.70E-09	1	1	1
Artificial grassland	Bareland	-0.802346	3.85E-09	1	1	1
Artificial grassland	Bareland	-0.924949	4.25E-09	1	1	1
Artificial grassland	Bareland	-0.497977	4.71E-09	1	1	1
Artificial grassland	Bareland	-0.946928	5.78E-08	1	1	1
Artificial grassland	Bareland	-0.384142	9.96E-09	1	1	1
Artificial grassland	Cropland	-0.735111	9.65E-09	1	1	1
Natural grassland	Cropland	-1.207022	5.34E-08	1	1	1
Forest	Abandoned land	2.5588236	4.68E-05	1.8	1.8	0.76
Natural grassland	Abandoned land	3.2245381	1.29E-05	1.8	1.8	0.76
Shrubland	Abandoned land	3.3435626	1.32E-05	1.8	1.8	0.76
Forest	Abandoned land	1.9878447	1.33E-07	1.8	1.8	0.79
Natural grassland	Abandoned land	2.6535592	1.35E-07	1.8	1.8	0.79
Shrubland	Abandoned land	2.7725837	3.02E-06	1.8	1.8	0.79
Forest	Abandoned land	1.8409836	1.23E-06	1.8	1.8	0.83
Natural grassland	Abandoned land	2.5066982	5.44E-06	1.8	1.8	0.83
Shrubland	Abandoned land	2.6257226	4.35E-07	1.8	1.8	0.83
Forest	Abandoned land	1.185108	1.24E-07	1.8	1.8	0.76
Natural grassland	Abandoned land	1.8508226	1.90E-06	1.8	1.8	0.76
Shrubland	Abandoned land	1.969847	3.13E-06	1.8	1.8	0.76
Artificial grassland	Cropland	-0.136475	1.91E-08	1	1	1
Forest	Cropland	-0.587786	4.48E-09	1	1	1
Natural grassland	Cropland	-1.086343	1.53E-07	1	1	1
Shrubland	Cropland	-0.246037	3.02E-08	1	1	1
Forest	Cropland	-0.012589	1.56E-08	2	1	0.65
Forest	Cropland	-0.299882	2.10E-08	2	1	0.65
Shrubland	Cropland	-0.443462	4.01E-08	2	1	0.65
Shrubland	Cropland	-0.184002	1.67E-08	2	1	0.65
Artificial grassland	Abandoned land	0.0682083	3.78E-07	1	1	1.13
Shrubland	Abandoned land	-0.77909	2.32E-07	1	1	0.8
Artificial grassland	Cropland	0.6292957	3.26E-07	1	1	1.42
Shrubland	Cropland	-0.218002	6.45E-07	1	1	1
Artificial grassland	Cropland	0.4590746	3.46E-07	1	1	1.55
Shrubland	Cropland	-0.388223	8.35E-07	1	1	1.09
Forest	Abandoned land	1.0162546	2.22E-06	1	1	60
Forest	Abandoned land	1.6176566	8.65E-06	1	1	64
Natural grassland	Abandoned land	0.7810253	1.55E-05	0.27	0.45	72
Shrubland	Abandoned land	0.1692597	9.54E-07	0.27	0.45	72
Forest	Bareland	0.6601898	2.31E-06	1	1	60

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3	Forest	Bareland	1.2615919	3.83E-06	1	1	64
4	Natural grassland	Bareland	0.4249605	5.08E-06	0.27	0.45	72
5	Shrubland	Bareland	-0.186805	9.63E-06	0.27	0.45	72
6							
7	Forest	Bareland	3.149883	0.0002917	0.4	0.4	60
8	Forest	Bareland	3.751285	0.0003882	0.4	0.4	64
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10	Natural grassland	Bareland	2.9146537	0.0008823	0.11	0.18	72
11	Shrubland	Bareland	2.3028881	2.81E-05	0.11	0.18	72
12	Forest	Bareland	-0.54737	1.21E-07	1	1	30
13	Forest	Bareland	0.0540316	2.68E-09	1	1	32
14	Natural grassland	Bareland	-0.7826	2.67E-06	0.27	0.45	36
15	Shrubland	Bareland	-1.394365	8.71E-07	0.27	0.45	36
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17	Forest	Bareland	-0.853475	4.23E-07	1	1	10
18	Forest	Bareland	-0.252073	1.17E-07	1	1	10.67
19	Natural grassland	Bareland	-1.088705	2.51E-07	0.27	0.45	12
20	Shrubland	Bareland	-1.70047	2.64E-06	0.27	0.45	12
21	Forest	Bareland	-0.57208	7.54E-07	1	1	60
22	Forest	Bareland	0.0293225	2.01E-07	1	1	64
23	Natural grassland	Bareland	-0.807309	1.89E-06	0.27	0.45	72
24	Shrubland	Bareland	-1.419074	9.59E-07	0.27	0.45	72
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26	Forest	Cropland	1.8269157	1.35E-05	1	1	30
27	Forest	Cropland	2.4283178	6.40E-06	1	1	32
28	Natural grassland	Cropland	1.5916864	4.85E-06	0.27	0.45	36
29	Shrubland	Cropland	0.9799209	1.32E-05	0.27	0.45	36
30	Forest	Cropland	1.3667464	2.86E-06	1	1	10
31	Forest	Cropland	1.9681485	4.36E-07	1	1	10.67
32	Natural grassland	Cropland	1.1315171	1.52E-05	0.27	0.45	12
33	Shrubland	Cropland	0.5197515	4.51E-06	0.27	0.45	12
34	Forest	Cropland	1.8196781	5.55E-05	1	1	
35	Forest	Cropland	2.4210801	3.71E-06	1	1	
36	Natural grassland	Cropland	1.5844488	3.29E-05	0.27	0.45	
37	Shrubland	Cropland	0.9726832	3.57E-05	0.27	0.45	
38	Forest	Cropland	1.1682547	1.72E-06	1	1	60
39	Forest	Cropland	1.7696568	1.57E-05	1	1	64
40	Natural grassland	Cropland	0.9330254	5.66E-06	0.27	0.45	72
41	Shrubland	Cropland	0.3212598	6.97E-06	0.27	0.45	72
42	Forest	Cropland	-2.736076	0.0460995	1	1	1
43	Forest	Cropland	-1.869043	0.0815114	1	1	1
44	Shrubland	Bareland	-0.104221	0.0471129	1	1	1
45	Shrubland	Bareland	-0.207037	0.1002999	1	1	1
46	Shrubland	Bareland	-1.372083	0.4811442	1	1	1
47	Shrubland	Cropland	-0.70876	0.4811151	1	1	1
48	Shrubland	Cropland	-0.811576	0.5343022	1	1	1
49	Shrubland	Cropland	-1.976622	0.9151464	1	1	1
50	Shrubland	Cropland	-0.507343	0.3167629	1	1	2.4
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Shrubland	Cropland	-0.610159	0.3699499	1	1	2.4
Shrubland	Cropland	-1.775205	0.7507941	1	1	2.4
Shrubland	Cropland	-0.745975	0.5760022	1	1	1.6
Shrubland	Cropland	-0.848792	0.6291892	1	1	1.6
Shrubland	Cropland	-2.013837	1.0100334	1	1	1.6
Shrubland	Cropland	-0.724858	0.5570448	1	1	1.2
Shrubland	Cropland	-0.827675	0.6102319	1	1	1.2
Shrubland	Cropland	-1.992721	0.9910761	1	1	1.2
Shrubland	Cropland	-0.664107	0.5938705	1	1	0.96
Shrubland	Cropland	-0.766923	0.6470576	1	1	0.96
Shrubland	Cropland	-1.931969	1.0279018	1	1	0.96
Shrubland	Cropland	-0.220473	0.3180229	1	1	0.8
Shrubland	Cropland	-0.323289	0.37121	1	1	0.8
Shrubland	Cropland	-1.488335	0.7520542	1	1	0.8
Forest	Abandoned land	1.6899575	0.0967994	40	4	1.36
Forest	Abandoned land	-0.334424	0.0968857	40	4	1
Forest	Abandoned land	-5.884873	4.5418206	40	4	0.84
Forest	Abandoned land	-4.710753	0.1401103	40	4	0.92
Forest	Abandoned land	-5.709024	0.919013	40	4	1.42
Forest	Abandoned land	-7.112894	0.0749613	40	4	1.04
Forest	Abandoned land	-5.569414	0.7346276	40	4	0.88
Forest	Abandoned land	-5.57397	0.9670767	40	4	0.96
Forest	Abandoned land	-5.593789	0.0247343	40	4	1.48
Forest	Abandoned land	-5.720831	0.0258228	40	4	1.09
Forest	Abandoned land	-6.675125	6.5782964	40	4	0.91
Forest	Abandoned land	-5.335351	0.1199661	40	4	1
Forest	Abandoned land	-6.133372	0.2876035	40	4	1.36
Forest	Abandoned land	-6.189829	0.8032135	40	4	1
Forest	Abandoned land	-6.552655	0.181648	40	4	0.84
Forest	Abandoned land	-5.992262	0.0716021	40	4	0.92
Artificial grassland	Bareland	-2.256688	6.90E-07	1	1	1
Artificial grassland	Bareland	-1.068731	4.82E-08	2.07	2.7	9.5
Forest	Bareland	-0.498186	1.61E-08	1	1	1
Forest	Bareland	-1.776225	9.01E-08	1.62	2	9.5
Forest	Bareland	-0.960809	1.21E-08	2.07	2.7	9.5
Artificial grassland	Bareland	-2.471578	7.46E-08	1	1	1
Artificial grassland	Bareland	-1.283621	5.69E-09	2.07	2.7	9.5
Forest	Bareland	-0.713076	1.20E-08	1	1	1
Forest	Bareland	-1.991116	2.29E-07	1.62	2	9.5
Forest	Bareland	-1.1757	6.35E-08	2.07	2.7	9.5
Artificial grassland	Bareland	-1.471357	1.66E-07	0.48	0.37	0.11
Artificial grassland	Bareland	-0.283399	1.29E-08	1	1	1
Forest	Bareland	0.2871454	1.08E-08	0.48	0.37	0.11
Forest	Bareland	-0.990894	1.76E-08	0.78	0.74	1

