Trait profiles and functional diversity following disturbance in a mixed grassland

Ellen A Smith [1], Emily M Holden [Corresp., 1], Charlotte Brown [1, 2], James F Cahill Jr. [1]

1 Department of Biological Sciences, University of Alberta, Edmonton, Alberta, Canada

2 Department of Ecology and Evolutionary Biology, University of Arizona, Tucson, Arizona, United States

Corresponding Author: Emily M Holden
Email address: eholden@ualberta.ca

Background. Localized disturbances within established grasslands alter a suite of biological and chemical properties, leading to shifts in species composition. For example, relatively rare species in established communities may become dominant in successional communities if they exhibit traits that are suited to disturbance conditions. Although the idea that plant species exhibit different trait 'strategies' is well established, it is unclear how ecological selection for specific traits may change as a function of disturbance. Further, there is little data available testing whether disturbances select for single trait-characters within communities (homogenization), or allow multiple trait-types to persist (diversification). We investigated how (a) traits and (b) functional diversity of post-disturbance communities compared to those in adjacent undisturbed grasslands, and (c) if changes in functional diversity resulted in the homogenization or diversification of functional traits within local communities.

Methods. Here we emulate the impacts of an extreme disturbance in a mixed grassland site. We measured plant community composition of twelve paired plots in a native grassland within the central parkland of Alberta, Canada. Each pair consisted of one undisturbed plot and one which had all plants terminated two years prior. We used species abundances in conjunction with a local trait database to calculate community weighted means for maximum height, specific leaf area, specific root length, leaf nitrogen percent, and root nitrogen percent. To test the impacts of disturbance on community functional traits, we calculated functional diversity measures and compared them between disturbed and undisturbed local communities.

Results. Within two years, species richness and evenness in disturbed communities had recovered and was equivalent to undisturbed communities. However, disturbed and undisturbed communities had distinct community compositions that differed in functional diversity. Functional divergence was significantly lower in the disturbed plots. Further, disturbance was also linked to increases in community-weighted mean trait values associated with resource-acquisitive traits, such as specific leaf area, and leaf and root nitrogen.

Discussion. Disturbance had lasting effects on the functional traits and diversity of communities, despite traditional measures of biodiversity such as richness and evenness recovering within two years. There was a discrete shift in the trait space of post-disturbance communities compared to undisturbed communities such that post-disturbance communities were dominated by traits that enhance resource uptake and growth rates. Overall, these results show that disturbance fundamentally changes the functional character of communities, even if they superficially appear recovered.

1 **Trait profiles and functional diversity following disturbance in a mixed grassland**

4 Ellen A. Smith[1], Emily M. Holden[1], Charlotte Brown[1,2], James F. Cahill Jr.[1]

6 [1]Department of Biological Sciences, University of Alberta, Edmonton, Alberta, Canada

7 [2] Department of Ecology and Evolutionary Biology, University of Arizona, Tucson, Arizona,

8 United States

11 Corresponding Author:

12 Emily M. Holden

13 CW 405, Biological Sciences Building, Department of Biological Sciences, University of

14 Alberta, Edmonton, Alberta, T6G 2E9, Canada

15 Email address: eholden@ualberta.ca

24   **Abstract**

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26   chemical properties, leading to shifts in species composition. For example, relatively rare

27   species in established communities may become dominant in successional communities if they

28   exhibit traits that are suited to disturbance conditions. Although the idea that plant species

29   exhibit different trait 'strategies' is well established, it is unclear how ecological selection for

30   specific traits may change as a function of disturbance. Further, there is little data available

31   testing whether disturbances select for single trait-characters within communities

32   (homogenization), or allow multiple trait-types to persist (diversification). We investigated how

33   (a) traits and (b) functional diversity of post-disturbance communities compared to those in

34   adjacent undisturbed grasslands, and (c) if changes in functional diversity resulted in the

35   homogenization or diversification of functional traits within local communities.

36   **Methods.** Here we emulate the impacts of an extreme disturbance in a mixed grassland site. We

37   measured plant community composition of twelve paired plots in a native grassland within the

38   central parkland of Alberta, Canada. Each pair consisted of one undisturbed plot and one which

39   had all plants terminated two years prior. We used species abundances in conjunction with a

40   local trait database to calculate community weighted means for maximum height, specific leaf

41   area, specific root length, leaf nitrogen percent, and root nitrogen percent. To test the impacts of

42   disturbance on community functional traits, we calculated functional diversity measures and

43   compared them between disturbed and undisturbed local communities.

44   **Results.** Within two years, species richness and evenness in disturbed communities had

45   recovered and was equivalent to undisturbed communities. However, disturbed and undisturbed

46   communities had distinct community compositions that differed in functional diversity.

47   Functional divergence was significantly lower in the disturbed plots. Further, disturbance was

48   also linked to increases in community-weighted mean trait values associated with resource-

49   acquisitive traits, such as specific leaf area, and leaf and root nitrogen.

