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vegetation ecology
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Plant beta diversity and its correlation with elevation at various distances scale in a 24 ha mid-subtropical evergreen broad-leaved forest in East Asia

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Beta diversity

(Whittaker 1960; 1972)

Comparing the species diversity between ecosystems or along environmental gradients.

Gives a quantitative measure of diversity of communities that experience changing environments.

Distance

Research area and hotspots

- Diversity description (Whittaker 1960; Hutchinson 1957; Sorenson 1948; *Condit et al.* 2002)
- Underline and mechanisms of beta diversity and its different patterns (Harms *et al.* 2001; Tilman 2004; Pierre *et al.* 2008)
- Biodiversity correlation with environment factors, spatially-structured habitat processes on the distributions of species richness and species composition (Karst *et al.* 2005; Gravel *et al.* 2006; Borda de Agua *et al.* 2007; Pierre *et al.* 2008; Mi *et al.* 2008)
- Niche-based model and neutral theory (Hubbell 2001; *Condit et al.* 2002; Pierre *et al.* 2008)

Similarity index

Whittaker index

$$\beta = \frac{S}{\bar{\alpha}} \quad or \quad \beta = \frac{S}{\bar{\alpha}} - 1$$

Jaccard index

β = j/(a+b-j)

Sorenson index

β =2*j/(a+b)

$$J(A,B) = \frac{|A \cap B|}{|A \cup B|}$$

	Assemblage 2	
	Present	Absent
Assemblage 1		
Present	A	B
Absent	C	–

Questions:

How similarity index varies with different distance in our plot and how they associate with other ecological variations (habitat)?

Study sites

Center for Tropical Forest Science (CTFS)

GTS Plot (29° 10'19"N, 118° 03'49"E)

24 ha (600m*400m), 600 20*20m quadrats

159 species, 141002 individual

Location, Topography

Quadrat	Elevation	Species	Abundance
0101	325.2	*S. superba*	4
…	…	…	…
…	…	…	…

Analysis

Advanced versiong of similarity index

$$Jaccard_{abd} = \frac{A}{A+B+C} = \frac{UV}{U+V-UV} \quad (1)$$

$$Sorenson_{abd} = \frac{2A}{2A+B+C} = \frac{2UV}{U+V} \quad (2)$$

Chao *et al.* 2005

Method

$$Jaccard_{abd} = \frac{A}{A+B+C} = \frac{UV}{U+V-UV} \quad (1)$$

$$Sorenson_{abd} = \frac{2A}{2A+B+C} = \frac{2UV}{U+V} \quad (2)$$

U total respective abundances of shared species in Assemblages 1

V total respective abundances of shared species in Assemblages 2

Method

380	144400	144800	146000	148000	150800	154400	158800	164000	170000	176800	184400	192800	202000	212000	222800	234400
360	129600	130000	131200	133200	136000	139600	144000	149200	155200	162000	169600	178000	187200	197200	208000	219600
340	115600	116000	117200	119200	122000	125600	130000	135200	141200	148000	155600	164000	173200	183200	194000	205600
320	102400	102800	104000	106000	108800	112400	116800	122000	128000	134800	142400	150800	160000	170000	180800	192400
300	90000	90400	91600	93600	96400	100000	104400	109600	115600	122400	130000	138400	147600	157600	168400	**180000**
280	78400	78800	80000	82000	84800	88400	92800	98000	104000	110800	118400	126800	136000	146000	**156800**	**168400**
260	67600	68000	69200	71200	74000	77600	82000	87200	93200	100000	107600	116000	125200	**135200**	**146000**	**157600**
240	57600	58000	59200	61200	64000	67600	72000	77200	83200	90000	97600	106000	**115200**	**125200**	**136000**	**147600**
220	48400	48800	50000	52000	54800	58400	62800	68000	74000	80800	88400	**96800**	**106000**	**116000**	**126800**	**138400**
200	40000	40400	41600	43600	46400	50000	54400	59600	65600	72400	**80000**	**88400**	**97600**	**107600**	**118400**	**130000**
180	32400	32800	34000	36000	38800	42400	46800	52000	58000	**64800**	**72400**	**80800**	**90000**	**100000**	**110800**	**122400**
160	25600	26000	27200	29200	32000	35600	40000	45200	**51200**	**58000**	**65600**	**74000**	**83200**	**93200**	**104000**	**115600**
140	19600	20000	21200	23200	26000	29600	34000	**39200**	**45200**	**52000**	**59600**	**68000**	**77200**	**87200**	**98000**	**109600**
120	14400	14800	16000	18000	20800	24400	**28800**	**34000**	**40000**	**46800**	**54400**	**62800**	**72000**	**82000**	**92800**	**104400**
100	10000	10400	11600	13600	16400	**20000**	**24400**	**29600**	**35600**	**42400**	**50000**	**58400**	**67600**	**77600**	**88400**	**100000**
80	6400	6800	8000	10000	**12800**	**16400**	**20800**	**26000**	**32000**	**38800**	**46400**	**54800**	**64000**	**74000**	**84800**	**96400**
60	3600	4000	5200	**7200**	**10000**	**13600**	**18000**	**23200**	**29200**	**36000**	**43600**	**52000**	**61200**	**71200**	**82000**	**93600**
40	1600	2000	**3200**	**5200**	**8000**	**11600**	**16000**	**21200**	**27200**	**34000**	**41600**	**50000**	**59200**	**69200**	**80000**	**91600**
20	400	**800**	**2000**	**4000**	**6800**	**10400**	**14800**	**20000**	**26000**	**32800**	**40400**	**48800**	**58000**	**68000**	**78800**	**90400**
NA	**0**	**400**	**1600**	**3600**	**6400**	**10000**	**14400**	**19600**	**25600**	**32400**	**40000**	**48400**	**57600**	**67600**	**78400**	**90000**
NA	NA	**20**	**40**	**60**	**80**	**100**	**120**	**140**	**160**	**180**	**200**	**220**	**240**	**260**	**280**	**300**