1							
2							
3	Forest	Bareland	-0.175478	5.99E-08	1	1	1
4	Forest	Cropland	0.0621962	1.34E-05	1	1	1
5	Forest	Cropland	-0.227162	2.92E-06	1	1	1.17
6							
7	Forest	Cropland	-0.282349	4.03E-05	1	1	1.17
8	Natural grassland	Cropland	0.3636028	9.17E-06	1	1	1
9							
10	Shrubland	Cropland	0.329573	1.84E-05	1	1	1
11	Shrubland	Cropland	-1.072226	0.0002122	1	1	1.17
12	Artificial grassland	Cropland	-1.087885	1.59E-07	1	1	1
13	Artificial grassland	Cropland	-0.111859	7.12E-08	1	1	1
14	Forest	Cropland	-1.963763	0.0864447	1	1	1
15	Forest	Cropland	-0.673685	0.0864442	1	1	1
16							
17	Natural grassland	Cropland	0.4223516	0.0864441	1	1	1
18	Shrubland	Cropland	-1.993575	0.0864456	1	1	1
19	Forest	Cropland	-1.674233	0.1223999	1	1	
20	Forest	Cropland	-1.102442	0.1223999	1	1	
21	Forest	Cropland	-0.820065	0.1224002	1	1	
22	Forest	Cropland	-6.648661	0.0285224	1	1	
23	Forest	Cropland	-6.977791	1.506993	1	1	
24	Forest	Cropland	-7.142907	0.4966	1	1	
25	Forest	Cropland	-6.678793	0.4222273	1	1	
26	Forest	Cropland	-6.703354	0.0353852	1	1	
27	Forest	Cropland	-6.63141	0.006179	1	1	
28							
29	Natural grassland	Cropland	-6.749822	1.1140664	1	1	
30	Shrubland	Cropland	-6.88469	0.1292524	1	1	
31	Shrubland	Cropland	-8.072726	1.2654959	1	1	
32	Shrubland	Cropland	-7.056175	2.1360947	1	1	
33	Shrubland	Cropland	-6.80213	0.0882905	1	1	
34	Forest	Abandoned land	-8.690977	0.0171513	1	1	1
35	Forest	Abandoned land	-9.053804	0.097834	1	1	1
36	Shrubland	Abandoned land	-8.49341	0.0346451	1	1	1
37	Natural grassland	Cropland	-0.561087	4.35E-08	1	1	0.8
38	Shrubland	Cropland	-0.77909	7.43E-07	1	1	0.8
39	Natural grassland	Cropland	-0.629296	6.53E-08	1	1	0.71
40	Shrubland	Cropland	-0.847298	1.45E-06	1	1	0.71
41	Artificial grassland	Cropland	-1.310297	1.84E-07			
42	Forest	Cropland	-3.953117	1.25E-06			
43	Natural grassland	Cropland	-2.565288	6.58E-06			
44	Artificial grassland	Abandoned land	-0.314493	4.42E-07	1	1	1
45	Artificial grassland	Abandoned land	-0.847298	2.27E-06	1	1	1
46	Artificial grassland	Abandoned land	-0.965081	1.31E-06	1	1	1
47	Artificial grassland	Abandoned land	-0.405465	5.24E-07	1	1	1
48	Artificial grassland	Abandoned land	-0.904456	5.22E-07	1	1	1
49	Artificial grassland	Abandoned land	-1.225364	6.27E-06	1	1	1
50	Shrubland	Abandoned land	-0.676552	0.1784125	1	1	1
51							
52							
53							
54							
55							
56							
57							
58							
59							
60							

1							
2							
3	Shrubland	Bareland	-1.215596	0.0411253	1	1	1
4	Artificial grassland	Bareland	-0.129799	0.2752135	1	1	1
5	Forest	Bareland	-1.893636	0.2752136	1	1	1
6							
7	Natural grassland	Bareland	0.4089494	0.2752134	1	1	1
8	Shrubland	Bareland	-2.105968	0.2752149	1	1	1
9							
10	Shrubland	Bareland	-2.244119	0.2752145	1	1	1
11	Shrubland	Cropland	-2.044272	0.0801396	1	1	
12	Forest	Abandoned land	-2.018183	0.0510361	1	1	1
13	Shrubland	Abandoned land	-0.505447	0.0876701	1	1	1
14	Forest	Cropland	-2.498343	0.1079629	1	1	1
15	Shrubland	Cropland	-0.985607	0.0838981	1	1	1
16							
17	Artificial grassland	Cropland	1.4387648	0.2229281			
18	Artificial grassland	Cropland	1.3029435	0.1806042			
19	Natural grassland	Cropland	1.1857613	0.1828801			
20							
21	Forest	Bareland	-0.50481	0.0066904	1	1	0.81
22	Forest	Bareland	-0.83798	0.007383	1	1	1
23	Natural grassland	Bareland	-0.219722	0.0059779	1	1	1
24	Shrubland	Bareland	-0.873368	0.0221685	1	1	0.89
25	Shrubland	Bareland	-0.725751	0.0359013	1	1	1.04
26	Forest	Bareland	-1.283066	0.0054832			
27							
28	Forest	Bareland	-1.526522	0.0054842			
29	Forest	Bareland	-2.026685	0.0054829			
30							
31	Natural grassland	Bareland	-0.642287	0.0054844			
32	Shrubland	Bareland	-1.779588	0.0054832			
33	Shrubland	Bareland	-1.737111	0.0054877			

Note: ERT: ecological restoration types; LDT: land degradation types

Table 8. Event soil erosion rate (lnRR) ratio of plot characteristics between ERT and LDT for meta-analysis.