50   **Discussion.** Disturbance had lasting effects on the functional traits and diversity of communities,

51   despite traditional measures of biodiversity such as richness and evenness recovering within two

52   years. There was a discrete shift in the trait space of post-disturbance communities compared to

53   undisturbed communities such that post-disturbance communities were dominated by traits that

54   enhance resource uptake and growth rates. Overall, these results show that disturbance

55   fundamentally changes the functional character of communities, even if they superficially appear

56   recovered.

57   **Introduction**

58   Habitat heterogeneity in grasslands is maintained in part by small-scale mortality

59   inducing disturbances, such fossorial mammal activity (Davidson and Lightfoot, 2008;

60   Davidson, Detling, and Brown, 2012), drought (Godfree et al., 2011), overgrazing (di Virgilio

61   and Morales, 2016), pathogens (Mursinoff and Tack, 2017), and even herbicide drift (Fried,

62   Villers, and Porcher, 2018). In extreme instances, disturbance can result in the total mortality of

63   mature vegetation (e.g. Cahill 2003). Though each of these disturbances have unique

64   characteristics, they all result in the localized death of established vegetation, creating vegetation

65   "gaps" (Suding, 2001). Gaps result in changes to competitive hierarchies and abiotic soil

66   conditions and competitive hierarchies (Suding and Goldberg, 2001; Suding, 2001), leading to

67   changes in species diversity and community composition.

68   Examining traits can shed light on the specific impacts of disturbance on plant

69   communities. Traits are measurable individual morphological, physiological, or phenological

70 characteristics that provide insight into life history strategies and influence plant ranges and

71 species interactions (Viole et al., 2007; Cadotte, Carscadden, & Mirotchnick, 2011). "Functional

72 traits" specifically impact growth, reproduction and survival (Viole et al., 2007). At small scales,

73 trait differences can influence local diversity patterns by determining competitive outcomes (Liu

74 et al., 2015). Traits can also provide insight as to species resource acquisition strategies by

75 indicating species location on the fast-slow plant economics spectrum, where "fast" strategies

76 prioritize resource acquisition and growth while "slow" strategies favour stress tolerance and

77 longevity (Reich et al., 2014). Measuring functional traits after a disturbance (such as those

78 which create gaps) can reveal how a community has changed in functional strategies and can be

79 used to examine the resulting community's functional diversity. Cadotte (2007) describes gap

80 species as prioritizing rapid resource uptake, whereas non-gap species take a slower, tolerance-

81 based approach. For example, specific leaf area (SLA) values are likely to be larger in post-

82 disturbance successional communities as high SLA is correlated to fast growth and low

83 competitive ability (Kunstler et al., 2016). Additionally, Loughnan and Gilbert (2017) found that

84 SLA may be involved with shifts in competitive ability as greater SLA is associated with more

85 sunlight acquisition and thus increased energy acquisition. Thus, changes in communities post-

86 disturbance are likely due to differences in the trait profiles of successional species.

87   It is important to note that these changes in species composition and community-level

88 traits changes may not be reflected in the total number of species in the community (i.e. species

89 richness). Disturbance may change the nature of community assembly in successional

90 communities by altering the process by which species from the regional pool are able to colonize

91 local communities (HilleRisLambers et al., 2012, Escobedo et al., 2021). Disturbance changes

92 the environmental filters which constrain species dispersal and recruitment to communities

93   (Myers et al., 2015; Brown & Cahill, 2020); in this case we would expect the resulting

94   community to contain species that possess functional traits better suited to the new set of

95   environmental filters, changing the community-level traits and functional diversity of the

96   disturbed community. Thus, if taxonomic measures like species richness or evenness remain

97   unchanged after disturbance, they may mask functional differences and result in a mirage of

98   stability when, in fact, the community has undergone great change. This emphasizes the

99   importance of studying functional traits and quantifying functional diversity to understand

100   community drivers.

101   Functional diversity is a subset of biological diversity which measures the traits present

102   in an ecosystem (Tillman, 2001). It is distinct from taxonomic diversity as it reflects the breadth

103   of the functional space occupied by species in a community (Rosenfeld, 2002; Villéger et al.,

104   2008), whereas taxonomic diversity indicates the number of species in a given community

105   separate from any measure of community function (Laliberté and Legendre, 2010). Some

106   functional diversity measures are not greatly influenced by taxonomic measures such as species

107   richness (Laliberté and Legendre, 2010) and can offer a more nuanced approach to understanding

108   community characteristics. Disturbance affects functional diversity (Parreira de Castro, Dolédec,

109   & Callisto, 2018) and can potentially result in functional homogenization, or selection for similar

110   trait-characters in species colonizing in disturbed communities (Olden et al., 2004). However,

111   resource fluxes associated with disturbance (Davis, Grime, & Thompson, 2000) may lead to trait

112   diversification within colonizing species to allow for more efficient utilization of the increased

113   resources available in disturbed communities (Chapman, Childers, & Vallino, 2016; Jentsch &

114   White, 2019). As functional diversity is associated with the provisioning of ecosystem services

115 (Díaz et al., 2007; Roscher et al., 2012; Pakeman, 2014), the homogenizing or diversifying

116 effects of disturbance on functional diversity must be better understood.