Distance gradients of all kinds of neighborhoods

Method

246800	260000	274000	288800	304400	320800	338000	356000	374800	394400	414800	436000	458000	480800	380
232000	245200	259200	274000	289600	306000	323200	341200	360000	379600	400000	421200	443200	466000	360
218000	231200	245200	260000	275600	292000	309200	327200	346000	365600	386000	407200	429200	452000	340
204800	218000	232000	246800	262400	278800	296000	314000	332800	352400	372800	394000	416000	438800	320
192400	205600	219600	234400	250000	266400	283600	301600	320400	340000	360400	381600	403600	426400	300
180800	194000	208000	222800	238400	254800	272000	290000	308800	328400	348800	370000	392000	414800	280
170000	183200	197200	212000	227600	244000	261200	279200	298000	317600	338000	359200	381200	404000	260
160000	173200	187200	202000	217600	234000	251200	269200	288000	307600	328000	349200	371200	394000	240
150800	164000	178000	192800	208400	224800	242000	260000	278800	298400	318800	340000	362000	384800	220
142400	155600	169600	184400	200000	216400	233600	251600	270400	290000	310400	331600	353600	376400	200
134800	148000	162000	176800	192400	208800	226000	244000	262800	282400	302800	324000	346000	368800	180
128000	141200	155200	170000	185600	202000	219200	237200	256000	275600	296000	317200	339200	362000	160
122000	135200	149200	164000	179600	196000	213200	231200	250000	269600	290000	311200	333200	356000	140
116800	130000	144000	158800	174400	190800	208000	226000	244800	264400	284800	306000	328000	350800	120
112400	125600	139600	154400	170000	186400	203600	221600	240400	260000	280400	301600	323600	346400	100
108800	122000	136000	150800	166400	182800	200000	218000	236800	256400	276800	298000	320000	342800	80
106000	119200	133200	148000	163600	180000	197200	215200	234000	253600	274000	295200	317200	340000	60
104000	117200	131200	146000	161600	178000	195200	213200	232000	251600	272000	293200	315200	338000	40
102800	116000	130000	144800	160400	176800	194000	212000	230800	250400	270800	292000	314000	336800	20
102400	115600	129600	144400	160000	176400	193600	211600	230400	250000	270400	291600	313600	336400	NA
320	340	360	380	400	420	440	460	480	500	520	540	560	580	NA

Distance gradients of all kinds of neighborhoods

Method

Association with beta diversity topography

Mantel test **(Mantel 1971)**

Whether there were significant interrelations between plant beta diversity and elevation