ERT	LDT	lnRR	VlnRR	Ratio of area	Ratio of slope length	Ratio of slope steepness
Artificial grassland	Cropland	-3.2153409	0.3101495	1	1	1
Natural grassland	Cropland	-3.5962433	0.52100589	1	1	1
Shrubland	Cropland	-4.8446014	0.63953667	1	1	1
Shrubland	Cropland	-5.3911451	0.7723778	1	1	1
Forest	Cropland	-1.6215239	0.77313976	1	1	1
Shrubland	Cropland	-11.010419	0.42477748	1	1	1
Shrubland	Bareland	-7.7160574	13949.9502	1	1	1
Shrubland	Bareland	-7.9451239	11770.0663	1	1	1
Forest	Bareland	-8.4770732	64266665.4	1	1	1
Shrubland	Bareland	-8.4548501	0.6715282	1	1	1
Shrubland	Cropland	-10.799052	591695.823	1	1	2.4
Shrubland	Cropland	-8.8410059	6289.85888	1	1	2.4
Forest	Cropland	-9.1234744	20850944.7	1	1	2.4
Shrubland	Cropland	-9.1234744	0.5948997	1	1	2.4
Shrubland	Cropland	-9.6382396	24670.0704	1	1	1.6
Shrubland	Cropland	-10.111389	33914.0539	1	1	1.6
Forest	Cropland	-9.2509728	11434071.1	1	1	1.6
Shrubland	Cropland	-9.3336849	0.62659388	1	1	1.6
Shrubland	Cropland	-9.667623	10226.2921	1	1	1.2
Shrubland	Cropland	-10.224434	16618.2815	1	1	1.2
Forest	Cropland	-1.0809876	1.02705812	1	1	1.2
Shrubland	Cropland	-11.54619	4.54387312	1	1	1.2
Shrubland	Cropland	-10.145654	22202.9646	1	1	0.96
Shrubland	Cropland	-11.697198	263809.424	1	1	0.96
Forest	Cropland	-9.8217968	11681882.6	1	1	0.96
Shrubland	Cropland	-10.542875	1.06147178	1	1	0.96
Shrubland	Cropland	-9.8068414	14438.7764	1	1	0.8
Shrubland	Cropland	-10.21498	17428.9157	1	1	0.8
Forest	Cropland	-11.083246	186463224	1	1	0.8
Shrubland	Cropland	-9.6945623	0.84760294	1	1	0.8
Shrubland	Abandoned land	-7.0854341	0.71235982	1	1	1
Natural grassland	Abandoned land	-5.811469	10203.7581	1	1	1
Artificial grassland	Abandoned land	-6.0829657	66192.3136	1	1	1
Forest	Abandoned land	-2.1517399	1.5911257	1	1	1
Shrubland	Abandoned land	-3.0680006	1.59103107	1	1	1
Forest	Abandoned land	-0.9279786	0.84372593	1	1	1
Shrubland	Abandoned land	-0.4653609	1.59113747	1	1	1
Forest	Abandoned land	0.6332514	0.8604502	1	1	1
Forest	Abandoned land	-5.2187734	0.72062712	1	1	1

1							
2							
3	Shrubland	Cropland	-9.2991232	0.94392225	1	1	1
4	Natural grassland	Cropland	-8.6626795	1967.77405	1	1	1
5	Artificial grassland	Cropland	-8.9918092	14322.021	1	1	1
6							
7	Forest	Cropland	-9.1569254	782.543167	1	1	1
8	Shrubland	Cropland	-8.6928116	49.9738836	1	1	1
9							
10	Forest	Cropland	-8.7173724	948.501589	1	1	1
11	Shrubland	Cropland	-8.6454289	8198.6468	1	1	1
12	Forest	Cropland	-8.7638409	25181.4542	1	1	1
13	Forest	Cropland	-8.8257404	0.53371799	1	1	1
14							
15	Forest	Abandoned land	-8.3449513	57.69538	0.94	0.63	
16	Shrubland	Abandoned land	-9.3241235	291.370589	0.94	0.63	
17	Natural grassland	Abandoned land	-8.5198378	286.979844	0.94	0.63	
18	Natural grassland	Abandoned land	-9.6922163	439.361224	0.94	0.63	
19	Natural grassland	Abandoned land	-4.052251	0.35957775	0.94	0.63	
20	Natural grassland	Abandoned land	-3.9270902	0.34660916	0.94	0.63	
21							
22	Forest	Bareland	-6.9728074	0.12028122	0.94	0.63	
23	Shrubland	Bareland	-6.8186584	0.11505675	0.94	0.63	
24	Natural grassland	Bareland	-6.3666737	0.12081173	0.94	0.63	
25	Natural grassland	Bareland	-7.0063745	0.11535632	0.94	0.63	
26	Natural grassland	Bareland	-6.9585797	0.12261143	0.94	0.63	
27	Natural grassland	Bareland	-6.8334189	0.10964285	0.94	0.63	
28							
29	Forest	Cropland	-7.8878351	0.64063716	0.94	0.63	
30	Shrubland	Cropland	-7.733686	0.63541269	0.94	0.63	
31	Natural grassland	Cropland	-7.2817013	0.64116767	0.94	0.63	
32	Natural grassland	Cropland	-7.9214021	0.63571225	0.94	0.63	
33							
34	Natural grassland	Cropland	-7.8736074	0.64296737	0.94	0.63	
35	Natural grassland	Cropland	-7.7484465	0.62999878	0.94	0.63	
36							
37	Forest	Abandoned land	-2.4952181	0.18798327	0.94	0.63	
38	Shrubland	Abandoned land	-2.3410691	0.1827588	0.94	0.63	
39	Natural grassland	Abandoned land	-1.8890844	0.18851378	0.94	0.63	
40	Natural grassland	Abandoned land	-2.5287852	0.18305837	0.94	0.63	
41	Natural grassland	Abandoned land	-2.4809904	0.19031348	0.94	0.63	
42	Natural grassland	Abandoned land	-2.3558296	0.1773449	0.94	0.63	
43							
44	Forest	Abandoned land	0.5110746	0.36411605	0.56	0.56	0.9
45	Shrubland	Abandoned land	0.8193191	0.35725412	0.56	0.56	0.9
46	Natural grassland	Abandoned land	0.9177266	0.35783284	0.56	0.56	0.9
47							
48	Forest	Cropland	-3.3102818	0.64750567	0.56	0.56	0.9
49	Shrubland	Cropland	-3.0020372	0.64064374	0.56	0.56	0.9
50	Natural grassland	Cropland	-2.9036297	0.64122246	0.56	0.56	0.9
51							
52	Forest	Abandoned land	2.0823351	0.19485179	0.56	0.56	0.9
53	Shrubland	Abandoned land	2.3905797	0.18798985	0.56	0.56	0.9
54	Natural grassland	Abandoned land	2.4889872	0.18856857	0.56	0.56	0.9
55							
56	Forest	Bareland	-2.3952542	0.12714974	0.56	0.56	0.9
57	Shrubland	Bareland	-2.0870096	0.1202878	0.56	0.56	0.9
58							
59							
60							

1							
2							
3	Natural grassland	Bareland	-1.9886021	0.12086652	0.56	0.56	0.9
4	Shrubland	Abandoned land	-0.8607975	0.50366105	1	1	1
5	Shrubland	Bareland	-3.7671263	0.26669474	1	1	1
6	Shrubland	Cropland	-4.9507842	1.01736962	1	1	1
7	Forest	Cropland	-5.6439314	0.75886485	1	1	1
8	Shrubland	Abandoned land	0.4418328	0.56471573	1	1	1
9	Forest	Abandoned land	-0.2513144	0.30621097	1	1	1
10	Forest	Cropland	-4.0699828	5.06E-09	0.2		1.55
11	Artificial grassland	Cropland	-1.245086	1.12E-10	0.1		1.5
12	Natural grassland	Cropland	-2.0301231	1.05E-09	0.39		1.85
13	Artificial grassland	Bareland	-2.5356292	0.3281973	1	1	1
14	Artificial grassland	Bareland	-2.0645269	0.34530288	1	1	1
15	Forest	Bareland	-0.3173913	1.04670441	1	1	1
16	Artificial grassland	Bareland	-1.3005193	0.81141653	1	1	1
17	Forest	Bareland	1.3425324	0.78410338	1.62	2	9.75
18	Artificial grassland	Bareland	2.643052	1.22034425	2.07	2.7	9.75
19	Forest	Bareland	2.489665	1.04233881	2.07	2.7	9.75
20	Forest	Bareland	-0.6434919	0.92395175	1	1	1
21	Artificial grassland	Bareland	-1.6266199	0.68866387	1	1	1
22	Forest	Bareland	1.0164319	0.66135071	1.62	2	9.75
23	Artificial grassland	Bareland	2.3169515	1.09759158	2.07	2.7	9.75
24	Forest	Bareland	2.1635645	0.91958614	2.07	2.7	9.75
25	Forest	Bareland	-3.0368525	1.29061774	0.48	0.37	0.1
26	Artificial grassland	Bareland	-4.0199805	1.05532986	0.48	0.37	0.1
27	Forest	Bareland	-1.3769288	1.0280167	0.78	0.74	1
28	Artificial grassland	Bareland	-0.0764092	1.46425757	1	1	1
29	Forest	Bareland	-0.2297962	1.28625213	1	1	1
30	Forest	Bareland	-3.0368525	1.29061774	0.48	0.37	0.1
31	Shrubland	Abandoned land	-1.1437327	4.11E-08	1	1	
32	Natural grassland	Abandoned land	0.0683799	6.18E-09	1	1	
33	Shrubland	Cropland	-7.3891634	1.36E-08	1	1	
34	Natural grassland	Cropland	-6.1770507	5.10E-09	1	1	
35	Shrubland	Cropland	-2.8024859	9.99E-09	1	1	
36	Natural grassland	Cropland	-1.5903732	7.23E-09	1	1	

