Answers to the reviewers' comments:

Dear Mr. Fiener,

Thank you again for your comments. Please find below our detailed answers to your specific comments (line indication refers to the revised manuscript):

Reviewer: Line 190. Omit 'moreover' at the beginning of the sentence.

Answer: Removed.

Reviewer: Line 196 and following. Explain/define the terms 'functional diversity', 'functional traits', 'species specific functional traits', 'tree species richness', and 'tree species identity' when first used in the text. After this definition use the terms consistently. Personally, I think the term 'tree species identity' is somewhat confusing. Why not just using 'tree species'.

Answer: We agree and now defined the above mentioned terms when introduced first(Line 46-48) and checked for consistency. "Tree species identity" at first looked confusing to us, too, but it is used frequently by our colleagues from ecology and botany, as well as the term "tree species richness" instead of "diversity of tree species". Nevertheless, we changed to "tree species" in the title and throughout the manuscript. Furthermore, we added one more citation on functional traits.

Reviewer: Line 201. 'Hotspots of biodiversity and woody plants' does not make sense. There could be 'hotspots of biodiversity' but not 'hotspots of woody plants'.

Answer: We agree that this phrasing was inappropriate. The research area is especially known as a hotspot of tree species richness. We rephrased the sentence to make it clearer (Line 52-54).

Reviewer: Line 203. Omit 'in China'.

Answer: Removed

Reviewer: Line 205. Replace 'generally' with 'often'

Answer: Replaced

Reviewer: Line 226. The term ‘sediment discharge’ is somewhat misleading as I guess you measure the total sediment delivered per event. A discharge indicates a rate. Therefore, I suggest using ‘surface runoff volume’ and ‘sediment delivery’ throughout the text.

Answer: We changed the term from “discharge” to “delivery” throughout the manuscript. Furthermore, we checked for consistency of the expression “surface runoff volume”.

Reviewer: Line 227. ‘Species identities in the leaf litter cover’ is unclear.

Answer: As you already suggested, it means “the leafs of different tree species within the leaf litter cover”. The whole sentence has been taken out of the revised manuscript.

Reviewer: Line 227. ‘Leaf species’ is unclear. Do you mean leafs of different species?

Answer: see answer above

Reviewer: Line 218-251. As already indicated by rev#2 I suggest to further shortening this paragraph. Actually, it seemed to be somewhat unstructured.

Answer: Thank you for pointing this out again. We now understood that mentioning the leaf species at this point was misleading and the text was too long. We further shortened the paragraph, which should shortly summarize the mechanism of a tree species richness effect on sediment delivery (Line 67-76).

Reviewer: Line 256. Change ‘are closely’ controlled to ‘can be monitored in detail’.

Answer: Changed

Reviewer: Line 278-279. Give reference for soil properties.

Answer: The basic soil properties have been recorded by our group. A more detailed description of the soil and topography data of the BEF China experimental sites is recently under review for a JPE special issue 1, 2016, but is not yet available as a citable manuscript. Should this be included to the manuscript?

Scholten T, Goebes P, Kühn P, Seitz S, Assmann T , Bauhus J, Bruelheide H, Buscot F, Erfmeier A, Fischer M, Härtle W, He JS, Ma K, Niklaus PA, Scherer-Lorenzen M, Schmid B, Shi X, Song Z, von Oheimb G, Wirth C, Wubet T, Schmidt K. On the combined effect of soil fertility and topography on tree growth in subtropical forest ecosystems - a study from SE China. Journal of Plant Ecology. Special Issue. under review.

Reviewer: Line 284-296. This paragraph is somewhat confusing. I suggest omitting the information regarding the 566 plots and just focus on the 34 plots. To make the different settings in the different plots clearer I strongly suggest adding a table presenting the following details: plot no., slope, SOC, …, vegetation properties (see line 337 to 339), species in each plot etc. Do not give any additional information in the appendix as this makes it hard to read.

Answer: Thank you for this suggestion. We shortened the paragraph and omitted information on the 566 plots (Line 125-135). A further table (Table 1) with information on the VIPs was added to the text. All tables were transferred from the appendix to the text. Former table A1 (now table 2) was modified, because 4 tree species were missing in the listing.

Reviewer: Line 298. 'initial sediment…' is unclear.

Answer: We rephrased the sentence (Line 139). The purpose of this clause was to underline that we are not measuring the sediment delivery of the whole hill slope, but of 40 cm length (initial interrill erosion).

Reviewer: Line 300. I assume that the throughfall is highly heterogeneous

Answer: We agree that the throughfall is heterogeneous between different trees. Thus, we tried to get a rainfall measurement under the tree canopy, as the rainfall measurements from climate stations allow only a very rough estimation of the total rainfall arriving at the ROPs. Installing a higher number of rainfall gauges under the canopy (e.g. 4 per ROP) was not feasible in the 2013 field campaign.

Reviewer: Line 311 + 317. Omit '(n=170)'

Answer: Removed

Reviewer: Line 311 ff. Give generally more details how the different variables were determine. It is unclear which variable is determined for the entire plot (e.g. species richness) or for the small 0.4 x 0.4 m erosion plot. If variables like canopy cover, LAI *relate to the plot it must be specified how to make sure that a canopy above the small plot was measured. If all these variables were determined for the entire plot (VIPs) it is necessary to discuss this in much more detail in the discussion. E.g. if an average LAIs are determined of the entire VIPs it is clear that the plot internal variability is more important for the individual measurement in the ROPs, than the differences in average LAI between the VIPs.*

Answer: Thank you for this suggestion. We restructured the paragraph and tried to clarify how the variables were determined (Line 151-163). Ground cover, LAI, surface cover, slope and rainfall amount were measured at every runoff plot with different camera systems, an inclinometer or rainfall gauges, respectively. Tree height, stem diameter, crown width and SOM were identified on VIP-scale, whereof the first three in each case represent a mean value of 36 trees per VIP. Soil texture has been taken out, as it was not part of the analysis.

Reviewer: Line 317-318. SOM cannot be measured in a Vario EL. The elemental analyser determines the total C content, so SOM must be calculated using as ratio of TOC to SOM.

Answer: You are right. We measured total C content and calculated SOM with the conversion factor 2 (see Prybil, 2010, Geoderma). Bedrock and underlying saprolites are non-calcareous (see site description). We corrected the phrasing (Line 160-162).

Reviewer: L 322-330. This paragraph is somewhat confusing. (i) Why did you use only four events if the entire year 2013 was measured? (ii) If only the four events were measured at all ROPs I suggest to omit the detailed information regarding the erosive events in 2013, as this is confusing.

Answer: We agree that beginning with erosive events of the entire year 2013 is confusing. Ten events were measured with ROPs in May and June and four of those events were considered erosive. We rephrased and shortened the paragraph to clarify the issue (Line 165-175).

Reviewer: Line 327. How did you define events?

Answer: Events were defined by breaks of at least 6 hours in rainfall (see above)

Reviewer: Line 327-328. If the Wischmeier and Smith threshold was confirmed by Yin et al. seems to be not important for the presented study.

Answer: Removed

Reviewer: Line 339-340. Explain the random effects in more detail.

Answer: More details were added (Line 182-185).

Reviewer: Line 355. Why are there 44 measurements, which are not valid? Explain how this was defined.

Answer: Further information has been added (Line 200-202). Invalid measurements were caused by technical problems.

Reviewer: Line 359-360. How to extrapolate from four events to a yearly value? (see comment above).

Answer: We determined the length of all erosive events following our definitions (>12.7 mm, at least 6 hours of break in between) and then extrapolated from the events measured in May and June to the whole year. Therefore, the number of erosive events in 2013 was mentioned in the methods section (see above, Line 171). We know that this is only a rough estimate, but we think that it helps to rank this study to others.