Result

```
> res.beta[1:12,]
   distance subplot.a subplot.b   jaccard  sorenson a.jaccard a.sorenson  a  b  j charich1 charich2
1       400    990101    990102 0.5744681 0.7297297 0.8503461  0.9191211 39 35 27       12        8
2       400    990102    990202 0.4375000 0.6086957 0.7398394  0.8504686 35 34 21       14       13
3       400    990103    990102 0.6888889 0.8157895 0.9242130  0.9606140 41 35 31       10        4
4       400    990104    990103 0.4912281 0.6588235 0.7770785  0.8745573 44 41 28       16       13
5       400    990104    990204 0.5744681 0.7297297 0.8146308  0.8978475 44 30 27       17        3
6       400    990105    990104 0.6153846 0.7619048 0.8892372  0.9413717 40 44 32        8       12
7       400    990106    990105 0.6078431 0.7560976 0.8243041  0.9036916 42 40 31       11        9
8       400    990107    990106 0.6382979 0.7792208 0.8051824  0.8920787 35 42 30        5       12
9       400    990107    990108 0.5238095 0.6875000 0.8118429  0.8961516 35 29 22       13        7
10      400    990108    990208 0.6000000 0.7500000 0.8463893  0.9168048 29 43 27        2       16
11      400    990109    990108 0.4888889 0.6567164 0.8517760  0.9199557 38 29 22       16        7
12      400    990109    990110 0.8205128 0.9014085 0.9686920  0.9840971 38 33 32        6        1
           U         V abun1 abun2 abunsim1 abunsim2    eleva     elevb     delev
1  0.9095745 0.9288703   188   239      171      222 54.89275  57.99200  -3.09925
2  0.7949791 0.9142857   239   210      190      192 57.99200  36.62350  21.36850
3  0.9507246 0.9707113   345   239      328      232 54.50325  57.99200  -3.48875
4  0.8625000 0.8869565   240   345      207      306 47.89600  54.50325  -6.60725
5  0.8541667 0.9462366   240   186      205      176 47.89600  34.69950  13.19650
6  0.9583333 0.9250000   216   240      207      222 46.18900  47.89600  -1.70700
7  0.8663102 0.9444444   187   216      162      204 51.84300  46.18900   5.65400
8  0.9657143 0.8288770   175   187      169      155 60.73600  51.84300   8.89300
9  0.8514286 0.9458333   175   240      149      227 60.73600  73.48775 -12.75175
10 0.9875000 0.8555556   240   270      237      231 73.48775  68.00475   5.48300
11 0.8775510 0.9666667   294   240      258      232 89.08200  73.48775  15.59425
12 0.9727891 0.9956710   294   231      286      230 89.08200 104.62625 -15.54425
> 
```

Result data pattern of beta diversity relative variation within 20m in GTS plot   **dim =c(179700, 21)**

Result

```
> sort(unique(res.beta$distance))
  [1]    400    800   1600   2000   3200   3600   4000   5200   6400   6800   7200   8000  10000
 [14]  10400  11600  12800  13600  14400  14800  16000  16400  18000  19600  20000  20800  21200
 [27]  23200  24400  25600  26000  27200  28800  29200  29600  32000  32400  32800  34000  35600
 [40]  36000  38800  39200  40000  40400  41600  42400  43600  45200  46400  46800  48400  48800
 [53]  50000  51200  52000  54400  54800  57600  58000  58400  59200  59600  61200  62800  64000
 [66]  64800  65600  67600  68000  69200  71200  72000  72400  74000  77200  77600  78400  78800
 [79]  80000  80800  82000  83200  84800  87200  88400  90000  90400  91600  92800  93200  93600
 [92]  96400  96800  97600  98000 100000 102400 102800 104000 104400 106000 107600 108800 109600
[105] 110800 112400 115200 115600 116000 116800 117200 118400 119200 122000 122400 125200 125600
[118] 126800 128000 129600 130000 131200 133200 134800 135200 136000 138400 139600 141200 142400
[131] 144000 144400 144800 146000 147600 148000 149200 150800 154400 155200 155600 156800 157600
[144] 158800 160000 160400 161600 162000 163600 164000 166400 168400 169600 170000 173200 174400
[157] 176400 176800 178000 179600 180000 180800 182800 183200 184400 185600 186400 187200 190800
[170] 192400 192800 193600 194000 195200 196000 197200 200000 202000 203600 204800 205600 208000
[183] 208400 208800 211600 212000 213200 215200 216400 217600 218000 219200 219600 221600 222800
[196] 224800 226000 227600 230400 230800 231200 232000 233600 234000 234400 236800 237200 238400
[209] 240400 242000 244000 244800 245200 246800 250000 250400 251200 251600 253600 254800 256000
[222] 256400 259200 260000 261200 262400 262800 264400 266400 269200 269600 270400 270800 272000
[235] 274000 275600 276800 278800 279200 280400 282400 283600 284800 288000 288800 289600 290000
[248] 291600 292000 293200 295200 296000 298000 298400 301600 302800 304400 306000 307600 308800
[261] 309200 310400 311200 313600 314000 315200 317200 317600 318800 320000 320400 320800 323200
[274] 323600 324000 327200 328000 328400 331600 332800 333200 336400 336800 338000 339200 340000
[287] 341200 342800 346000 346400 348800 349200 350800 352400 353600 356000 359200 360000 360400
[300] 362000 365600 368800 370000 371200 372800 374800 376400 379600 381200 381600 384800 386000
[313] 392000 394000 394400 400000 403600 404000 407200 414800 416000 421200 426400 429200 436000
[326] 438800 443200 452000 458000 466000 480800
```