Note: ERT: ecological restoration types; LDT: land degradation types

Table 9. Annual soil erosion rate (lnRR) ratio of plot characteristics between ERT and LDT for meta-analysis.

ERT	LDT	lnRR	VlnRR	Ratio of area	Ratio of slope length	Ratio of slope steepness
Artificial grassland	Bareland	-0.56132	7.83E-14	1	1	1
Artificial grassland	Bareland	-3.483967	1.25E-11	1	1	1
Artificial grassland	Bareland	-0.351479	1.41E-13	1	1	1
Artificial grassland	Bareland	-0.314616	1.95E-14	1	1	1
Artificial grassland	Bareland	-0.324167	9.10E-14	1	1	1
Artificial grassland	Bareland	-2.344414	1.20E-11	1	1	1
Artificial grassland	Bareland	-1.574848	1.00E-13	1	1	1
Artificial grassland	Cropland	-3.215909	5.43E-10	1	1	1
Natural grassland	Cropland	-2.596825	3.69E-10	1	1	1
Forest	Abandoned land	0.7595254	1.12E-09	1.8	1.8	0.76
Natural grassland	Abandoned land	1.2087262	1.06E-09	1.8	1.8	0.76
Shrubland	Abandoned land	1.1903665	2.69E-12	1.8	1.8	0.76
Forest	Abandoned land	1.5489517	1.69E-09	1.8	1.8	0.79
Natural grassland	Abandoned land	1.9981525	3.96E-10	1.8	1.8	0.79
Shrubland	Abandoned land	1.9797928	8.82E-10	1.8	1.8	0.79
Forest	Abandoned land	1.8950444	3.89E-11	1.8	1.8	0.83
Natural grassland	Abandoned land	2.3442451	1.14E-08	1.8	1.8	0.83
Shrubland	Abandoned land	2.3258854	2.85E-10	1.8	1.8	0.83
Forest	Abandoned land	2.4033663	1.12E-08	1.8	1.8	0.76
Natural grassland	Abandoned land	2.8525671	0.037812	1.8	1.8	0.76
Shrubland	Abandoned land	2.8342074	0.037812	1.8	1.8	0.76
Artificial grassland	Cropland	-0.865199	0.0665285	1	1	1
Forest	Cropland	-2.591463	0.0665285	1	1	1
Natural grassland	Cropland	-2.974455	0.0665285	1	1	1
Shrubland	Cropland	-1.453752	0.0665285	1	1	1
Forest	Cropland	-1.930974	0.1726457	1	1	1
Forest	Cropland	-1.94045	0.1726457	1	1	1
Shrubland	Bareland	-2.149311	0.9277359	1	1	1
Shrubland	Bareland	-2.695855	0.9277369	1	1	1
Shrubland	Bareland	-4.577782	0.9277935	1	1	1
Shrubland	Cropland	-7.476017	0.980223	1	1	1
Shrubland	Cropland	-7.258368	0.9802231	1	1	1
Shrubland	Cropland	-8.28208	0.9806724	1	1	1
Shrubland	Cropland	-6.665714	0.6925706	1	1	2.4
Shrubland	Cropland	-5.874509	0.6925336	1	1	2.4
Shrubland	Cropland	-6.110201	0.692627	1	1	2.4
Shrubland	Cropland	-8.242234	0.8686787	1	1	1.6
Shrubland	Cropland	-8.151131	0.8686548	1	1	1.6
Shrubland	Cropland	-7.196772	0.8686442	1	1	1.6