Reviewer: Line 365-367. If these results were not significant, I would not use this argument here and in the following.

Answer: We agree on your comment and deleted this description of trends in the results and conclusions part.

Reviewer: Line 374. I would expect also information regarding the monocultures.

Answer: This sentence is pointing on the issue that there were monocultures with tree heights <1m and crown cover <10 % which did not enter the analysis (see methods line 134-135). In those excluded monocultures, minimum tree height was 10 cm and minimum crown cover was 0. Mixtures did not have to be excluded.

Reviewer: Line 378. As indicated earlier I think the term species identity should be changed to species or individual species.

Answer: Changed throughout the manuscript.

Reviewer: Line 379-381. Just a suggestion to make things clearer: 'Individual tree species in monocultures show significant differences in sediment delivery (Fig. 3) ranging from … to ….

Answer: Thank you for this suggestion. We adopted the phrasing.

Reviewer: Line 381 ff. What about runoff volume in case of individual species.

Answer: Some few species also affected runoff volume, but this opened up a new chapter in interpretation. We felt that the study should not be charged with more details on runoff volume, which should then also be shown for the functional traits to be consistent. Thus, we would rather omit it in 3.1 than adding more data to the other points. Please let us know your opinion about this issue.

Reviewer: Line 393. Give details regarding the measurements of stone and biological curst cover in methods.

Answer: We added further information to the methods section (Line 155-156). The development and influence of biological crusts will be presented in a separate manuscript and we suggest not discussing it in further detail at this point.

Reviewer: Line 395-396. I guess you mean 'Sediment delivery decreased with increasing SOM content'.

Answer: You are right. We changed the phrasing.

Reviewer: Line 411-426. I do not see the relation to the rest of the study. Hence, I suggest omitting this paragraph.

Answer: We agree that this paragraph is not directly related to biodiversity or species effects. Nevertheless, when presenting our results, very often questions about the small plot size arose. Thus, we felt that some explaining words are necessary in the manuscript and that we should put our measured and calculated erosion rates in some context. Furthermore, it is slightly introducing into chapter 4. Would some further shortening be appropriate or should we take it out completely?

Reviewer: Line 432. Replace 'Whereas' through 'In contrast'

Answer: Changed

Reviewer: Line 438-439. Not clear from results.

Answer: We specified the statement on 8- and 16-species mixtures (Line 273-274).

Reviewer: Line 439-440. Somewhat confusing as the monocultures seem to have significant differences.

Answer: That is right. But as only eight out of 20 monocultures have significant differences, we believe that their effects are leveled when comparing all monocultures to all mixtures.

Reviewer: Line 441-442. I guess that the missing effect of species richness is also a result of the very small plots not representing a variable canopy (see comment regarding methods).

Answer: Thank you for this suggestion. We agree that the small plot sizes might have some limitations in measurements. Thus, we are currently thinking about using slightly bigger plot sizes for further experiments. Nevertheless, crown cover and LAI have been measured vertically above every ROP in an area covering several square meters of canopy (see above). Moreover, we have 5 replications for every treatment. Results of our research partners show, that it is mostly the young stand age with homogenous canopy characteristics between young tree species that can subdue a biodiversity effect.

Reviewer: Line 452-454. This is true if there is no understory.

Answer: We agree and added this clause to the sentence (Line 290).

Reviewer: Line 529-530. Speculation.

Answer: We agree that those lines are speculative. We changed the phrasing (Line 364-369) to underline that those are assumptions.

Reviewer: Line 530-534. Not supported by the presented data. Speculative.

Answer: see above

Reviewer: Line 564-566. As there are no significant effects, I suggest omitting this at least in the conclusion.

Answer: Removed (see above)

Reviewer: Line 592 ff. Omit the appendix and integrate information in text (see comment above).

Answer: We agree and integrated Table A1 to the text (now Table 2, Line 137).

Manuscript version with marked changes:

Tree species ~~identity~~ and functional traits but not species richness affect interrill erosion processes in young subtropical forests

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Abstract

Soil erosion is seriously threatening ecosystem functioning in many parts of the world. In this context, it is assumed that tree species richness and functional diversity of tree communities can play a critical role in improving ecosystem services such as erosion control. An experiment with 170 micro-scale runoff plots was conducted to investigate the influence of

tree species and tree species richness and identity as well as tree functional traits on interrill erosion in a young forest ecosystem. An interrill erosion rate of 47.5 Mg ha^{-1} a^{-1} was calculated. This study provided evidence that different tree species affect interrill erosion differently, while tree species richness did not affect interrill erosion in young forest stands. Thus, different tree morphologies have to be considered, when assessing soil erosion under forest. High crown cover and leaf area index reduced interrill erosion in initial forest ecosystems, whereas rising tree height increased it. Even if a leaf litter cover was not present, remaining soil surface cover by stones and biological soil crusts was the most important driver for soil erosion control. Furthermore, soil organic matter had a decreasing influence on interrill erosion. Long-term monitoring of soil erosion under closing tree canopies is necessary and a wide range of functional tree traits should be considered in future research.

1 Introduction

Soil erosion is considered as one of the most severe environmental challenges globally (Morgan, 2005). It is also a serious challenge in the PR China, especially in the southern tropical and subtropical zone. Although important improvements in erosion control have been achieved in this area in the last decades (Zhao et al., 2013), the annual soil loss rates range between 0.28 Mg ha^{-1} and 113 Mg ha^{-1} (Guo et al., 2015). Thereby, soil erosion is negatively affecting e.g. soil fertility or nutrient cycling (Pimentel et al., 1995; Richter, 1998).

Moreover, sSoil erosion can negatively influence biodiversity (Pimentel and Kounang, 1998), but it is assumed that this relationship also acts vice versa (Körner and Spehn, 2002; Geißler et al., 2012b; Brevik et al., 2015). It has been shown that a change in biodiversity can have remarkable effects on ecosystem functions and stability (e.g. Hooper et al., 2005; Scherer-Lorenzen, 2005). In many cases, increasing biodiversity enhanced ecosystem productivity and stability (Loreau, 2001; Jacob et al., 2010). In particular, tree species richness (the diversity of tree species) as well as functional diversity (the diversity of functional traits as morpho-physiophenological attributes of a given species, cf. Violle et al., 2007) of tree communities can play a critical role in improving ecosystem services such as water filtration or climate regulation (Quijas et al., 2012; Chisholm et al., 2013; Scherer-Lorenzen, 2014). As forests are generally considered beneficial for erosion control, afforestation is a common measure of soil protection (Romero-Diaz et al., 2010; Jiao et al., 2012). This also applies to the south-eastern part of China, which is known as a hotspot of biodiversity and especially tree species richness and woody plants (Barthlott et al., 2005; Bruelheide et al., 2011). Guo et al. (2015) showed that forests in this area experienced the lowest soil loss rates of all land use types in China. Considering that studies on soil erosion under forest have mostly focused on deforestation (Blanco-Canqui and Lal, 2008) and counteracting measures such as afforestation generally often result in monoculture stands (Puettmann et al., 2009), it appears that the role of tree species richness for soil erosion has been largely disregarded. Zhou et al. (2002) and Tsujimura et al. (2006) demonstrated that tree monocultures have only limited mitigation potential for soil losses, but further research is scarce. Nevertheless, there is growing evidence that higher species richness can reduce soil erosion (Körner and Spehn, 2002). Bautista et al. (2007) pointed out that an increase in functional diversity within a perennial vegetation cover decreased soil losses in a semiarid Mediterranean landscape. Pohl et al. (2009) showed that an increase in the diversity of root types led to higher soil stability on an alpine grassy hillslope and most recently Berendse et al. (2015) found that a loss of grass species diversity reduced erosion resistance on a dike slope.