117   If species in post-disturbance areas are more likely to possess traits which support faster

118 resource acquisition (e.g. Cadotte, 2007; Kunstler et al., 2016), then shifts in trait distributions

119 after disturbance may alter functional diversity by changing the success of different trait suites to

120 favor "fast" traits prioritizing resource acquisition.at the local scale. However, it is unclear which

121 traits differ between plants in disturbed and undisturbed areas, and how these different strategies

122 are reflected in functional diversity. To resolve these outstanding questions, we ask:

123   1. How do functional traits of a grassland community change after disturbance?

124   2. How does functional diversity change after disturbance?

125   3. If functional distributions do change, will it result in the homogenization or

126   diversification of community-level traits?

127 If disturbance causes shifts in habitat filters, then we expect to observe shifts in the functional

128 trait space of the resulting community. If disturbance constrains the competitive strategies that

129 succeed in successional communities (for instance, favouring plants with resource-acquisitive

130 traits), we would expect changes in trait values (i.e. community-weighted means) and potentially

131 the homogenization of community-level traits. Alternatively, if species turnover after disturbance

132 drives shifts in community traits, we then expect to observe both taxonomic and functional trait

133 shifts, which could in turn diversify community-level traits.

134 **Methods**

135 **Study site**

136   Our study site was located in the Roy Berg Kinsella Research Ranch in Kinsella, AB,

137 Canada (53°5′ N, 111°33′ W). Data collection took place in a native grassland dominated by

138   *Hesperostipa curtiseta* (Hitchc.) Barkworth, *Festuca hallii* (Vasey) Piper and *Poa pratensis* (L.)

139   (Brown and Cahill, 2019). The site is part of the Aspen Parkland ecoregion, a savanna-type

140   habitat characterized by a mosaic of mixed-grass prairie and trembling aspen (*Populus*

141   *tremuloides* Michx.). The field site is periodically grazed by cattle with a heavy grazing event in

142   October 2019 and a light grazing event occurring in May 2020.

143   **Study design**

144   We sampled twelve plots (50 cm x 50 cm), arranged in six pairs, which were originally

145   established in 2016 (Brown & Cahill, 2020). Each pair contained an undisturbed plot, where no

146   standing vegetation was terminated, and a disturbed plot, where all standing vegetation was

147   terminated. Disturbed plots were created in May 2016, by having all biomass trimmed to the soil

148   surface and a glyphosate herbicide (Roundup©) applied to the remaining stems to ensure death

149   of the resident vegetation. This treatment was maintained through August 2018 with any

150   regenerating plant materials trimmed and painted with herbicide during the growing seasons.

151   This treatment does not represent any specific natural event, and instead is testing the extreme

152   event of complete removal of the resident vegetation. Additionally, this treatment does not

153   remove the seed bank present at the site (Brown and Cahill, 2020) and thus does not affect

154   community regeneration from seed (see Grubb, 1977).

155   Plant community composition was measured in July 2018 by visually estimating percent

156   cover of all species present within each plot. Two years post-treatment, in July 2020, plots were

157   revisited, by which time vegetation had regenerated in the disturbed plots. Community

158   composition was measured using percent cover estimation of each species. Sedges were unable

159   to be identified to species and were recorded as "*Carex* spp.".

160   *Plant traits*

161   Disturbance can alter abiotic conditions (Suding and Goldberg 2001); however, here we

162   focus on its impacts on vegetative traits. Plant trait data came from a database developed

163   principally at this field site (Cahill, 2020), thus representing local trait data. Details of trait

164   measures are found in Cahill (2020), but largely follow the methods outlined in Cornelissen et al.

165   (2003) and Pérez-Harguindeguy et al. (2013). Here we focused on five traits which encompass

166   aspects of plant structure and above- and belowground resource acquisition: maximum height,

167   specific leaf area (SLA), specific root length (SRL), leaf nitrogen percentage (N %), and root N

168   %. See Cahill (2020) for trait definitions. These traits were chosen to provide a holistic scope of

169   above and below ground functional strategies with reference to trait groups described by Cadotte

170   (2017). Site-specific trait data was available in the database for all species except for *Cirsium*

171   *vulgare* (Savi) Tenore, *Collomia linearis* Nuttall, *Gentianella amarella* (Linnaeus) Börner,

172   *Sonchus arvensis* Linnaeus, and two unidentified forbs. Trait data was obtained for species that

173   represent at least 93% of total composition, which exceeds the 80% threshold standard for trait

174   studies (Pakeman & Quested 2007).