1							
2							
3	Shrubland	Cropland	-6.642609	0.9357582	1	1	1.2
4	Shrubland	Cropland	-6.7139	0.93576	1	1	1.2
5	Shrubland	Cropland	-7.649717	0.935835	1	1	1.2
6							
7	Shrubland	Cropland	-7.409081	0.9538069	1	1	0.96
8	Shrubland	Cropland	-6.897239	0.9537997	1	1	0.96
9							
10	Shrubland	Cropland	-7.84943	0.9537989	1	1	0.96
11	Shrubland	Cropland	-7.200605	0.8686879	1	1	0.8
12	Shrubland	Cropland	-6.547185	0.8686654	1	1	0.8
13	Shrubland	Cropland	-7.081528	0.8687784	1	1	0.8
14	Artificial grassland	Bareland	-8.590929	0.0001489	1	1	1
15	Artificial grassland	Bareland	-7.570384	1.56E-05	2.07	2.7	9.5
16	Forest	Bareland	-7.969248	2.00E-07	1	1	1
17							
18	Forest	Bareland	-8.687949	2.20E-06	1.62	2	9.5
19	Forest	Bareland	-7.927541	7.39E-05	2.07	2.7	9.5
20							
21	Artificial grassland	Bareland	-8.005592	3.42E-05	1	1	1
22	Artificial grassland	Bareland	-8.596713	6.20E-06	2.07	2.7	9.5
23	Forest	Bareland	-10.00681	0.0022607	1	1	1
24	Forest	Bareland	-7.946349	2.21E-05	1.62	2	9.5
25	Forest	Bareland	-8.015412	0.0001209	2.07	2.7	9.5
26							
27	Artificial grassland	Bareland	-10.77242	0.0002582	0.48	0.37	0.11
28	Artificial grassland	Bareland	-11.64608	0.0005278	1	1	1
29	Forest	Bareland	-10.44653	5.73E-05	0.48	0.37	0.11
30	Forest	Bareland	-10.51059	5.79E-05	0.78	0.74	1
31	Forest	Bareland	-10.82023	0.000103	1	1	1
32							
33	Forest	Abandoned land	-10.62486	0.0001471	0.87	0.87	1
34	Forest	Abandoned land	-10.0478	0.00035	0.36	0.41	2.17
35	Forest	Abandoned land	-10.22059	5.38E-06	1.23	1.37	1.28
36	Forest	Abandoned land	-9.464552	8.83E-06	1.03	1.08	1
37	Forest	Abandoned land	-9.898716	0.0001375	0.42	0.51	2.17
38	Forest	Abandoned land	-9.387918	3.61E-06	1.46	1.7	1.28
39	Forest	Abandoned land	-10.42442	0.0001439	4.08	2.1	0.46
40	Forest	Abandoned land	-10.51304	4.07E-05	1.67	1	1
41	Forest	Abandoned land	-10.2465	5.14E-05	5.78	3.32	0.59
42	Forest	Abandoned land	-11.32265	5.08E-05	3.93	2.26	0.46
43	Forest	Abandoned land	-10.21757	1.12E-06	1.6	1.07	1
44	Forest	Abandoned land	-10.06867	0.0001186	5.56	3.57	0.59
45	Forest	Abandoned land	-11.97829	0.007085	0.6	0.61	0.78
46	Forest	Abandoned land	-11.25112	0.0015054	0.24	0.29	1.7
47	Forest	Abandoned land	-11.01226	0.0013002	0.85	0.96	1
48	Forest	Cropland	-7.686742	2.55E-05	1	1	1
49	Forest	Cropland	-7.112123	1.40E-05	1	1	1.17
50	Forest	Cropland	-7.80199	0.0001536	1	1	1.17
51	Natural grassland	Cropland	-8.244545	0.0004044	1	1	1
52	Shrubland	Cropland	-7.415381	2.44E-06	1	1	1
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3	Shrubland	Cropland	-7.37112	6.39E-05	1	1	1.17
4	Artificial grassland	Cropland	-8.660424	3.90E-11	1	1	1
5	Artificial grassland	Cropland	-8.787113	7.87E-05	1	1	1
6							
7	Forest	Cropland	-9.090594	7.73E-06	1	1	1
8	Forest	Cropland	-8.137208	6.79E-08	1	1	1
9							
10	Natural grassland	Cropland	-8.355333	5.33E-06	1	1	1
11	Shrubland	Cropland	-9.643734	8.43E-05	1	1	1
12	Forest	Cropland	-8.684158	0.1660635			
13	Forest	Cropland	-8.133491	0.1660218			
14	Forest	Cropland	-7.868563	0.1660216			
15	Forest	Cropland	-6.909631	3.33E-06			
16	Forest	Cropland	-9.871874	0.0335344			
17	Forest	Cropland	-8.38711	1.51E-05			
18	Forest	Cropland	-7.816815	1.57E-07			
19	Forest	Cropland	-7.49374	5.75E-05			
20	Forest	Cropland	-7.261567	1.11E-05			
21							
22	Natural grassland	Cropland	-7.197746	1.26E-05			
23	Shrubland	Cropland	-9.233337	5.56E-05			
24	Shrubland	Cropland	-8.69069	9.84E-06			
25	Shrubland	Cropland	-7.54392	8.00E-05			
26	Shrubland	Cropland	-7.080023	8.87E-05			
27							
28	Natural grassland	Cropland	-12.31022	8.11E-06	1	1	0.8
29	Shrubland	Cropland	-15.54097	0.0083735	1	1	0.8
30	Natural grassland	Cropland	-2.28352	7.56E-10	1	1	0.71
31	Shrubland	Cropland	-3.090168	6.62E-10	1	1	0.71
32	Artificial grassland	Cropland	-0.592178	3.01E-10			
33	Forest	Cropland	-3.645729	6.16E-07			
34	Natural grassland	Cropland	-2.9888	1.02E-07			
35	Artificial grassland	Abandoned land	-1.118613	4.82E-08	1	1	1
36	Artificial grassland	Abandoned land	-1.670682	3.64E-09	1	1	1
37	Artificial grassland	Abandoned land	-1.90707	3.57E-07	1	1	1
38	Artificial grassland	Abandoned land	-1.247825	3.80E-08	1	1	1
39	Artificial grassland	Abandoned land	-1.842532	1.27E-08	1	1	1
40	Artificial grassland	Abandoned land	-2.217225	6.67E-08	1	1	1
41	Shrubland	Abandoned land	2.9063314	2.29E-10	1	1	1
42	Shrubland	Bareland	3.7671325	2.19E-09	1	1	1
43	Artificial grassland	Bareland	0.362015	2.56E-10	1	1	1
44	Forest	Bareland	-3.008943	1.16E-07	1	1	1
45	Natural grassland	Bareland	0.9032223	3.21E-10	1	1	1
46	Shrubland	Bareland	-2.624984	1.57E-07	1	1	1
47	Shrubland	Bareland	-3.01606	6.20E-07	1	1	1
48	Shrubland	Cropland	-4.611318	1.93E-11	1	1	
49	Forest	Abandoned land	-1.504077	5.28E-08	1	1	1
50	Shrubland	Abandoned land	-0.649662	2.64E-09	1	1	1
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Forest	Cropland	-4.808723	1.28E-12	1	1	1
Shrubland	Cropland	-3.954308	3.24E-09	1	1	1
Artificial grassland	Cropland	1.1332138	9.68E-10			
Artificial grassland	Cropland	0.7885825	1.68E-10			
Natural grassland	Cropland	0.5125991	4.44E-10			
Artificial grassland	Abandoned land	0.6455191	3.29E-06	1	1	1
Forest	Abandoned land	-2.151762	0.0003396	1	1	1
Forest	Abandoned land	-0.927987	7.84E-06	1	1	1
Forest	Abandoned land	0.633249	2.42E-06	1	1	1
Forest	Abandoned land	-7.762054	28.561139	1	1	1
Natural grassland	Abandoned land	-2.10526	5.82E-06	1	1	1
Shrubland	Abandoned land	-3.33639	0.0038386	1	1	1
Shrubland	Abandoned land	-2.724215	0.0002187	1	1	1
Shrubland	Abandoned land	-2.972425	9.80E-05	1	1	1
Artificial grassland	Cropland	-5.277844	5.35E-06	1	1	1
Forest	Cropland	-5.942939	0.0004418	1	1	1
Forest	Cropland	-5.786049	4.18E-07	1	1	1
Forest	Cropland	-5.889622	0.0003639	1	1	1
Forest	Cropland	-7.399588	0.0084892	1	1	1
Natural grassland	Cropland	-7.877049	0.000132	1	1	1
Shrubland	Cropland	-6.588154	1.29E-05	1	1	1
Shrubland	Cropland	-5.431299	0.0001145	1	1	1
Shrubland	Cropland	-6.996022	0.0002554	1	1	1

Note: ERT: ecological restoration types; LDT: land degradation types

Appendix 3. Spatial variability of effect size**Table 10.** Regression analysis of annual and event runoff (lnRR) and soil erosion rate (lnRR) along longitude, latitude, MAT and MAP according to ecological restoration types.

Ecological resoration types	Response variables	Dependent variables		Estimate	Standard error	t value	p value	Sig.
Overall	Annual runoff depth (lnRR)	Longitude	Intercept	12.91297	9.78424	1.32	0.188	
			Slope	-0.1286	0.08948	-1.437	0.152	
		Latitude	Intercept	9.9388	5.0451	1.97	0.0503	.
			Slope	-0.302	0.1374	-2.199	0.0291	*
		MAT	Intercept	-0.38564	1.79393	-0.215	0.83	
			Slope	-0.08239	0.19912	-0.414	0.679	
	MAP	Intercept	0.48419	1.83786	0.263	0.792		
		Slope	-0.0032	0.00359	-0.892	0.374		
	Annual soil erosion rate (lnRR)	Longitude	Intercept	30.906	18.3815	1.681	0.0948	.
			Slope	-0.3298	0.1676	-1.968	0.051	.
		Latitude	Intercept	8.2671	9.7753	0.846	0.399	
			Slope	-0.3657	0.2642	-1.384	0.168	
		MAT	Intercept	-8.6028	3.2798	-2.623	0.00965	**
			Slope	0.3764	0.3735	1.008	0.31522	
	MAP	Intercept	-2.70667	3.17816	-0.852	0.396		
		Slope	-0.00504	0.00625	-0.807	0.421		
	Event runoff depth (lnRR)	Longitude	Intercept	-4.79133	10.07266	-0.476	0.635	
			Slope	0.03339	0.09146	0.365	0.716	
Latitude		Intercept	-0.01025	3.79365	-0.003	0.998		
		Slope	-0.02985	0.10254	-0.291	0.771		
MAT		Intercept	4.8552	1.9756	2.458	0.0151	*	
		Slope	-0.6412	0.2118	-3.027	0.0029	**	