Conceivable mechanisms underlying positive species richness effects on soil erosion are that vegetation covers with a high number of species include a high number of plant functional groups which complement one another. Thus, they are more effective in controlling erosion processes than vegetative covers with few species (Pohl et al., 2012). For example, ~~a~~ high tree species richness ~~may~~ can result in an increased stratification of canopy layers (Lang et al., 2010)~~. As a consequence, crown overlap, biomass density~~ and a higher total canopy cover ~~often are higher in mixtures than in monocultures~~ (Lang et al., 2012). In addition, a highly diverse structure within the leaf litter layer on the forest floor seems to improve its protecting effect (Martin et al., 2010). ~~Recently, Seitz et al. (2015) pointed out that sediment discharge depends on the species identities in the leaf litter cover, whereas there was no effect of leaf species richness or functional diversity on soil erosion.~~ Further research on the influence of tree species richness on erosion control ~~seems~~ appears to be necessary, but the complex system of interacting functional groups within the vegetation cover is also of great interest.

Vegetation covers are generally considered a key factor for the occurrence and dimension of soil erosion (Thornes, 1990; Hupp et al., 1995; Morgan, 2005). A leaf litter layer on the forest floor, for example, protects the soil from direct raindrop impact and modifies the water flow and storage capacities on the soil surface (Kim et al., 2014). Moreover, forests can provide a multi-storey canopy layer which largely influences rain throughfall patterns and leads to the capture of raindrops as well as the storage of water within the tree crown (Puigdefábregas, 2005). Nevertheless, large drops can be formed at leaf apexes of tall trees (Geißler et al., 2012a) and thus may increase the kinetic energy of throughfall in older forest stands up to a factor of 2 to 3 compared to open fields (Nanko et al., 2008; Nanko et al., 2015). This leads to considerable soil loss if the forest floor is unprotected, which may be the case if protecting layers diminish e.g. under shady conditions (Onda et al., 2010) or fast decomposition (Razafindrabe et al., 2010). Whereas the effects of soil surface covers on soil erosion is well studied (Thornes, 1990; Blanco-Canqui and Lal, 2008), much less is known about the influence of species-specific functional traits of the tree layer such as crown or stem characteristics (Lavorel and Garnier, 2002; Guerrero-Campo et al., 2008). Moreover, most

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research on the latter aspects was performed in old-grown forests (e.g. Zhou et al., 2002; Nanko et al., 2008; Geißler et al., 2012a), whereas forests in an early-successional stage are rarely mentioned. In those young forests, tree heights are lower than in later stages, but structural and spatial complexity is high and species-specific growth rates differ considerably (Swanson et al., 2011). It is assumed that these species-specific differences in structure and growth will influence soil erosion rates.

This research focused on the influence of tree species~~ richness~~, tree species ~~identity ~~richness and species-specific functional traits on interrill erosion in young forests, when a leaf litter cover is not present. Testing for those effects on soil erosion requires a common garden situation, in which confounding factors such as different tree ages and sizes, inclination or soil conditions ~~are closely controlled~~can be monitored in detail. These requirements were met in the forest biodiversity-ecosystem functioning experiment in subtropical China (BEF-China; cf. Bruelheide et al., 2014). Within this experiment, 170 micro-scale runoff plots were established in a randomly dispersed and replicated design. Thereby, the following hypotheses were postulated:

1. Increasing tree species richness decreases interrill erosion rates.
2. Tree species differ in their impact on interrill erosion rates.
3. The effects of different tree species on interrill erosion rates can be explained by species-specific functional traits.

2 Methodology

2.1 Study site and experimental design

The study was conducted in Xingangshan, Jiangxi Province, PR China (29°06.450′ N and 117°55.450′ E) at the experimental sites A and B of the BEF China project (Bruelheide et al., 2014). Together, both sites comprise an area of about 50 ha in a mountainous landscape with an elevation range from 100 m to 265 m a.s.l.. Slopes range from 15 ° to 41 °. The bedrock of the experimental site consists of non-calcareous slates with varying sand and silt contents and is intermittent by siliceous-rich joints. Prevailing soil types are Cambisols with Anthrosols in downslope positions and Gleysols in valleys (cf. IUSS, 2006) covering saprolites. Soil bulk density is low (0.98 g cm^{-3}) and soil reaction acidic (mean pH in KCl 3.68). Soil texture ranges from silt loam to silty clay loam. The climate in Xingangshan is humid and subtropical and ranked as Cwa after the Köppen-Geiger classification. It is characterized by an annual average temperature of 17.4 °C and a mean annual rainfall of 1635 mm (Goebes et al., 2015b).

The experimental area has been used as a commercial forest plantation (*Cunninghamia lancelota* and *Pinus massoniana*) until 2007. It was clear-cut and replanted in 2009-2010 following an experimental plot-based design with different extinction scenarios (Bruelheide et al., 2014). The experimental site represented an early successional stage with tree ages from four to five years at the time of measurements. ~~In total, 566 experimental plots were established using a pool of 40 native tree species, as well as bare ground and free succession plots.~~ Trees were planted randomly in ~~seven~~ different species richness levels ~~(div0, 1, 2, 4, 8, 16, 24)~~ with a planting distance of 1.29 m, following a broken stick design ~~(Bruelheide et al., 2014)~~. This study focused on the Very Intensively studied Plots (VIPs, cf. Bruelheide et al., 2014) of which 34 were used (Table 1)~~in this study~~. ~~The monocultures with tree heights lower than 1 m or crown covers less than 10 % were excluded from the analysis.~~ The selected set comprised a bare ground feature (4 × div0) and four levels of tree species richness (20 × div1, 4 × div8, 4 × div16 and 2 × div24) with a total of 2~~2~~6 tree species, ~~two~~ six of which only appeared in mixtures (Appendix Table A12). The mMonocultures with tree heights lower than 1 m or crown covers less than 10 % were excluded from the analysis.

[Table 1]

[Table 2]

2.2 Erosion measurements

To determine initial sediment discharge delivery (as initial interrill erosion) and surface runoff volume, micro-scale runoff plots (ROP, 0.4 m × 0.4 m) were used (cf. Seitz et al., 2015; without fauna treatment). Each ROP was connected to a 20 L reservoir and a rainfall gauge was placed next to it (Fig. 1). All 34 VIPs were equipped with five ROPs each, resulting in a total number of 170 ROPs. Within each VIP, areas of 220 m^2 were sectioned for ROP measurements to avoid interferences with other BEF China experiments. Those selected areas were representative for the range of surface properties in the plot and the ROPs were placed randomly therein. All leaf litter was removed from the ROPs prior to measurements. The ROPs were operated in May and June 2013 during the rainy season. Runoff volume and rainfall amount were determined in situ and sediment was assessed after sampling by drying at 40 °C and weighing. The capacity of the reservoirs was not exceeded in any rainfall event.

[Figure 1]

At each ROP, tree crown cover, leaf area index (LAI), soil surface cover, slope and rainfall amount were measured. Crown cover and LAI were determined using a fish-eye camera system (Nikon D100 with Nikon AF G DX 180°) and the HemiView V.8 software (Delta-T devices, Cambridge, UK) adjusted on the canopy area vertically above the ROP. Soil surface cover was measured photogrammetrically (grid quadrat method with GIMP 2.8) and separated into organic and inorganic covers by colour distinction. Slope was measured with an inclinometer. Rainfall amount at each ROP was determined by rainfall gauges (see above). At each VIP, total tree height, stem diameter at 5 cm above ground (hereafter, stem diameter) and crown width were measured and calculated as the mean of 36 tree individuals per VIP (Li et al., 2014). Additionally, soil organic matter (SOM) was identified for each VIP (5 cm depth, 9 replicates) by measuring total organic carbon with a Vario EL III elemental analyser (Elementar, Hanau, Germany) and multiplying it by the conversion factor 2 (Pribyl, 2010). Tree species richness was known from the VIP-setup.