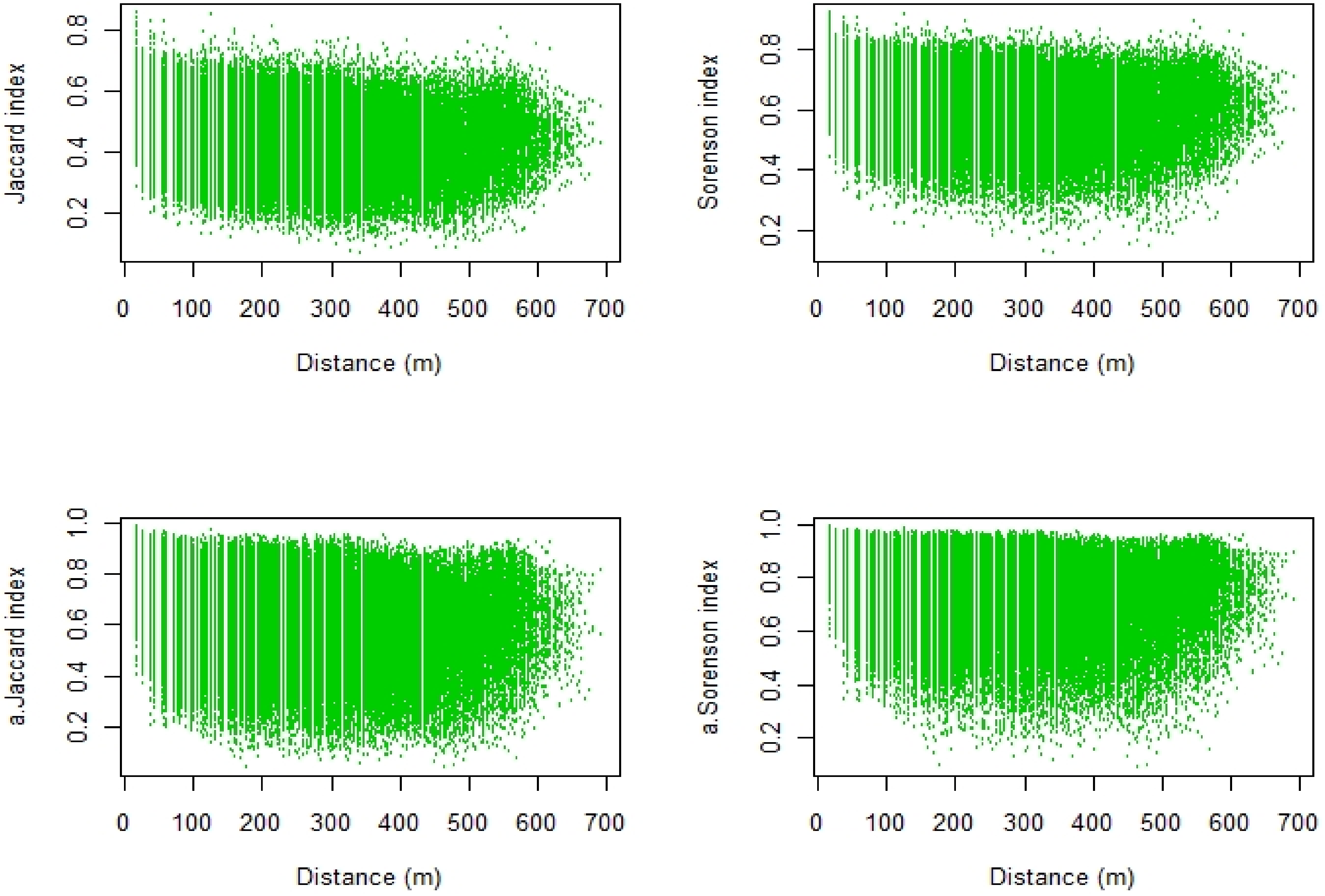
Distance variation between neighbors in GTS plot within 20m scale

Result

```
> str(res.beta)
'data.frame':   179700 obs. of  21 variables:
 $ distance  : int  400 400 400 400 400 400 400 400 400 400 ...
 $ subplot.a : int  990101 990102 990103 990104 990104 990105 990106 990107 990107 990108 ...
 $ subplot.b : int  990102 990202 990102 990103 990204 990104 990105 990106 990108 990208 ...
 $ jaccard   : num  0.574 0.438 0.689 0.491 0.574 ...
 $ sorenson  : num  0.730 0.609 0.816 0.659 0.730 ...
 $ a.jaccard : num  0.850 0.740 0.924 0.777 0.815 ...
 $ a.sorenson: num  0.919 0.850 0.961 0.875 0.898 ...
 $ a         : int  39 35 41 44 44 40 42 35 35 29 ...
 $ b         : int  35 34 35 41 30 44 40 42 29 43 ...
 $ j         : int  27 21 31 28 27 32 31 30 22 27 ...
 $ charich1  : int  12 14 10 16 17 8 11 5 13 2 ...
 $ charich2  : int  8 13 4 13 3 12 9 12 7 16 ...
 $ U         : num  0.910 0.795 0.951 0.863 0.854 ...
 $ V         : num  0.929 0.914 0.971 0.887 0.946 ...
 $ abun1     : int  188 239 345 240 240 216 187 175 175 240 ...
 $ abun2     : int  239 210 239 345 186 240 216 187 240 270 ...
 $ abunsim1  : int  171 190 328 207 205 207 162 169 149 237 ...
 $ abunsim2  : int  222 192 232 306 176 222 204 155 227 231 ...
 $ eleva     : num  54.9 58.0 54.5 47.9 47.9 ...
 $ elevb     : num  58.0 36.6 58.0 54.5 34.7 ...
 $ delev     : num  -3.10 21.37 -3.49 -6.61 13.20 ...
```