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		MAP	Intercept	0.52744	1.29787	0.406	0.685	
			Slope	-0.00324	0.00255	-1.27	0.206	
	Event soil erosion rate (lnRR)	Longitude	Intercept	-88.6679	31.9726	-2.773	0.00682	**
			Slope	0.7725	0.2895	2.669	0.00912	**
		Latitude	Intercept	-50.1103	11.2164	-4.468	2.42E-05	***
			Slope	1.2494	0.2995	4.171	7.28E-05	***
		MAT	Intercept	-17.7985	6.8092	-2.614	0.0106	*
			Slope	1.5396	0.7245	2.125	0.0365	*
		MAP	Intercept	3.24414	4.05361	0.8	0.426	
			Slope	-0.01327	0.00812	-1.634	0.106	
	Annual runoff depth (lnRR)	Longitude	Intercept	6.26347	5.48404	1.142	0.263	
			Slope	-0.06282	0.0501	-1.254	0.22	
		Latitude	Intercept	4.6185	3.632	1.272	0.214	
			Slope	-0.13959	0.09687	-1.441	0.161	
		MAT	Intercept	-0.59191	1.06151	-0.558	0.582	
			Slope	0.000632	0.12543	0.005	0.996	
		MAP	Intercept	-2.18164	1.70548	-1.279	0.211	
			Slope	0.00339	0.00366	0.925	0.363	
Artificial grassland	Annual soil erosion rate (lnRR)	Longitude	Intercept	4.98283	24.84942	0.201	0.843	
			Slope	-0.06824	0.22578	-0.302	0.766	
		Latitude	Intercept	-18.0669	17.3718	-1.04	0.312	
			Slope	0.4184	0.4675	0.895	0.383	
		MAT	Intercept	2.211	4.2224	0.524	0.607	
			Slope	-0.5651	0.4993	-1.132	0.273	
		MAP	Intercept	-0.000303	6.96711	0	1	
			Slope	-0.00522	0.01435	-0.364	0.72	

	Event runoff depth (lnRR)	Longitude	Intercept	109.6715	37.5569	2.92	0.00914	**
			Slope	-1.0097	0.3439	-2.936	0.00883	**
		Latitude	Intercept	25.3753	12.6314	2.009	0.0598	.
			Slope	-0.7085	0.3446	-2.056	0.0546	.
		MAT	Intercept	2.0317	5.0863	0.399	0.694	
			Slope	-0.2837	0.5493	-0.517	0.612	
		MAP	Intercept	-3.68811	5.7411	-0.642	0.529	
			Slope	0.00594	0.011	0.54	0.596	
	Event soil erosion rate (lnRR)	Longitude	Intercept	621.513	141.841	4.382	0.00137	**
			Slope	-5.685	1.292	-4.399	0.00134	**
		Latitude	Intercept	144.548	437.381	0.33	0.748	
			Slope	-4.007	11.92	-0.336	0.744	
		MAT	Intercept	-58.402	16.212	-3.602	0.00483	**
			Slope	5.884	1.704	3.453	0.0062	**
		MAP	Intercept	-51.19154	16.95633	-3.019	0.0129	*
			Slope	0.09158	0.03185	2.876	0.0165	*
	Annual runoff depth (lnRR)	Longitude	Intercept	26.0205	21.3445	1.219	0.227	
			Slope	-0.2551	0.1954	-1.305	0.196	
		Latitude	Intercept	15.2336	9.8264	1.55	0.1252	
			Slope	-0.4665	0.2684	-1.738	0.0862	.
		MAT	Intercept	2.5044	4.3935	0.57	0.57	
			Slope	-0.467	0.4741	-0.985	0.328	
		MAP	Intercept	0.09011	4.04416	0.022	0.982	
			Slope	-0.00366	0.00766	-0.478	0.634	
	Annual soil erosion rate (lnRR)	Longitude	Intercept	47.073	26.7432	1.76	0.083	.
			Slope	-0.4783	0.2441	-1.959	0.0543	.

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		Latitude	Intercept	13.3732	13.4953	0.991	0.325	
			Slope	-0.5059	0.365	-1.386	0.17	
		MAT	Intercept	-9.8034	4.6835	-2.093	0.0404	*
			Slope	0.4998	0.534	0.936	0.3529	
		MAP	Intercept	-7.57522	4.88879	-1.55	0.126	
			Slope	0.00452	0.00972	0.465	0.643	
	Event runoff depth (lnRR)	Longitude	Intercept	-31.7922	18.9633	-1.677	0.0984	.
			Slope	0.2752	0.1721	1.599	0.1146	
		Latitude	Intercept	-8.2544	7.4451	-1.109	0.272	
			Slope	0.1838	0.2017	0.911	0.366	
		MAT	Intercept	5.6444	3.4679	1.628	0.1084	
			Slope	-0.768	0.3735	-2.056	0.0437	*
		MAP	Intercept	2.25431	2.33908	0.964	0.339	
			Slope	-0.00733	0.00458	-1.6	0.114	
	Event soil erosion rate (lnRR)	Longitude	Intercept	-151.4454	44.2031	-3.426	0.00197	**
			Slope	1.3413	0.3996	3.356	0.00236	**
		Latitude	Intercept	-61.3422	16.3608	-3.749	8.56E-04	***
			Slope	1.5468	0.4342	3.562	0.00139	**
		MAT	Intercept	-18.482	12.587	-1.468	0.154	
			Slope	1.639	1.338	1.224	0.231	
		MAP	Intercept	12.7951	6.21155	2.06	0.0492	*
			Slope	-0.03252	0.01265	-2.571	0.016	*
	Annual runoff depth (lnRR)	Longitude	Intercept	-6.59983	26.34747	-0.25	0.804	
			Slope	0.06271	0.24235	0.259	0.798	
	Natural grassland	Latitude	Intercept	6.2491	11.4672	0.545	0.591	
			Slope	-0.1662	0.3157	-0.526	0.603	

		MAT	Intercept	-6.3433	4.0336	-1.573	0.129	
			Slope	0.7393	0.445	1.662	0.11	
		MAP	Intercept	-2.1549	4.80311	-0.449	0.658	
			Slope	0.00452	0.00911	0.496	0.625	
	Annual soil erosion rate (lnRR)	Longitude	Intercept	82.1005	61.9098	1.326	0.203	
			Slope	-0.7901	0.5625	-1.405	0.179	
		Latitude	Intercept	15.4878	29.8888	0.518	0.611	
			Slope	-0.5484	0.8054	-0.681	0.506	
		MAT	Intercept	-20.424	11.165	-1.829	0.0861	
			Slope	1.743	1.243	1.403	0.1799	
		MAP	Intercept	-20.82733	11.41619	-1.824	0.0868	
			Slope	0.03241	0.02303	1.407	0.1786	
	Event runoff depth (lnRR)	Longitude	Intercept	-5.26249	32.6057	-0.161	0.874	
			Slope	0.03845	0.29634	0.13	0.898	
		Latitude	Intercept	-3.0617	11.3565	-0.27	0.791	
			Slope	0.0551	0.3082	0.179	0.86	
		MAT	Intercept	10.1252	4.1316	2.451	0.0254	*
			Slope	-1.2197	0.4509	-2.705	0.015	*
		MAP	Intercept	4.58319	3.32076	1.38	0.185	
			Slope	-0.01123	0.00662	-1.697	0.108	
	Event soil erosion rate (lnRR)	Longitude	Intercept	-124.8552	47.0829	-2.652	0.019	*
			Slope	1.1094	0.4256	2.607	0.0207	*
		Latitude	Intercept	-53.4483	16.6717	-3.206	0.00635	**
			Slope	1.359	0.4412	3.08	0.00815	**
		MAT	Intercept	-7.1224	12.461	-0.572	0.577	
			Slope	0.5343	1.3305	0.402	0.694	

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		MAP	Intercept	12.6505	6.54138	1.934	0.0736	.
			Slope	-0.03045	0.01342	-2.269	0.0396	*
	Annual runoff depth (lnRR)	Longitude	Intercept	6.72346	17.64236	0.381	0.704	
			Slope	-0.07132	0.16082	-0.443	0.659	
		Latitude	Intercept	12.8984	9.5346	1.353	0.181	
			Slope	-0.3819	0.26	-1.469	0.147	
		MAT	Intercept	-4.2511	3.0463	-1.395	0.168	
			Slope	0.3555	0.3421	1.039	0.303	
		MAP	Intercept	0.10452	2.9235	0.036	0.972	
			Slope	-0.00238	0.00576	-0.414	0.68	
	Annual soil erosion rate (lnRR)	Longitude	Intercept	17.7187	41.0303	0.432	0.668	
			Slope	-0.2218	0.3746	-0.592	0.557	
		Latitude	Intercept	15.7201	21.2035	0.741	0.463	
			Slope	-0.604	0.5741	-1.052	0.299	
		MAT	Intercept	-21.1393	8.0838	-2.615	0.0123	*
			Slope	1.6473	0.9125	1.805	0.0782	.
		MAP	Intercept	0.29581	5.39913	0.055	0.957	
			Slope	-0.01296	0.01013	-1.28	0.208	
	Event runoff depth (lnRR)	Longitude	Intercept	1.63947	12.75421	0.129	0.898	
			Slope	-0.02257	0.11544	-0.196	0.846	
		Latitude	Intercept	4.4392	4.5494	0.976	0.334	
			Slope	-0.142	0.1219	-1.165	0.25	
		MAT	Intercept	4.6024	3.0394	1.514	0.1368	
			Slope	-0.5769	0.3207	-1.799	0.0787	
		MAP	Intercept	-1.27206	1.63238	-0.779	0.44	