~~At each ROP (n=170), tree crown cover and leaf area index (LAI) were measured using a fish-eye camera system (Nikon D100 with Nikon AF G DX 180°) and the HemiView V.8 software (Delta-T devices, Cambridge, UK). Total tree height, stem diameter at 5 cm above ground (hereafter, stem diameter) and crown width for each tree individual were measured to represent the tree characteristics (Li et al., 2014). Soil surface cover was measured photogrammetrically (grid quadrat method with GIMP 2.8) and slope with an inclinometer at each ROP (n=170), respectively. Soil texture and soil organic matter (SOM) were identified for each VIP (5 cm depth, 9 replicates, n=34) using a SediGraph III 5120 (Micromeritics, Aachen, Germany) and a Vario EL III elemental analyser (Elementar, Hanau, Germany).~~

2.3 Rainfall patterns

Weather conditions were recorded by an on-site climate station (ecoTech datalogger with Vaisala weather transmitter and ecoTech tipping bucket balance) in 5-min intervals. The total precipitation ~~in~~ at the study area in 2013 was 1205 mm and lower than the mean of the preceding three years (1635 mm). In ~~total~~May and June, 10 rainfall events were captured with ROP measurements at the study area ~~in May and June~~. Events were determined by breaks in rainfall of at least 6 hours. Four of those events (E1 - E4) ~~can be considered erosive.~~ ~~Of this amount, a fraction of 957 mm (33 events)~~ were strong enough to trigger soil erosion (out of 33 events over the entire year 2013) following Wischmeier and Smith (1978) who used an event threshold of 12.7 mm. ~~This threshold was confirmed by Yin et al. (2007) to be valid for southeast China.~~ ~~In total, 10 rainfall events were captured at the study area in May and June. Four of those events (E1 - E4) can be considered erosive.~~ The total rainfall amount from May to June was 185 mm, of which 135 mm fell during erosive rainfall events. The mean and peak intensities as well as the total rainfall amount (except for E4) increased from May to June (Table ~~1~~3), reflecting a growing monsoon influence from beginning to mid-summer.

[Table ~~1~~3]

2.4 Statistical analysis

Linear mixed effects models with restricted maximum likelihood were performed with R 3.0.2 (R Core Team, 2013) and "lmerTest" (Kuznetsova et al., 2014) to investigate the influences on sediment ~~discharge~~delivery. Models were fitted with crown cover, leaf area index, tree height, stem diameter, crown width, slope, surface cover, SOM, amount of precipitation and tree species richness as fixed effects. As random effects, precipitation event (E1 - E4) nested in plot, tree composition (species pool), site (A or B) and ROP nested in plot were used. Nesting was introduced to avoid pseudoreplication considering the degrees of freedom in our hypotheses tests. Tree and crown characteristics were fitted one after the other, because they were highly correlated. Contrasts of diversity levels (div0 to div1-24, div1 to div8-24) were introduced to quantify the effects of bare plots vs. tree plots and tree monocultures vs. mixtures, respectively. The effect of individual tree species (div1) was tested separately against the mean sediment ~~discharge~~ delivery using crown cover, slope, surface cover, SOM and amount of precipitation as fixed factors and site and ROP nested in plot as random factor (n=200). The maximum likelihood approach was used to obtain model simplification by step-wise backward selection, eliminating the least significant variable except for tree species richness. If multicolinearity was detected (spearman $\rho>0.7$), co-variables were omitted. All variables were continuous and scaled, so model estimates could be compared. The data was log-transformed and the residuals did not show any deviation from normality. Hypotheses were tested with an ANOVA type 3 with Satterthwaite approximation for degrees of freedom and p-values were obtained by likelihood ratio tests.

3 Results

The results were based on 334 ROP measurements out of a total of 378 measurements. Invalid measurements were caused by technical constraints such as plugged tubes or toppled rainfall gauges. Sediment ~~discharge~~ delivery over all VIPs and rainfall events ranged from 14 g m^{-2} to 920 g m^{-2} per ROP. Event-based mean sediment ~~discharge~~ delivery increased with peak intensity from precipitation event 1 to event 4 with 42 g m^{-2} (E1), 85 g m^{-2} (E2), 120 g m^{-2} (E3) and 283 g m^{-2} (E4). The interrill soil erosion rate determined by micro-scale ROPs and extrapolated for all erosive precipitation events (>12.7 mm rainfall amount) in 2013 was estimated to be 47.5 Mg ha^{-1}.

3.1 Species richness effects on interrill erosion processes

Tree species richness did not affect sediment ~~discharge~~ delivery or runoff volume (Table ~~2~~ 4 and Fig. 2). ~~Sediment discharge tended to decrease from diversity level 0 to 8 and to increase to diversity level 24, while runoff volume tended to decrease from diversity level 0 to 16 and to increase to diversity level 24, but shifts were non-significant.~~ Sediment ~~discharge~~ delivery and runoff volume did not differ between bare plots (div0) and plots with trees (div1-div24), just as between monocultures (div1) and species mixtures (div8, div16, div24). The standard deviations of sediment ~~discharge~~ delivery (g m^{-2}) and runoff volume (l m^{-2}) in relation to diversity levels were high (Fig. 2 and Table ~~3~~5). Mean crown cover in mixed stands was 44 % and mean tree height was 2.30 m compared to monocultures with 22 % and 1.63 m. In this experiment tree height in mixed stands was not lower than 1.07 m and crown cover achieved at least 29 %.

[Table ~~2~~4]

[Figure 2]

[Table ~~3~~5]

3.2 Species ~~identity~~ effects on interrill erosion processes

Individual tree species in monocultures ~~affected~~ showed significant differences in sediment ~~discharge~~ delivery ~~differently~~ (Fig. 3) ~~and sediment discharge rates ranged~~ranging from 90 g m^{-2} (*L. formosana*) to 560 g m^{-2} (*Ch. axillaris*) per rainfall event.

[Figure 3]

The mean sediment ~~discharge~~ delivery is 199 g m^{-2} across all tree monocultures, among which *Ch. axillaris*, *C. glauca*, *R. chinensis* and *K. bipinnata* showed above average and *M. yuyuanensis*, *L. glaber*, *E. chinensis* and *L. formosana* below average sediment ~~discharge~~delivery. The growth characteristics of these tree species differed considerably between the species (Table ~~4~~6).

[Table ~~4~~6]

3.3 Effects of ~~tree~~ species-specific functional traits and site characteristics

Crown cover was highly correlated with LAI, tree height, stem diameter and crown width (r=0.82, 0.80, 0.75, 0.77, respectively). Crown cover ($p<0.01$) and LAI ($p<0.05$) negatively affected sediment ~~discharge~~delivery. Tree height marginally positively affected sediment ~~discharge~~ delivery ($p<0.1$), whereas stem diameter and crown width had no influence (Fig. 4, Table ~~2~~4). The soil surface cover consisted of stones and biological soil crusts and covered on average one fifth of the ROP surfaces in May and June 2013. It affected sediment ~~discharge~~ delivery negatively ($p<0.001$). ~~Mean soil organic matter content in the top layer was high and reduced sediment discharge~~Sediment ~~-~~delivery decreased with increasing SOM content ($p<0.05$). An indication of hydrophobic surface coatings and a significant role of water repellency could not be found. The mean slope angle did not affect sediment ~~discharge~~ delivery (Fig. 4, Table ~~2~~4).