175   *Trait profiles and functional diversity*

176   To characterize communities by their traits, we first calculated community weighted

177   means (CWMs) for five traits: SLA, maximum height, leaf N %, root N %, and SRL. CWMs are

178   the average value of a given trait in a community weighted by the abundance of all species

179   possessing said trait (Lavorel et al., 2008), and are useful for understanding community

180   properties and dynamics, as well as quantifying community change (Garnier et al., 2004, 2007;

181   Louault et al., 2005). CWMs were calculated at the species-level. While disturbance is likely to

182   result in intraspecific variability in functional traits, here we focus on species-level values as a

183   first-level test to detect if disturbance does result in persistent change to community functional

184   traits. Outlier trait values (values more than three standard deviations away from the species'

185   mean) were removed prior to calculating CWM. We then quantified the functional diversity of

186   communities using functional richness (FRic), functional evenness (FEve), functional divergence

187   (FDiv), and Rao's quadratic entropy (Q) (Villéger, Mason, & Mouillot, 2008; Mouchet et al.,

188   2010; Table 1). These metrics allow us to characterize the volume (via FRic), evenness (via

189   FEve), and spread (via FDiv and Q) of the communities' functional traits in multidimensional

190   space. By using these multivariate descriptors of communities, we are able to compare

191   communities' character before and after disturbance, as well as to determine if community traits

192   become more or less homogenous as a result of disturbance. We used package vegan (Oksanen et

193   al., 2017) in program R (v 4.0.0; R Core Team, 2020) to compute species richness and evenness,

194   using methods from Oksanen (2020). We used package FD (Laliberté, Legendre, & Shipley,

195   2014) to compute CWMs. We also computed FRic, FDiv, FEve, and Rao's Q using package FD.

196   **Statistical analysis**

197   To determine if community traits differed between control and disturbed treatments after

198   recovery, we used five separate linear models (LMs). The CWM's for SLA, height, leaf N %,

199   root N %, and SRL were used as response variables, plot type (disturbed or undisturbed) was a

200   fixed effect and plot pair (i.e., disturbed and undisturbed plot location) was a random effect. All

201   LMMs were run using an underlying normal distribution with the lme4 (Bates et al., 2015) and

202   lmerTest (Kuznetsova, Brockhoff, & Christensen, 2017) packages. We also used four separate

203   LMMs to quantify how functional diversity measures, namely FRic, FDiv, FEve, and Rao's Q,

204   differed between disturbance types. FRic, FDiv, FEve, and Roa's Q were used as response

205   variables, plot pair was included as a random effect and plot type (disturbed or undisturbed) was

206   a fixed effect in all models. Functional richness was log-transformed to fit assumptions of

207   normality. To determine whether disturbed and undisturbed communities had different

208   community compositions, we conducted a permutational multivariate analysis of variance

209   (PERMANOVA), with plot as a strata, using packages vegan and RVAideMemoire (Hervé,

210   2021).

211   **Results**

212   Between 2018 and 2020, total species richness in undisturbed plots decreased from 55 to

213   52 while average species richness in disturbed plots increased from 0 in 2018 to 53 in 2020

214   (Table S1). Six species were found only in disturbed communities (*Androsace septentrionalis*,

215   *Cirsium arvense*, *Mulgedium pulchellum*, *Thalictrum venulosum*, an unidentified *Brassicaceae*

216   plant, and an unidentified herbaceous dicot; Table S1). *Androsace septentrionalis*, *Cirsium*

217   *arvense*, and *Mulgedium pulchellum* are commonly found in disturbed areas (Tannas, 2004). In

218   particular, *Cirsium arvense* is associated high rates of reproduction and dispersal. 15 species

219   were found only in undisturbed communities (Table S1). These species, except *Fallopia*

220   *convolvulus*, are all native to Alberta (Desmet and Brouilet, 2013).

221   Despite persistent effects on local diversity, and although disturbed plots began with zero

222   species present in 2018, within two years there was no significant difference between plot-level

223   (alpha) richness and evenness between disturbed and undisturbed plots (richness = 17, evenness

224   = 0.82; Fig.1). However, underlying this similarity are differences in species composition (R^2 =

225   0.24, F = 7.06, p = 0.001; Fig. 2), with one third of plant species unique to either treatment type

226   (Fig. 1, Table S1). Post-disturbance communities were segregated from undisturbed communities

227   in multivariate space, with the exception of one disturbed/undisturbed pair (pair #12) (Fig. 2).

228   Community weighted means of SLA, leaf N %, and root N % differed between disturbed

229   and undisturbed plots, with disturbed plots typically having trait values more consistent with the

230 'fast' end of the leaf economics spectrum. Specifically, disturbed plots had significantly larger

231 CWM for SLA, leaf %N, root %N, and there was a trend towards larger root SRL (Fig.3; Table

232 2). There was no difference in CWM of maximum height, indicating a more rapid recovery to

233 overall physiognomy relative to other functional characteristics of the communities.