		Slope	0.0008316	0.00323	0.258	0.798
Event soil erosion rate	Longitude	Intercept	-54.3258	60.7169	-0.895	0.379
(lnRR)		Slope	0.4502	0.5496	0.819	0.42
	Latitude	Intercept	-40.7148	21.374	-1.905	0.0671
		Slope	0.968	0.5726	1.691	0.102
	MAT	Intercept	-7.1976	11.3521	-0.634	0.531
		Slope	0.2787	1.2124	0.23	0.82
	MAP	Intercept	-2.984	7.23123	-0.413	0.683
		Slope	-0.00323	0.01449	-0.223	0.825

Note: Significant level as follows: 0.001-‘***’, 0.01-‘**’, 0.05-‘*’, 0.1-‘.’, 1-‘ ’. MAT: mean annual temperature. MAP: mean annual precipitation.

Appendix 4. Fit statistic of the optimal model and model reliability in meta-analysis

1. Fit statistics and model choice

The fit statistic variables of the optimal model as follows.

Table 11. Fit statistic variable of optimal mixed-effect model regarding of the topological context and ecological restoration types.

Statistic variable	Annual runoff		Annual soil erosion rate		Event runoff		Event soil erosion rate	
	Overall	Individual	Overall	Individual	Overall	Individual	Overall	Individual
LogLik:	-335.55	-334.316	-352.64	-342.285	-149.29	-143.412	-134.98	-126.696
Deviance:	2001.90	1999.42	705.285	684.570	298.591	286.823	269.971	253.391
AIC:	681.111	684.631	715.285	700.570	308.591	302.823	279.971	269.391
BIC:	696.761	709.670	729.545	723.196	322.228	324.427	290.765	286.278
AICc:	681.479	685.531	715.776	701.811	309.151	304.249	281.005	272.160

Note: LogLik, BIC, AIC and AICc refer to Log-likelihood, Bayesian information criterion, Akaike information criterion and the sample-size corrected Akaike Information Criterion, respectively.

2. Model reliability

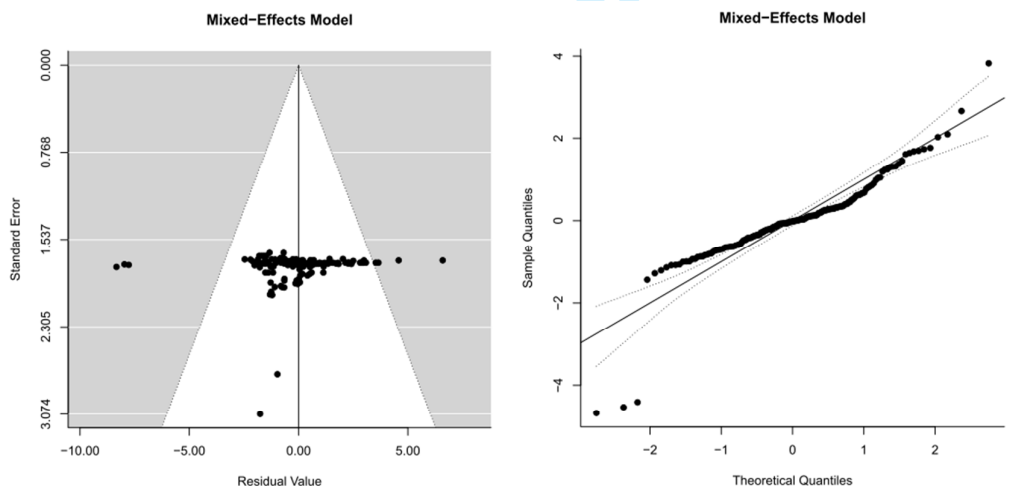


Figure 7. The funnel and Q-Q plot between standard error and overall effect model residual in the annual runoff. A pseudo confidence interval region is drawn around this value with bounds equal to ± 1.96 SE, where SE is the standard error value from the y-axis (assuming level=95%).

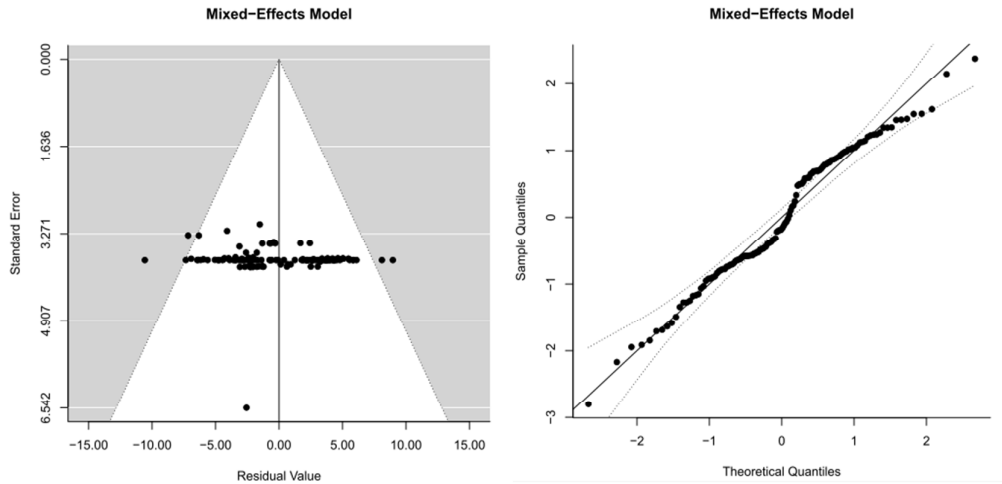


Figure 8. The funnel and Q-Q plot between standard error and overall effect model residual in the annual soil erosion rate. A pseudo confidence interval region is drawn around this value with bounds equal to ± 1.96 SE, where SE is the standard error value from the y-axis (assuming level=95%).

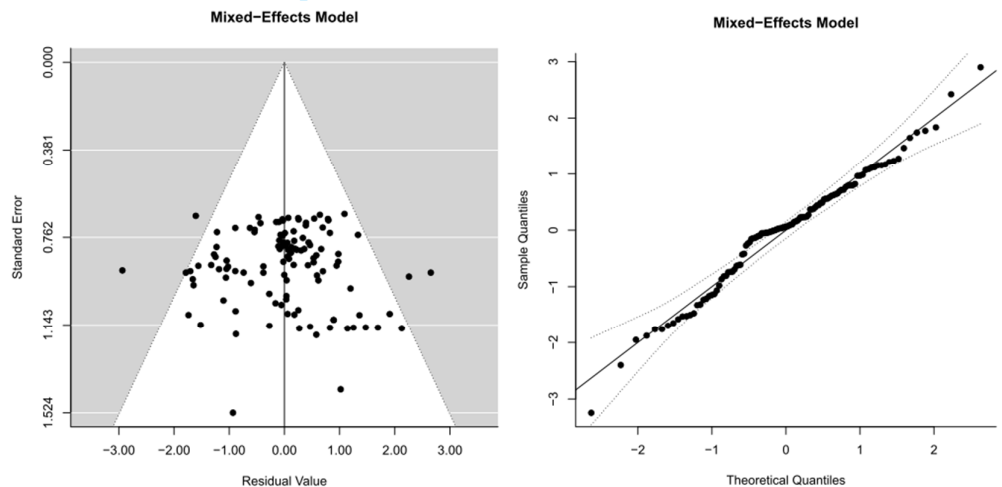


Figure 9. The funnel and Q-Q plot between standard error and overall effect model residual in the event runoff. A pseudo confidence interval region is drawn around this value with bounds equal to ± 1.96 SE, where SE is the standard error value from the y-axis (assuming level=95%).