[Figure 4]

Growth characteristics were highly variable between tree species, which was reflected by high standard deviations of the respective variables. In contrast, site characteristics of these plots showed a low variability (Table ~~5~~7).

[Table ~~5~~7]

4 Discussion

The soil loss rate determined by micro-scale ROPs (47.5 Mg ha^{-1} a^{-1}) for 2013 was considerably higher than the average rate Guo et al. (2015) recently calculated for South China (approx. 20 Mg ha^{-1} a^{-1}) in a study based on small-scale and field ROPs. Pimentel (1993) reported an average rate of 36 Mg ha^{-1} a^{-1} for the same area. Zheng et al. (2007) stated an average soil loss rate of 31 Mg ha^{-1} a^{-1} determined with ^{137}Cs/^{210}Pb tracing techniques in Sichuan Province, PR China. These different rates are due to different land use types and measurement techniques, but also due to the scale-dependent nature of soil erosion and runoff generation (cf. Boix-Fayos et al., 2006; Cantón et al., 2011). The micro-scale ROPs used in this study quantified interrill wash and sediment detachment by raindrop impact (Agassi and Bradford, 1999; cf. Cerdà, 1999; Parsons et al., 2003; García-Orenes et al., 2012). However, an important part of erosion appears in the rilling system and the influence of interrill processes on soil erosion varies greatly (Govers and Poesen, 1988). Sediment ~~discharge~~ delivery and runoff volume change with ROP length (cf. Abrahams et al., 1995) and boundary effects increasingly influence the results with decreasing plot sizes (Mutchler et al., 1994). Nevertheless, Mutchler et al. (1994) stated that micro-scale ROPs are suitable to study basic aspects of soil erosion and furthermore, those measurements are particularly appropriate to define impacts of vegetation by interplot comparison (Wainwright et al., 2000).

4.1 Species richness effects on interrill erosion processes

Tree species richness did not affect sediment ~~discharge~~ delivery or runoff volume and thus the first hypothesis has to be rejected. Nevertheless, a trend of decreasing sediment ~~discharge~~ delivery and runoff volume from diversity level 0 to 8 was visible. However, both parameters were nearly the same at diversity level 1 and 24 and standard deviations were high. ~~Whereas~~ In contrast to tree growth patterns in monocultures which were highly variable, mixed stands indicated a more balanced development (Kelty, 2006). All species mixtures in this experiment assured a higher level of tree height and ground coverage after four to five years of tree growth, whereas in monocultures the canopy cover was lower and highly tree species specific. Thus, several monoculture plots were excluded before ~~measurements~~the analysis, because some species could not provide any considerable ground coverage. At the same time, sediment ~~discharge~~ delivery in 8- and 16-species mixtures~~ stands~~ was lower than in monocultures. Nevertheless, contrasts in the model could not show any statistical difference between monocultures and mixtures or bare and covered plots.

The absence of a species richness effect on interrill erosion is likely attributable to the early successional stage of the forest experiment with low tree ages. Full canopy covers with high stratification and overlap have not yet been developed at the study site and the trees did by far not reach terminal height (Goebes et al., 2015b; Li et al., 2014). It is assumed that these vegetation characteristics will change with increasing tree age and tree species richness may become evident in adult stands. Young trees are functionally more equivalent than older trees (Barnes and Spurr, 1998) and specific crown traits may emerge more distinctly in later successional stages. Geißler et al. (2013) found that the erosion potential was higher in medium and old grown forests than in young forests. This effect is caused by raindrop transformation processes during the canopy passage, resulting in higher throughfall kinetic energy under forest than on fallow land (Geißler et al., 2010) and has only been proved for advanced successional forest stages (Nanko et al., 2008; Geißler et al., 2013). With ongoing time of the experiment and increasing tree height increasing throughfall kinetic energy is expected, which in turn increases the general soil erosion potential if an understory is missing.

4.2 Species ~~identity~~ effects on interrill erosion processes

Trees in monocultures differed in their impact on interrill erosion and thus hypothesis 2 can be confirmed. In a study on common European tree species, Augusto et al. (2002) showed that the tree species composition of forests has an impact on chemical, physical and biological soil properties. Several studies revealed that individual plants are important for erosion control in arid and semi-arid Mediterranean landscapes (e.g. Bochet et al., 2006; cf. Durán Zuazo and Rodríguez Pleguezuelo, 2008) and Xu et al. (2008) showed that different plant morphologies may control soil loss and improved soil properties in a dry river valley in China.

In this study, four tree species (*Ch. axillaris, C. glauca, R. chinensis, K. bipinnata*) seemed to foster interrill erosion rates, whereas another four species (*M. yuyuanensis, L. glaber, E. chinensis*, *L. formosana*) showed a mitigating effect on interrill erosion at this initial stage of the forest ecosystem. Thus, a species-specific effect on sediment ~~discharge~~ delivery for this subtropical experimental area can be confirmed. Species-specific effects can result from different throughfall kinetic energy, which was recently shown by Goebes et al. (2015a) at the same study site in China. The effect of throughfall kinetic energy was ascribed to different tree architectural characteristics and leaf traits. The authors found three out of 11 tree species to have distinct differences in mean throughfall kinetic energy. *Ch. axillaris* and *S. saponaria* showed higher values, whereas *S. superba* was characterized by lower values of throughfall kinetic energy. At the experimental site, varying tree species revealed heterogeneous growth patterns, which were caused by species-specific growth variation and abiotic site conditions (Li et al., 2014). *Ch. axillaris* was the tallest tree species with a nearly closed canopy and caused the highest amount of sediment ~~discharge~~ delivery in this study. Raindrops falling from leaves of this species nearly reached terminal velocity and hence throughfall kinetic energy was high (Morgan, 2005; Goebes et al., 2015a). This finding explained the high erosion rates below this fast-growing species. Further stands with significantly higher erosion rates and the four tree species with a mitigating effect on interrill erosion showed lower tree heights and thus lower throughfall kinetic energy. Their effect on sediment ~~discharge~~ delivery has to be explained by further functional traits.

4.3 Effects of ~~tree~~ species-specific functional traits and site characteristics

Tree species differed widely in canopy characteristics and sediment ~~discharge~~ delivery was significantly related to crown cover, LAI and tree height. Therefore, the species-specific effects of interrill erosion can be partially contributed to species-specific functional traits, which confirms hypothesis 3. The falling velocities of throughfall drops are highly variable under different tree species due to the species-specific growth pattern and crown characteristics (Goebes et al., 2015a). Frasson and Krajewski (2011) showed that the mechanisms of interception are manifold even within a single canopy and varying canopy levels create different drop size distributions.

Increasing crown cover and LAI were mitigating interrill erosion in this early ecosystem stage. The magnitude of canopy cover determines the proportion of raindrops intercepted (Blanco-Canqui and Lal, 2008) and it has been shown that drop size distributions differ between different canopy species (Nanko et al., 2006). High crown cover and leaf area increase the interception of rain drops and the storage capacity of water in the canopy (Aston, 1979; Geißler et al., 2012a), which can lead to higher stemflow and thus decreasing throughfall (Herwitz, 1987). Nevertheless, Herwitz (1987) equally showed that canopy drainage can lead to larger throughfall drops and thus to increasing throughfall kinetic energy depending on the leaf species (Hall and Calder, 1993; Geißler et al., 2012a; Goebes et al., 2015a). Anyhow, LAI showed a weaker significance than crown cover, probably because many trees had not yet developed a multi-layered canopy structure.