234   Post-disturbance communities were functionally distinct from undisturbed communities

235 after two years of recovery. Undisturbed communities showed higher FDiv values (FDiv = 0.08±

236 0.02, p = 0.0020; Fig.4). FEve (FEve = 0.07± 0.02, p = 0.0129; Fig.4), FRic (difference = 1.07±

237 1.16, p = 0.376; Fig.4), and Rao's Q (difference = 0.004± 0.002, p = 0.0733; Fig.4) were not

238 significantly different among the two treatments (Table 3).

239 **Discussion**

240   Although local communities recovered in species richness after only two years, there

241 were a number of legacies of disturbance found in functional traits. There are persistent effects of

242 disturbance on local diversity, suggesting successional communities are shaped by a combination

243 of local dispersal and niche conditions. However, given competition can be reduced by

244 disturbance (Wilson & Tilman, 1993), dispersal most likely limits recruitment in post-

245 disturbance communities. At the same time, at the plot level we find there is great stability in

246 species richness and evenness, suggesting the local structure of communities in this system is

247 highly stable but the species who fill each "role" are variable. Thus, the functional differences

248 we observe are not due to fundamental changes in the dominance structure (i.e. evenness) of

249 successional communities, but rather due to species filtering.

250 **Traits after disturbance**

251   Consistent with *a priori* expectations, we show disturbance leads to functional shifts

252 favouring species with higher SLA, leaf N %, and root N %, which are important for the rapid

253 acquisition of resources. SLA and leaf nitrogen content are widely viewed as indicative of a fast-

254 growing, rapid nutrient acquisition strategy (Wright et al., 2004; Liu et al., 2017). Greater leaf

255 nitrogen content works in concert with high SLA to increase energy exploitation through

256 improved photosynthetic capacity, as high leaf N content is necessary for photosynthetic protein

257 functioning (Wright et al., 2004). High root N is also indicative of quick resource acquisition as

258 it is related to high root respiration, high foraging ability, and low root longevity (Craine et al.,

259 2002; Reich, 2014; Roumet et al., 2016; McCormack et al., 2017). SRL, while higher in post-

260 disturbance communities, was not significantly different between plot types. Typically SRL

261 indicates potential resource uptake per root mass investment (Reich, 2014), and high SRL is

262 associated with quick growth, high foraging capacity, and lower root longevity (Comas and

263 Eissenstat, 2004; Roumet et al., 2016); as such, that disturbed communities did not show

264 significantly higher SRL is contrary to our expectations. Overall, the higher levels of SLA, leaf

265 N %, and root N % among the post-disturbance plots signal disturbed conditions permit the

266 success of quick-growing plants that can quickly access resources. Thus, it is likely that the

267 spatial variability of disturbances in this system are an important means to create functional

268 variation across the landscape.

269 Height variation in grasslands is a significant predictor of species richness and

270 community productivity (Brown and Cahill, 2019), yet we found that maximum height recovers

271 quickly (within two years) after disturbance and is not significantly different among successional

272 and undisturbed communities. This is surprising as greater height is thought to be indicative of

273 greater competitive ability (Givnish, 1995; Cornelissen et al., 2003; Falster and Westoby, 2003).

274 **Functional diversity after disturbance**

275   Disturbance causes a number of changes to functional diversity, with functional diversity

276 typically increasing in post-disturbance communities (Purschke et al., 2013; Eler et al., 2018).

277 However, we observed that disturbance either decreased or did not affect functional diversity

278 measures. There was no difference in FRic values between the disturbed and undisturbed plots,

279 indicating both treatments filled the same amount of functional niche space (Schleuter et al.,

280 2010). Similarly, FEve did not differ between treatments, denoting that species abundances

281 and/or the functional distances between species were equally even in disturbed and undisturbed

282 plots. However, FDiv values were significantly higher in undisturbed communities. Lower FDiv

283 values in the disturbed plots signify that the most abundant species in disturbed plots had more

284 homogenous trait ranges. Thus, while disturbance does not affect the breadth or evenness of

285 community functional traits, it does lower FDiv, promoting homogenization of functional

286 diversity.

287 **Conclusions**

288   Overall, we found while traditional metrics of community composition such as species

289 richness and evenness recovered within two years of disturbance, there were persistent impacts

290 of disturbance on community-level traits and functional diversity. SLA, leaf N %, and root N %

291 values were significantly larger in the disturbed condition, supporting the conclusion that species

292 in post-disturbance areas are more likely to possess traits that support faster resource acquisition.

293 The prevalence of individuals possessing these "fast" traits was reflected in distinct differences

294 in community membership among undisturbed and post-disturbance communities. Disturbance

295 also impacted functional diversity by promoting homogenization of community's functional

296 traits. In all, this work suggests functional trait shifts from small disturbances are a critical

297   mechanism for maintaining spatial heterogeneity in grassland systems, even as species richness

298   and evenness recover.

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Functional diversity metric definitions.