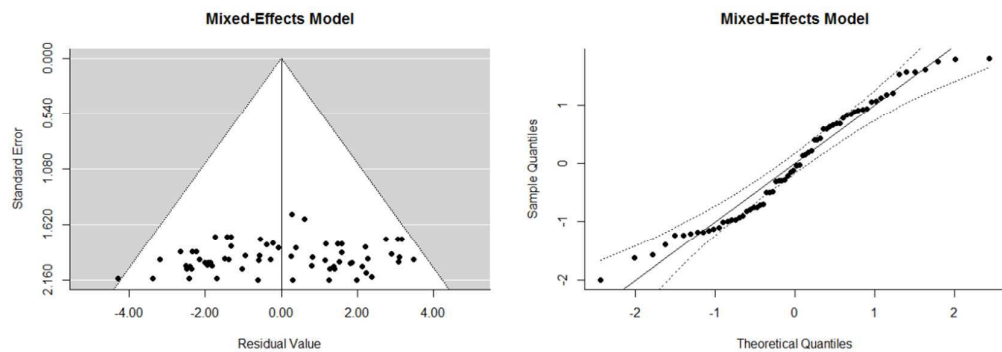


Figure 10. The funnel and Q-Q plot between standard error and overall effect model residual in the event soil erosion rate. A pseudo confidence interval region is drawn around this value with bounds

equal to ± 1.96 SE, where SE is the standard error value from the y-axis (assuming level=95%).

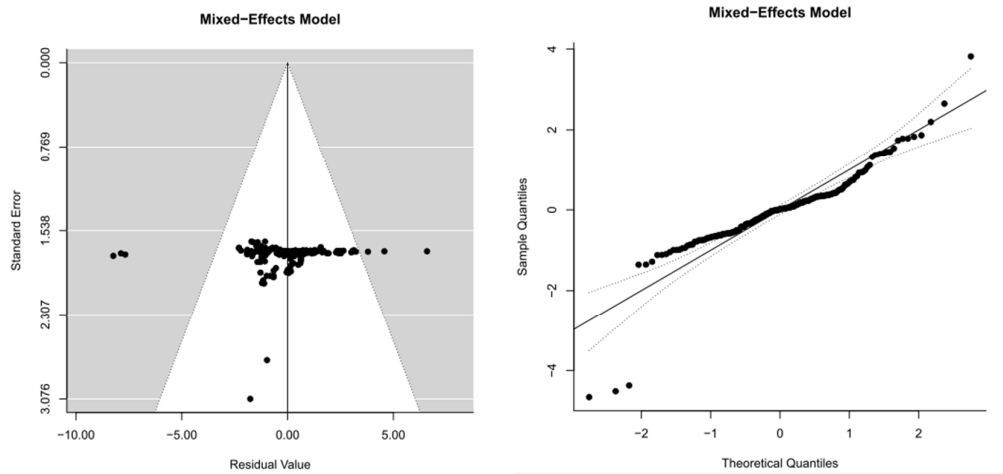


Figure 11. The funnel and Q-Q plot between standard error and Individual effect optimal model residual in the annual runoff. A pseudo confidence interval region is drawn around this value with bounds equal to ± 1.96 SE, where SE is the standard error value from the y-axis (assuming level=95%).

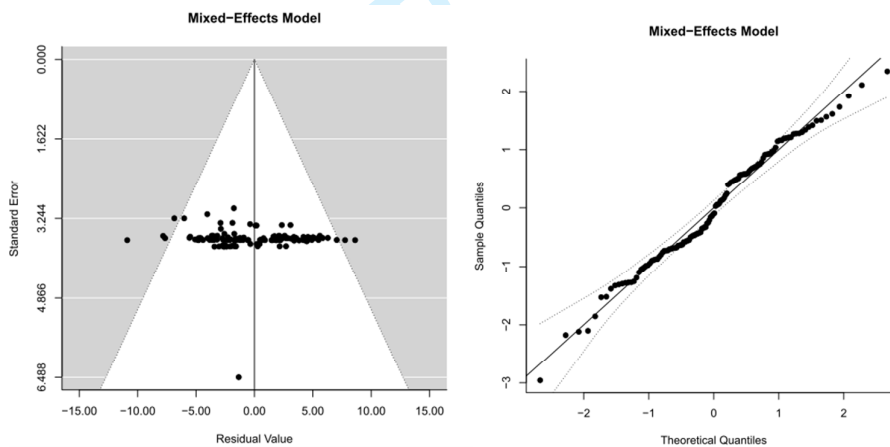
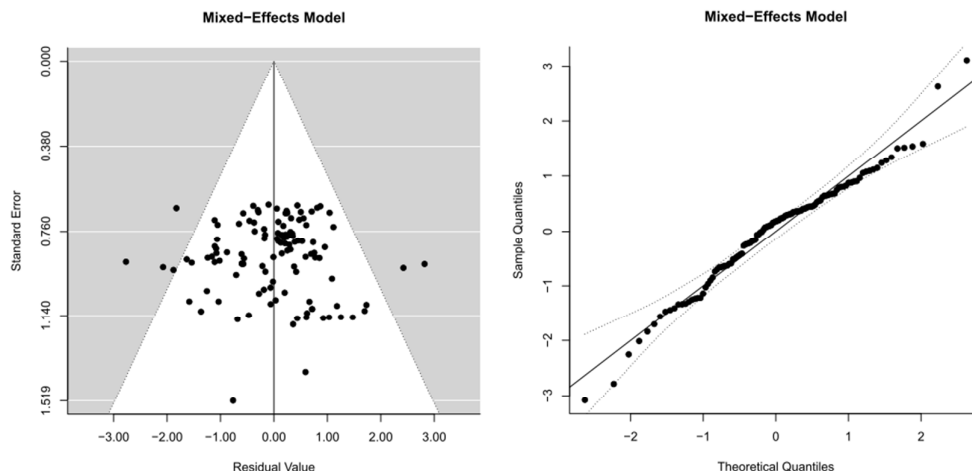


Figure 12. The funnel and Q-Q plot between standard error and Individual effect model residual in the annual soil erosion rate. A pseudo confidence interval region is drawn around this value with bounds equal to ± 1.96 SE, where SE is the standard error value from the y-axis (assuming level=95%).



1
2
3 **Figure 13.** The funnel and Q-Q plot between standard error and Individual effect model residual in the
4 event runoff. A pseudo confidence interval region is drawn around this value with bounds equal to \pm
5 1.96 SE, where SE is the standard error value from the y-axis (assuming level=95%).
6
7

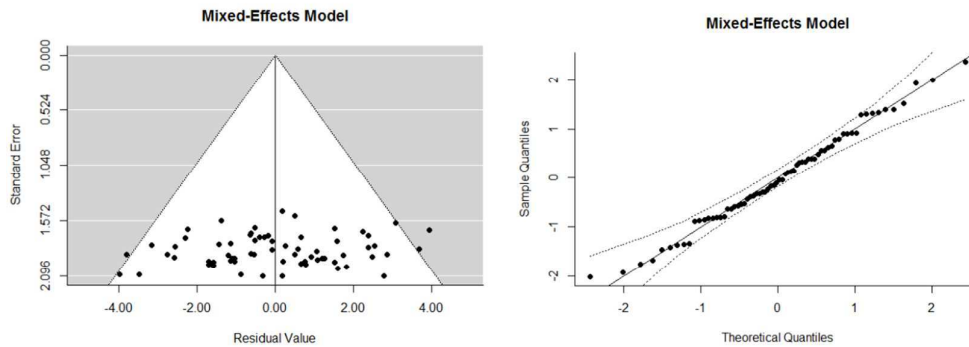


Figure 14. The funnel and Q-Q plot between standard error and Individual effect model residual in the
event soil erosion rate. A pseudo confidence interval region is drawn around this value with bounds
equal to \pm 1.96 SE, where SE is the standard error value from the y-axis (assuming level=95%).