It has been shown that tree height is an import factor for sediment detachment under forest (Geißler et al., 2013), mostly due to increasing drop falling heights (Gunn and Kinzer, 1949). As trees did not yet reach adult height (mean height <2 m) in this study, the kinetic energy of raindrops formed at leaf tips was lower than in grown up tree stands and drops did not reach terminal velocities (Morgan, 2005; Geißler et al., 2013; Goebes et al., 2015a). Therefore, tree height had a weak effect on sediment ~~discharge~~ delivery ($p<0.1$) in this study and ~~sediment discharge rates~~ under trees ~~were~~ it was not exceeding ~~those~~ sediment delivery on bare ground. Nevertheless, high sediment ~~discharge~~ delivery under *Ch. axillaris*, by far the fastest growing tree in this experiment, showed the potential of high trees to increase soil erosion on uncovered forest floors.

Stem diameter and crown width did not seem to influence erosion processes in early stage forest ecosystems. Several other tree-related functional traits (Pérez-Harguindeguy et al., 2013) could be used to explain sediment ~~discharge~~ delivery such as branching architecture, specific leaf area and root system morphology. Especially studies on leaf traits (Nanko et al., 2013) as well as belowground stratification (Gyssels et al., 2005; Stokes et al., 2009) showed the potential to influence soil loss and pointed out the complexity of factors mitigating soil erosion in forest ecosystems.

Results showed that soil surface cover and ~~soil organic matter~~SOM affect interrill erosion. Even though a leaf litter cover was not present in this experiment, the remaining soil surface cover by stones and biological soil crusts was the most important driver to reduce sediment ~~discharge~~delivery. This finding underlines the general importance of covered soil surfaces for erosion control (cf. Thornes, 1990; Morgan, 2005) and shows that the protecting effect of leaf litter could not only be replaced by soil skeleton but also by topsoil microbial communities in young forest stands. The mitigating effect of leaf litter on soil losses has not been in the focus of this experimental approach, but it is presumed that the fall of leaves even in young aged forests reduces soil erosion considerably compared to bare land (Blanco-Canqui and Lal, 2008; Seitz et al., 2015). Furthermore, ~~soil organic matter~~SOM ~~effectively prevented~~reduced interrill erosion which could be explained by its ability to bind~~ing~~ primary particles into aggregates (Blanco-Canqui and Lal, 2008). If ~~soil organic matter~~we assume that SOM increases with increasing species richness, as it was recently demonstrated in a grassland study by Cong et al. (2014), an indirect effect of biodiversity on soil erosion c~~an~~ould be ~~presumed~~supposed. At last, slope angle was not affecting interrill erosion due to the short plot length that limits runoff velocities (cf. Seitz et al., 2015).

5 Synthesis and conclusions

An experiment with 170 micro-scale runoff plots was conducted to investigate the influence of tree species and tree species richness ~~and identity~~ as well as ~~tree~~ species-specific functional traits on interrill soil erosion processes in a young forest ecosystem. The results led to the following conclusions:

1. Tree species richness did not affect sediment ~~discharge~~ delivery and runoff volume, although ~~a negative trend was visible from diversity level 1 to 8 and~~

mixed stands showed a more balanced and homogenous vegetation development than monocultures. This finding was ascribed to the young successional stage of the forest experiment. Future research should concentrate on how erosion rates change with increasing stand age. Therefore, long-term monitoring of soil erosion under closing tree canopies is necessary.

2. This study provided evidence that different tree species affect interrill erosion processes. Different tree morphologies have to be considered, when regarding erosion in young forest ecosystems. The appropriate choice of tree species for afforestation against soil erosion becomes already important in an early successional stage.
3. Species-specific functional traits and site characteristics affected interrill erosion rates. High crown cover and leaf area index reduced soil erosion, whereas it was slightly increased by increasing tree height. Thus, low tree stands with high canopy cover were effectively counteracting soil loss in initial forest ecosystem. In further studies, a wider range of functional tree traits such as leaf habitus or belowground stratification should be taken into consideration. Moreover, investigations on the influence of biological soil crusts, topsoil microbial communities and their impact on organic matter accumulation will open the way to new insights on soil erosion processes.

~~Appendices~~

~~[Table A1]~~

Author contribution

Thomas Scholten, Peter Kühn and Steffen Seitz designed the experiment and Steffen Seitz carried it out. Steffen Seitz, Philipp Goebes and Helge Bruelheide developed the model code and performed the statistics. Ying Li and Werner Härdtle provided data on tree growth and species-specific functional traits. Steffen Seitz prepared the manuscript with contributions from all co-authors.

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Table 1: Mean characteristics of the 34 selected Very Important study Plots (VIPs) in 2013 in the BEF China experiment, Xingangshan, Jiangxi Province, PR China.

VIP no.	Species number	Crown cover (%)	Leaf area index	Tree height (m)	Stem diameter (m)	Crown width (m)	Slope (°)	Surface cover (%)	Soil organic matter (%)
F27	0	-	-	-	-	-	26	10	5.4
H28	0	-	-	-	-	-	34	15	5.9
L20	0	-	-	-	-	-	24	11	8.3
Q23	0	-	-	-	-	-	15	23	6.2
E31	1	16	0.19	1.25	0.02	0.80	22	39	5.5
E33	1	20	0.28	2.32	0.03	1.09	19	41	4.4
E34	1	87	2.07	5.96	0.06	3.00	21	11	6.1
I25	1	11	0.14	1.62	0.04	0.96	29	11	5.3
I28	1	15	0.19	2.28	0.04	1.64	26	32	8.9
K19	1	93	4.20	3.67	0.06	1.66	24	32	8.3
L11	1	10	0.11	1.36	0.02	0.90	28	19	7.1
M7	1	46	0.62	2.01	0.03	1.28	31	8	6.8
N05	1	9	0.10	1.16	0.03	0.40	32	0	6.3
N11	1	42	0.55	1.68	0.03	0.96	26	32	9.7
N13	1	13	0.13	3.05	0.05	1.56	31	30	7.9
N17	1	47	0.85	1.82	0.03	1.62	28	1	7.9
O27	1	90	2.27	7.40	0.07	2.21	21	9	5.7
Q13	1	19	0.30	1.97	0.03	1.15	30	1	6.9
Q27	1	24	0.47	3.37	0.04	1.37	35	3	6.0
R14	1	51	0.93	1.25	0.02	0.64	30	1	7.6
R29	1	21	0.24	1.44	0.03	0.95	33	18	6.3
U16	1	10	0.14	2.26	0.05	1.10	20	5	4.7
V24	1	64	1.02	2.19	0.05	0.96	32	11	4.3
W11	1	34	0.43	2.61	0.06	1.13	19	6	6.0
J29	8	29	0.34	1.47	0.05	0.76	31	13	9.4
Q17	8	30	0.37	1.74	0.05	1.05	22	6	5.2
S10	8	99	5.35	3.85	0.05	2.19	36	29	4.2
T15	8	31	0.38	1.96	0.03	1.15	30	20	4.8
M22	16	87	2.06	4.35	0.06	2.09	23	44	7.2
S22	16	34	0.42	1.07	0.04	0.56	33	24	6.6
U10	16	48	0.56	3.06	0.06	1.56	22	10	6.0
V27	16	42	0.54	2.09	0.05	0.99	34	9	6.4
N09	24	11	0.17	2.08	0.04	1.29	33	38	8.8
R30	24	37	0.46	1.67	0.04	0.97	27	19	4.2

Table A12: 226 selected tree species used in the experiment according to the Flora of China (http://www.efloras.org). Asterisks (*) mark species which only appear in mixtures.