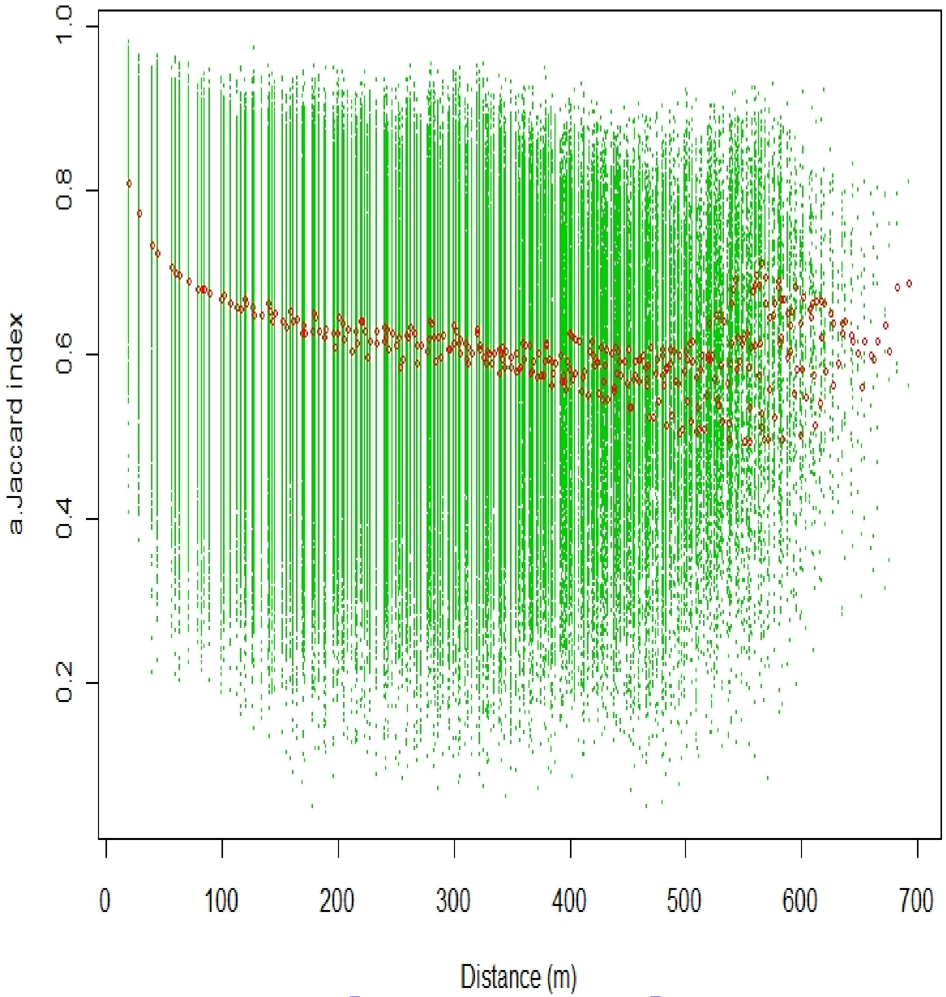
Result

Four similarity indices distribution along neighbors' distance within 20m

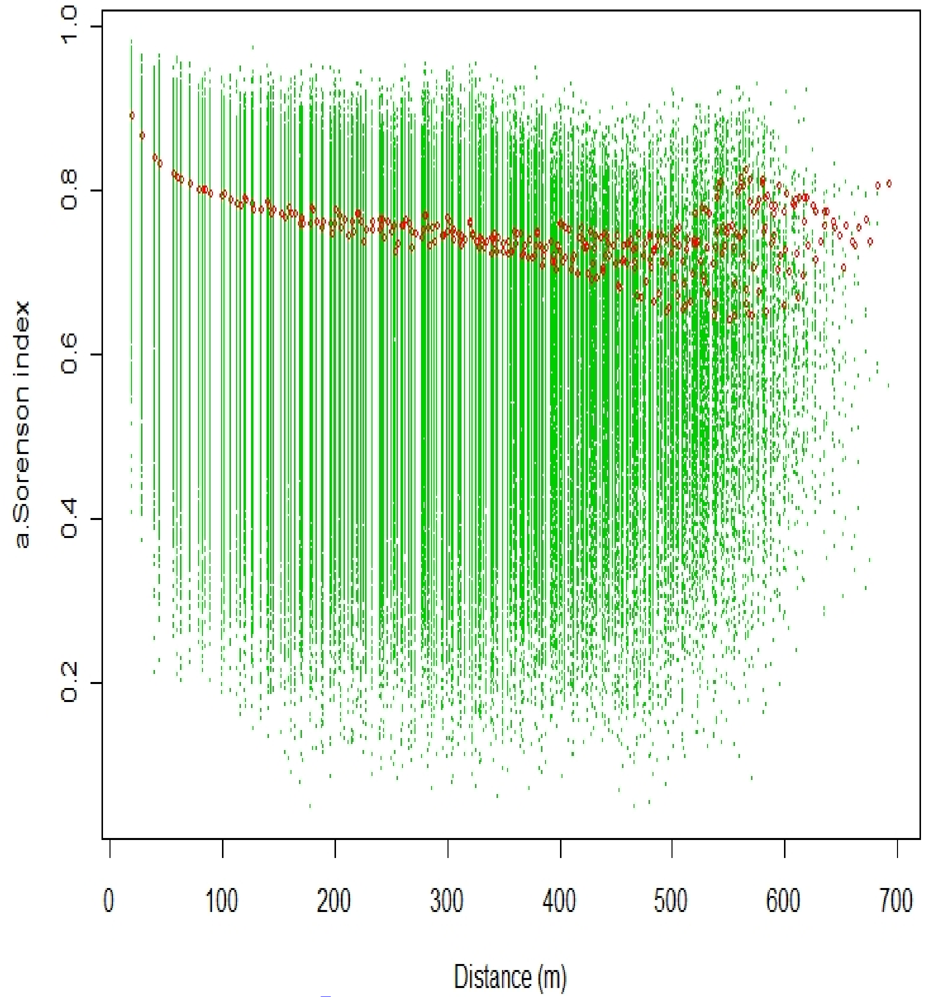


Result

Chao's similarity distribution