Functional diversity metric definitions	
Functional diversity (FD)	The functional space occupied by species, where axes are functional features (Rosenfeld, 2009; Villeger et al. 2008). The functional differences between a group of species (Tillman, 2001)
Functional richness (FRic)	The breadth of functional space filled by a communities (Villeger et al. 2008)
Functional evenness (FEve)	The evenness of the distribution of abundances and functional features of species (Villeger et al. 2008)
Functional divergence (FDiv)	The average distance of species abundances from the centre of functional space (Mouchet et al. 2010)
Rao's quadratic entropy (Q)	The average functional distance between two randomly selected species in a group (Mouchet et al. 2010).

Results of the linear mixed models (LMM) for traits.

Community weighted means for specific leaf area (SLA), height, shoot percent nitrogen (shoot N %), root percent nitrogen (root N %), and specific root length (SRL) were used as response variables in separate models. Plot pair (i.e., disturbed and undisturbed plot location) was a random effect and plot type (disturbed or undisturbed) was used as the fixed effect. SE stands for standard error and df denotes degrees of freedom. Bold type indicates significant results.

	Disturbed plot mean ± SE	Undisturbed plot mean ± SE	df	p-value
Maximum height (cm)	35.78 (± 0.03)	36.30 (± 0.02)	11	0.66
Specific leaf area (cm^2/g)	139.96 (± 3.27)	119.34 (± 2.69)	11	**2.64×10^{-5}**
Specific root length (cm/g)	5612.82 (± 492.72)	4550.30 (± 398.71)	11	0.09
Leaf nitrogen (%)	1.92 (± 0.06)	1.74 (± 0.03)	11	**0.01**
Root nitrogen (%)	1.05 (± 0.03)	0.95 (± 0.02)	11	**0.02**

Results of the linear mixed models (LMM) for functional diversity.

Functional richness (FRic), functional divergence (FDiv), functional evenness (FEve), and Rao's Q were used as response variables in separate models. Plot pair (i.e., disturbed and undisturbed plot location) was a random effect and plot type (disturbed or undisturbed) was a fixed effect. SE stands for standard error and df denotes degrees of freedom. Bold type indicates significant results.

	Disturbed plot mean ± SE	Undisturbed plot mean ± SE	df	*p*-value
FRic (log transformed)	-39.96 (± 0.99)	-38.75 (± 0.85)	11	0.345
FEve	0.66 (± 0.02)	0.69 (± 0.02)	11	0.218
FDiv	0.73 (± 0.02)	0.81 (± 0.02)	11	**0.003**
Rao's Q	0.02 (± 0.001)	0.02 (± 0.002)	11	0.078

Figure 1

Average species richness of disturbed and undisturbed plots in 2018 and 2020.

In disturbed plots, all biomass was trimmed to the soil surface and a glyphosate herbicide (Roundup©) applied to the remaining stems to ensure death of the resident vegetation from 2016 - 2018. Plots were allowed to regenerate from 2018 - 2020. Undisturbed plots had no standing vegetation removed. Species richness was recorded in the summer of 2020. Error bars represent standard error.
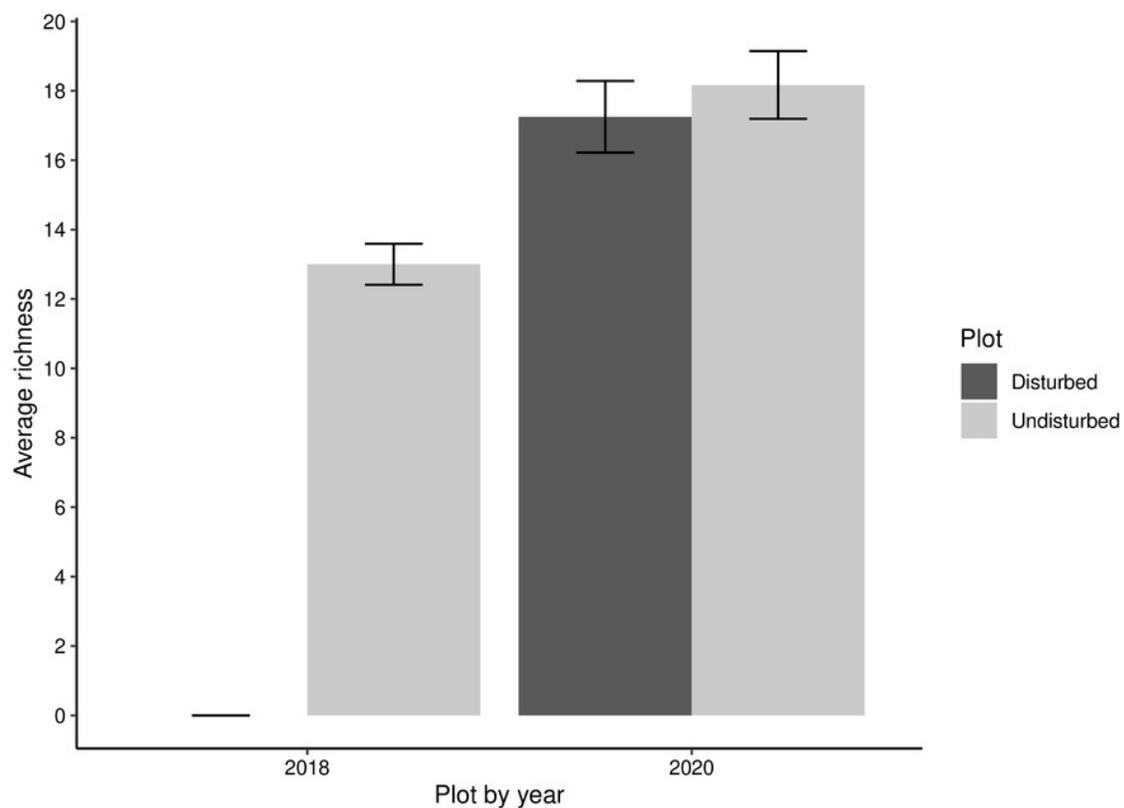
Figure 2