Species name and author	
Ailanthus altissima (Miller) Swingle	*Koelreuteria bipinnata* Franch.
Alniphyllum fortunei (Hemsl.) Makino	*Liquidambar formosana* Hance
Betula luminifera H. Winkl.	*Lithocarpus glaber* (Thunb.) Nakai
Castanea henryi (Skan) Rehd. et Wils.	*Magnolia yuyuanensis* Hu
Castanopsis fargesii Franch.	*Nyssa sinensis* Oliver *
Castanopsis sclerophylla (Lindl.) Schott.	*Rhus chinensis* Mill.
Choerospondias axillaris (Roxb.) Burtt et Hill.	*Sapindus saponaria* Gaertn.
Cyclobalanopsis glauca (Thunb.) Oerst.	*Schima superba* Gardn. et Champ.
Elaeocarpus chinensis Gardn. et Chanp.	*Triadica sebifera* (L.) Roxb.
Elaeocarpus glabripetalus Merr.	*Quercus fabri* Hance
Elaeocarpus japonicus Sieb. et Zucc.	*Quercus phillyreoides* A. Gray *

Species name and author	
Ailanthus altissima (Miller) Swingle	*Koelreuteria bipinnata* Franch.
Alniphyllum fortunei (Hemsl.) Makino	*Liquidambar formosana* Hance
Betula luminifera H. Winkl.	*Lithocarpus glaber* (Thunb.) Nakai
Castanea henryi (Skan) Rehd. et Wils.	*Machilus grijsii* Hance *
Castanopsis fargesii Franch.	*Machilus leptophylla* Hand.-Mazz. *
Castanopsis sclerophylla (Lindl.) Schott.	*Magnolia yuyuanensis* Hu
Celtis Biondi Nakai *	*Nyssa sinensis* Oliver *
Choerospondias axillaris (Roxb.) Burtt et Hill.	*Rhus chinensis* Mill.
Cyclobalanopsis glauca (Thunb.) Oerst.	*Sapindus saponaria* Gaertn.
Elaeocarpus chinensis Gardn. et Chanp.	*Schima superba* Gardn. et Champ.
Elaeocarpus glabripetalus Merr.	*Triadica sebifera* (L.) Roxb.
Elaeocarpus japonicus Sieb. et Zucc.	*Quercus fabri* Hance
Idesia polycarpa Maxim. *	*Quercus phillyreoides* A. Gray *

Table ~~1~~3: Characteristics of rainfall events considered erosive (threshold 12.7 mm) in Xingangshan, Jiangxi Province, PR China in May and June 2013.

Event	Mean intensity (mm h^{-1})	Peak intensity (mm h^{-1})	Total rainfall amount (mm)
E 1	1.38	11.4	20.29
E 2	2.34	23.04	25.74
E 3	3.19	45.24	54.42
E 4	14.60	83.04	34.01

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Table ~~2~~4: Results of the basic linear mixed effect model for sediment ~~discharge~~ delivery (* : p<0.001, ** : p<0.01, * : p<0.05, . : p<0.1, n.s. : not significant; n=334). Crown cover was highly correlated with the four other vegetation characteristics and therefore, they have been exchanged and fitted in separate models.**

		denDF	F	Pr	estimates
Fixed effects	~~Surface r~~Runoff volume	204	49.0	<0.001 ***	0.33
	Crown cover	120	7.25	0.008 **	(-) 0.18
	Slope	141	1.33	0.250 n.s.	0.05
	Surface cover	140	56.1	<0.001 ***	(-) 0.46
	Soil organic matter	42	5.61	0.022 *	(-) 0.07
	Precipitation	70	0.12	0.733 n.s.	(-) 0.01
	Tree species richness	25	0.30	0.589 n.s.	0.05
		sd	variance		
Random effects	Precipitation event : plot	0.204	0.042		
	Tree composition	0.332	0.110		
	Site	0.577	0.333		
	Plot : rop	0.503	0.253		
Vegetation characteristics fitted in exchange to crown cover					
	Leaf area index	95	5.16	0.026 *	(-) 0.17
	Tree height	31	3.58	0.069 .	0.10
	Tree stem diameter	30	0.20	0.661 n.s.	(-) 0.04
	Tree crown width	31	0.79	0.383 n.s.	(-) 0.08

Table ~~3~~5: Mean sediment ~~discharge~~delivery in g m^{-2} and surface runoff volume in L m^{-2} (standard deviation in brackets, n=334) for tree species richness in May and June 2013.

	Diversity 0-24	Diversity 0	Diversity 1-24	Diversity 1	Diversity 8	Diversity 16	Diversity 24
Sediment ~~discharge~~delivery	199 (106)	361 (187)	188 (90)	202 (105)	103 (57)	135 (123)	204 (107)
Runoff volume	32.6 (21.4)	47.8 (32.1)	29.8 (18.5)	31.9 (20.9)	27.5 (14.5)	22.5 (15.7)	30.2 (19.7)

Table ~~4~~6: ~~Discharge rates~~Sediment delivery and growth characteristics (means) of tree species with significant differences in ~~sediment discharge~~delivery at the experimental site in Xingangshan, Jiangxi Province, PR China.

	Sediment ~~discharge~~ delivery (g m^{-2})	Crown cover (%)	Leaf area index	Tree height (m)	Stem diameter (m)	Crown width (m)
Mean	199	32	0.75	1.84	0.03	0.94
Monocultures	202	22	0.63	1.63	0.02	0.78
Tree mixtures	135	44	1.18	2.30	0.04	1.26
Ch. axillaris	566	90	2.27	7.40	0.07	2.21
C. glauca	556	51	0.93	1.25	0.02	0.65
R. chinensis	502	47	0.85	1.82	0.03	1.62
K. bipinnata	378	19	0.30	1.97	0.03	1.15
M. yuyuanensis	64	11	0.14	1.62	0.04	0.95
L. glaber	114	20	0.28	2.32	0.03	1.09
E. chinensis	66	64	1.02	2.19	0.05	0.97
L. formosana	91	15	0.19	2.28	0.04	1.64

Table ~~5~~7: Growth characteristics of the 20 tree species in monocultures analysed and associated plot characteristics in Xingangshan, Jiangxi Province, PR China (mean, standard deviation (sd), maximum (max) and minimum (min)).

	Mean	Sd	Max	Min
Vegetation				
Crown cover (%)	37	31	93	1
Leaf area index	0.88	1.08	4.20	0.03
Tree height (m)	2.55	1.64	7.40	1.16
Stem diameter (m)	0.04	0.02	0.07	0.02
Crown width (m)	1.25	0.61	3.00	0.40
Site				
Soil surface cover (%)	16	14	55	1
Soil organic matter (%)	6.4	1.4	9.4	4.3
Slope (°)	27	5	35	19

Crown cover: proportion of soil surface area covered by crowns of live trees (%), leaf area index: one-sided green leaf area per unit soil surface area (dimensionless), tree height: distance from stem base to apical meristem (m), stem diameter: cross-section dimension of the tree stem at 5 cm above ground (m), crown width: length of longest spread from edge to edge across the crown (m), soil surface cover: proportion of soil surface area covered by stones, biocrusts and litter (%), soil organic matter: fraction of organic carbon containing substances in the soil (%), slope: inclination (°).

Table A1: 22 selected tree species used in the experiment according to the Flora of China (http://www.efloras.org). Asterisks (*) mark species which only appear in mixtures.

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Species name and author	
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Betula luminifera H. Winkl.	*Lithocarpus glaber* (Thunb.) Nakai
Castanea henryi (Skan) Rehd. et Wils.	*Magnolia yuyuanensis* Hu
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Castanopsis sclerophylla (Lindl.) Schott.	*Rhus chinensis* Mill.
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Elaeocarpus glabripetalus Merr.	*Quercus fabri* Hance
Elaeocarpus japonicus Sieb. et Zucc.	*Quercus phillyreoides* A. Gray *

Figure 1: Measurement setup showing a runoff plot (ROP, 0.4 m × 0.4 m) with reservoir and rainfall gauge on the experimental site in Xingangshan, Jiangxi Province, PR China.