along neighbors' distance within 20m



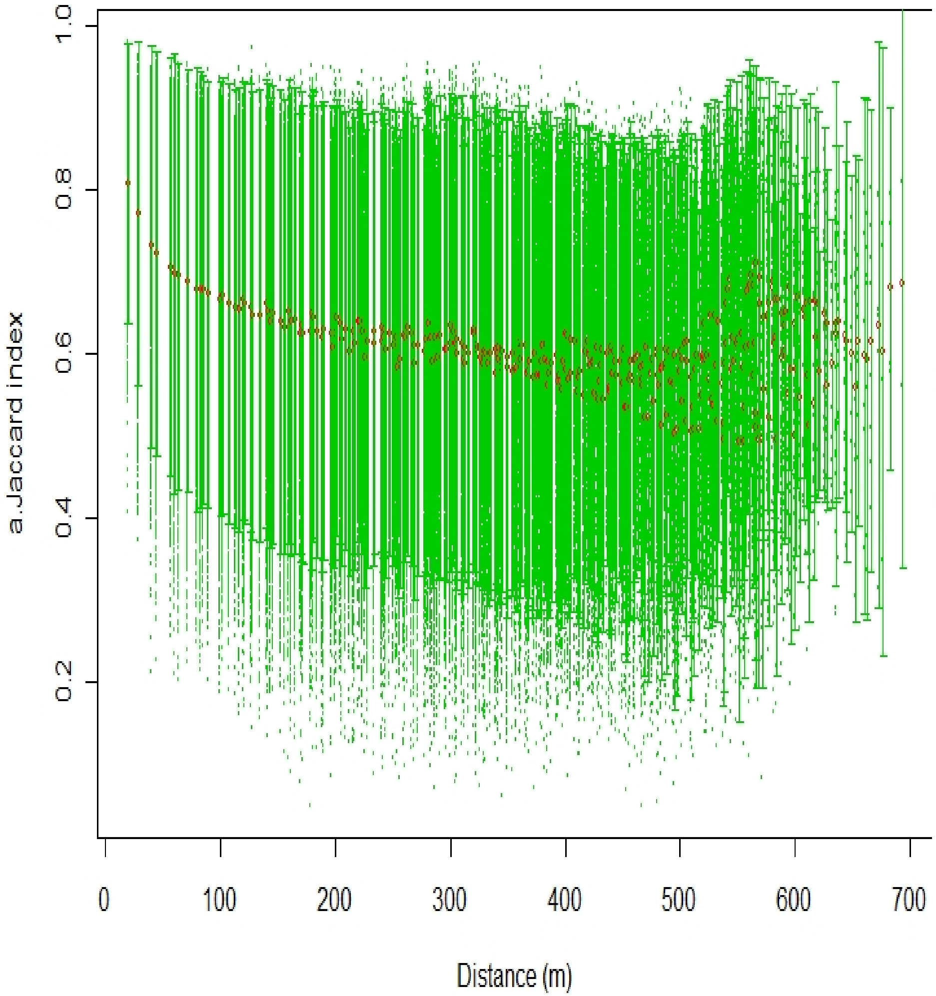
Chao's Jaccard



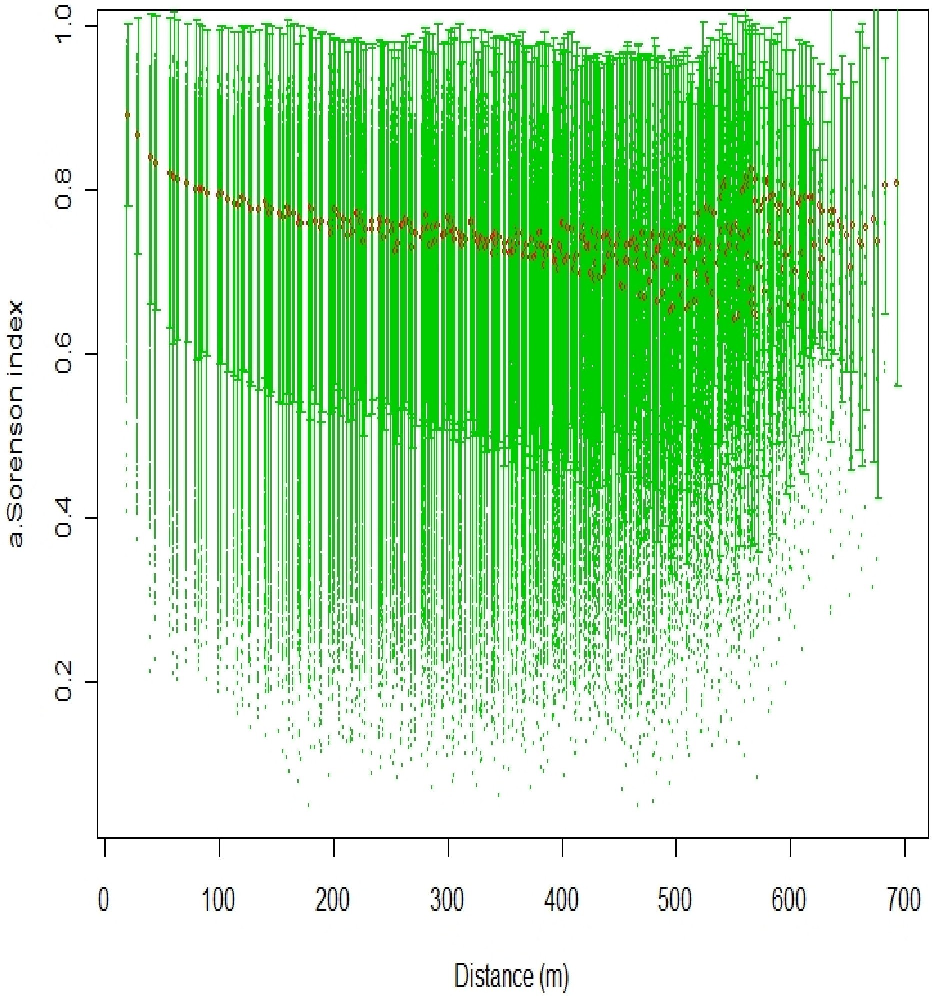
Chao's Sorenson

Result

Chao's similarity distribution along neighbors' distance within 20m