Metric multidimensional scaling (MDS) of disturbed and undisturbed community composition.

Data points denote 2020 plant community composition in disturbed and undisturbed plots. In disturbed plots, all biomass was trimmed to the soil surface and a glyphosate herbicide (Roundup©) applied to the remaining stems to ensure death of the resident vegetation from 2016 - 2018. Plots were allowed to regenerate from 2018 - 2020. Undisturbed plots had no standing vegetation removed. Community composition was assessed in the summer of 2020.
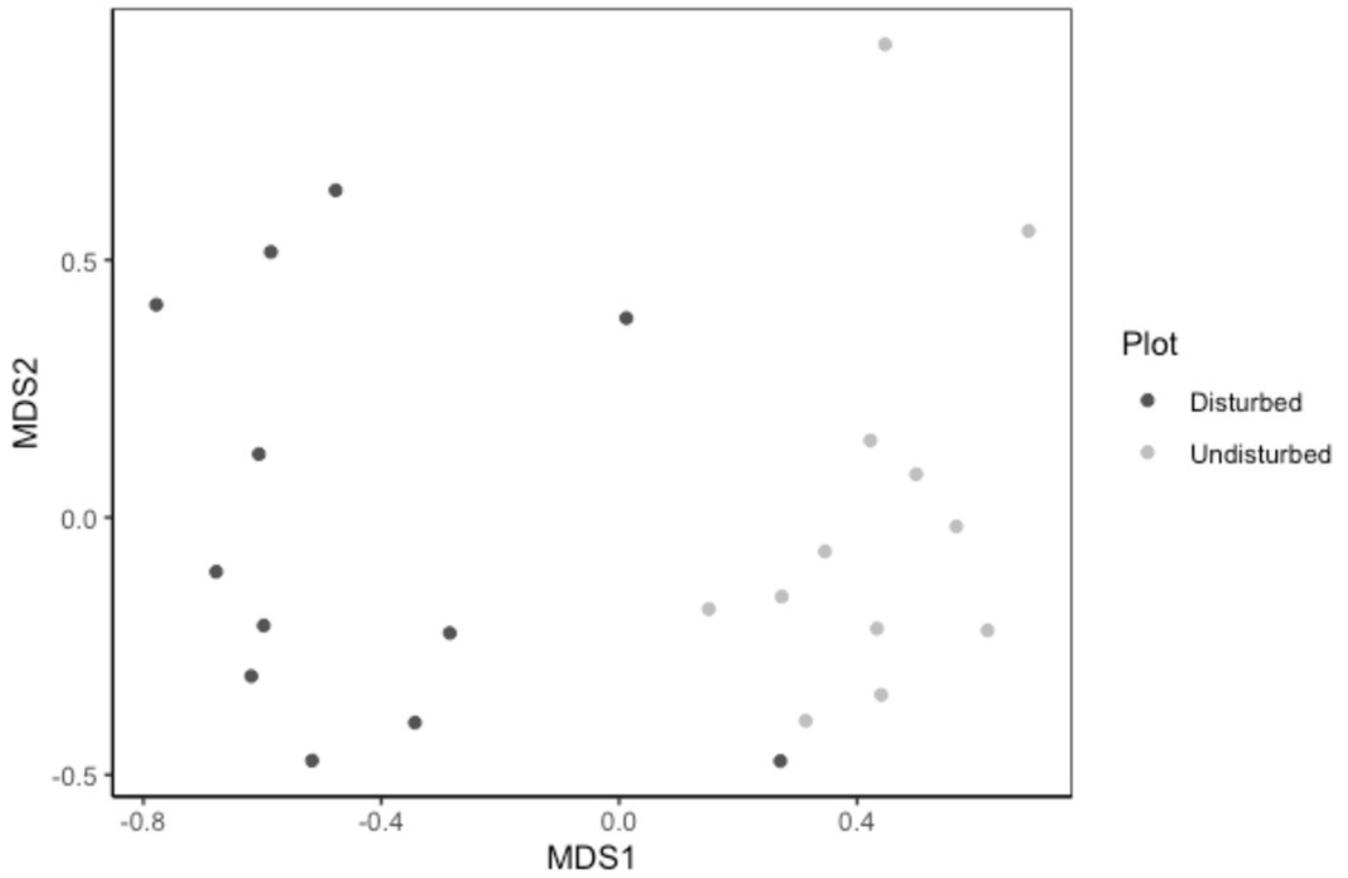
Figure 3

Mean trait values in 2020 disturbed and undisturbed communities.