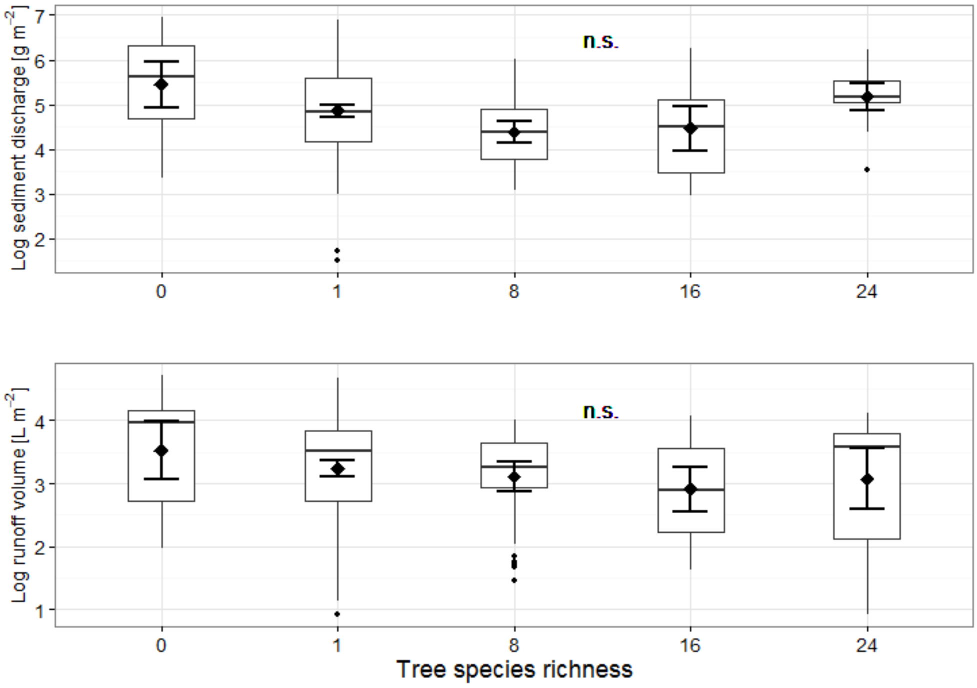

Figure 2: Sediment ~~discharge~~ delivery and runoff volume at five diversity levels based on four rainfall events in May and June 2013 in Xingangshan, Jiangxi Province, PR China (n.s.: not significant, n=334). Horizontal line within boxplot represents median and diamond represents mean.

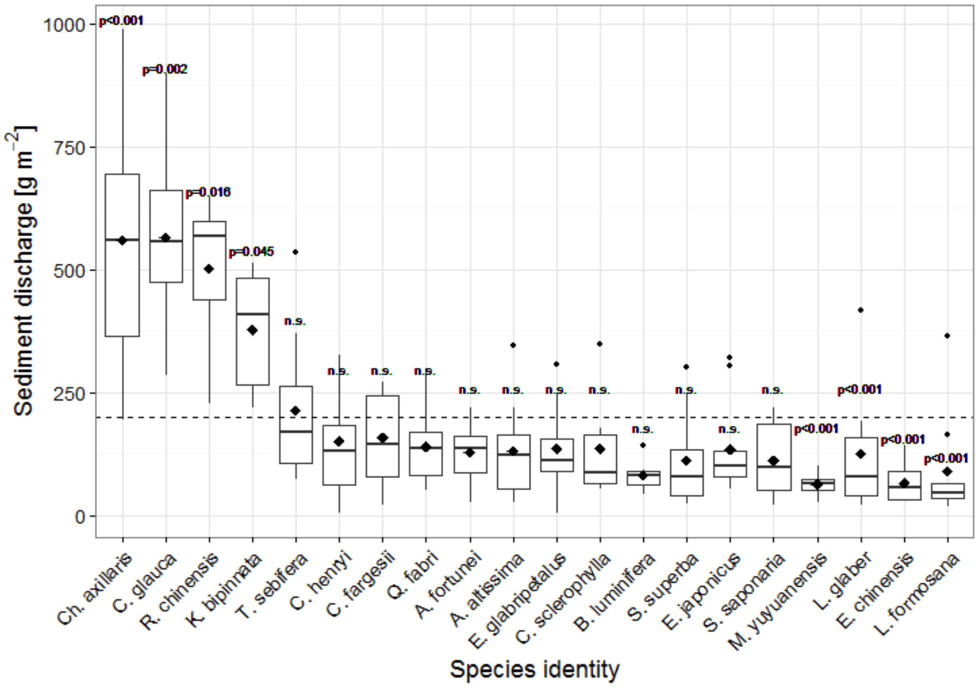

Figure 3: Sediment ~~discharge~~ delivery under 20 tree species in monocultures based on four rainfall events in May and June 2013 in Xingangshan, Jiangxi Province, PR China. Dashed line indicates mean sediment ~~discharge~~ delivery of all 20 species. Horizontal lines within boxplot represent median and diamonds represent mean values found for a respective species.

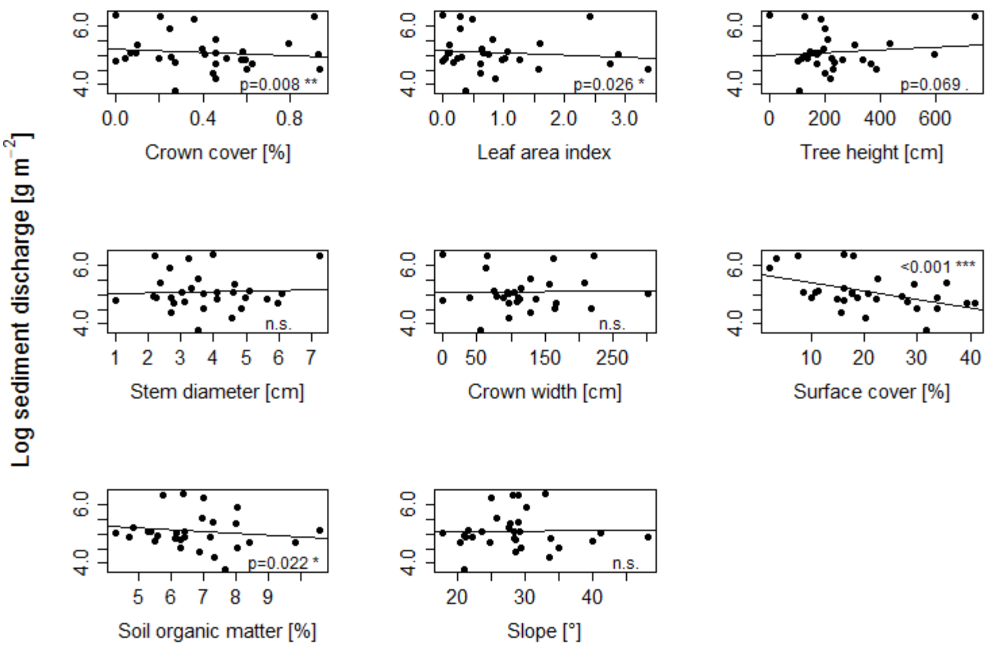

Figure 4: Effects of ~~tree~~species-specific functional traits and site characteristics on sediment ~~discharge~~delivery. Analyses were based on four rainfall events in May and June 2013 in Xingangshan, Jiangxi Province, PR China. Black lines symbolize linear trends.