Comparisons of specific root length, maximum height, specific leaf area, root nitrogen, and leaf nitrogen between disturbed and undisturbed communities. Error bars represent standard error. Associated statistics are found in Table 2.
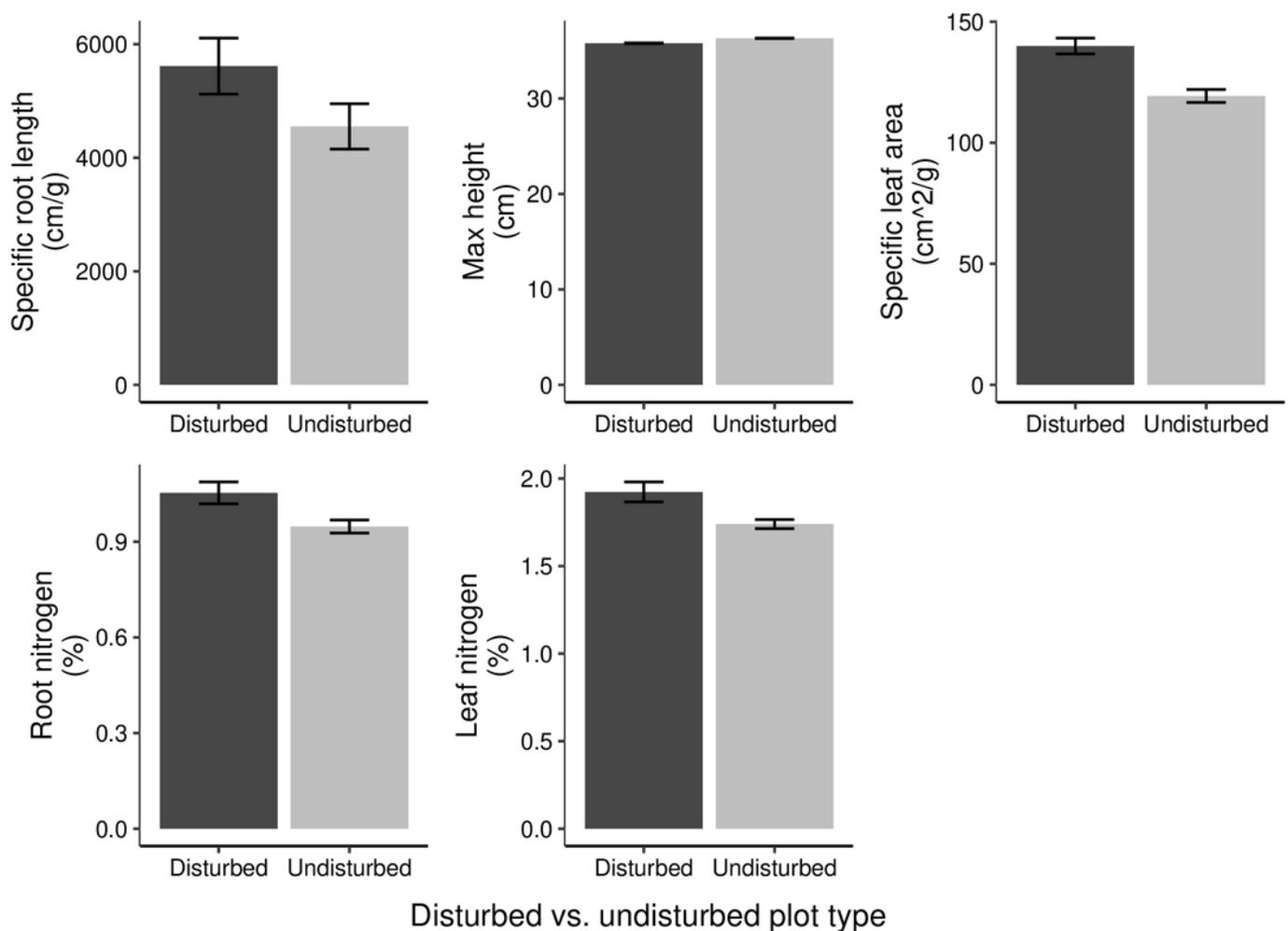
Figure 4

Estimates of functional diversity values in 2020 disturbed and undisturbed communities.

Comparisons of functional richness, functional evenness, functional divergence, and Rao's quadratic entropy between disturbed and undisturbed communities. Functional richness was log-transformed to meet the assumption of normality and was multiplied by negative one. Error bars represent standard error. Associated statistics are found in Table 3.