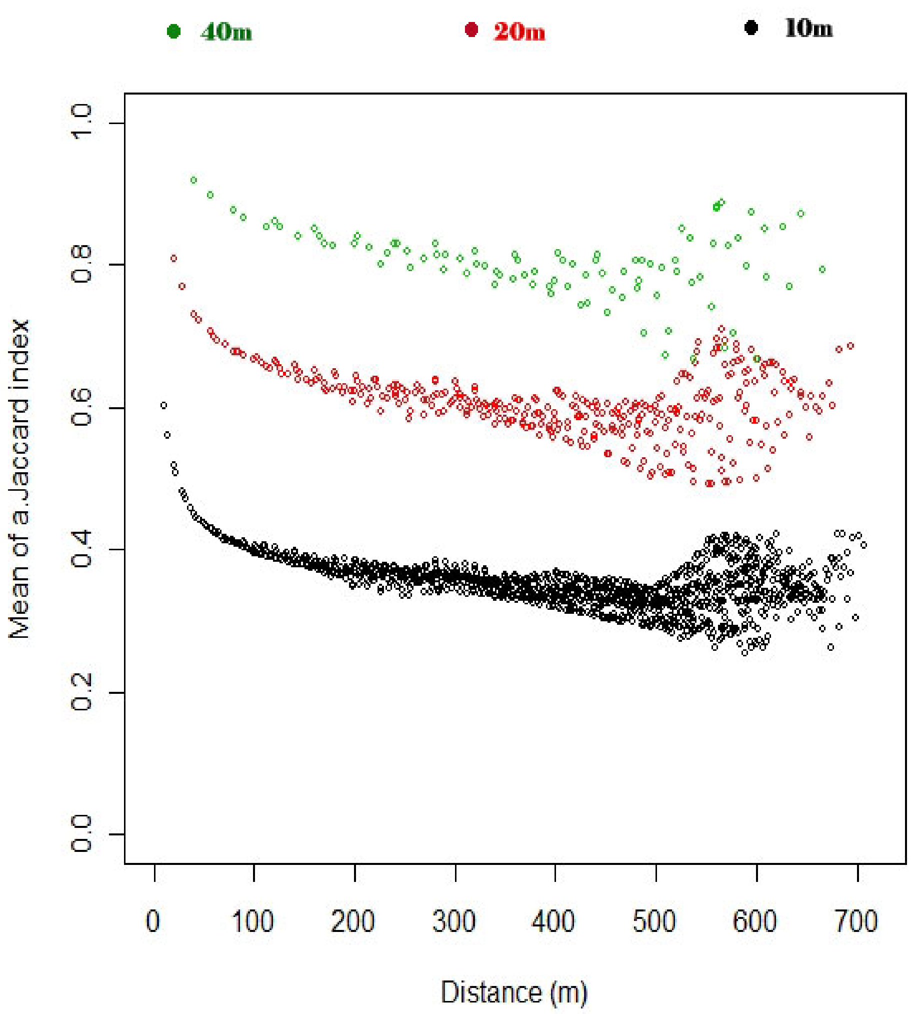


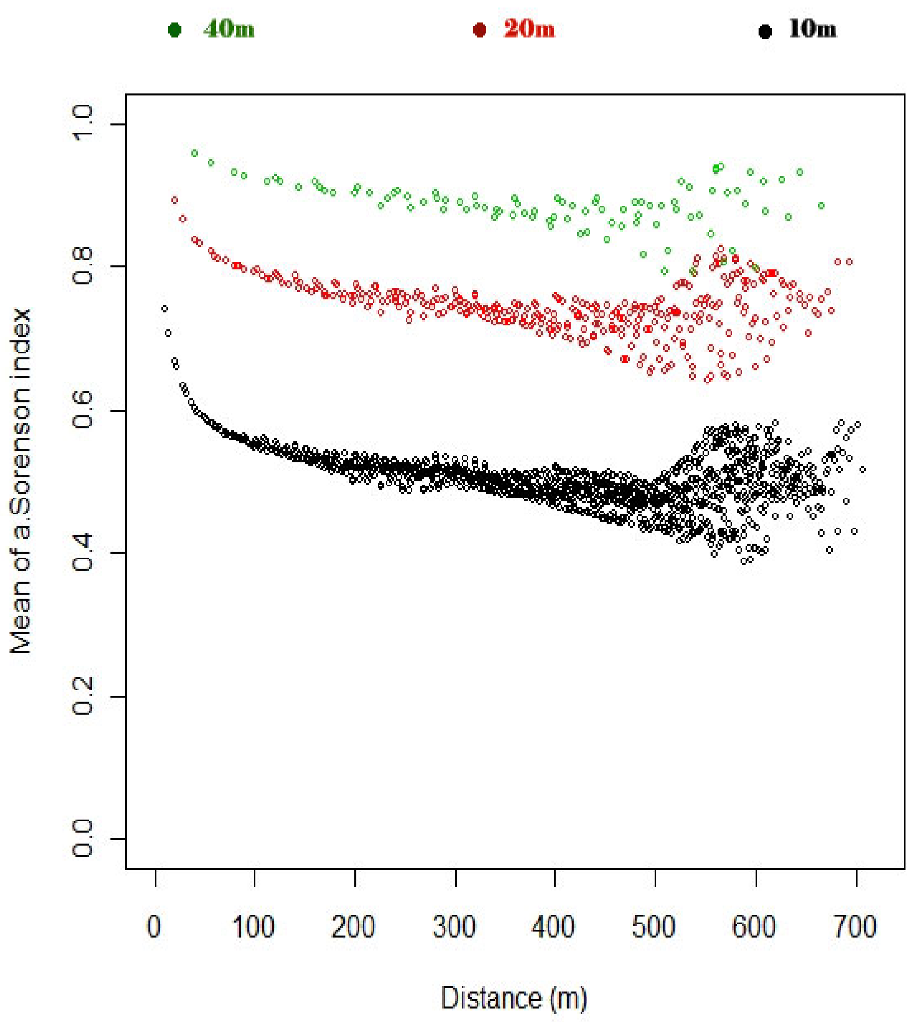
Chao's Jaccard



Chao's Sorenson

Result


40m
20m
10m
Mean of a.Jaccard index
0.0
0.2
0.4
0.6
0.8
1.0
0
100
200
300
400
500
600
700
Distance (m)


40m
20m
10m
Mean of a.Sorenson index
0.0
0.2
0.4
0.6
0.8
1.0
0
100
200
300
400
500
600
700
Distance (m)

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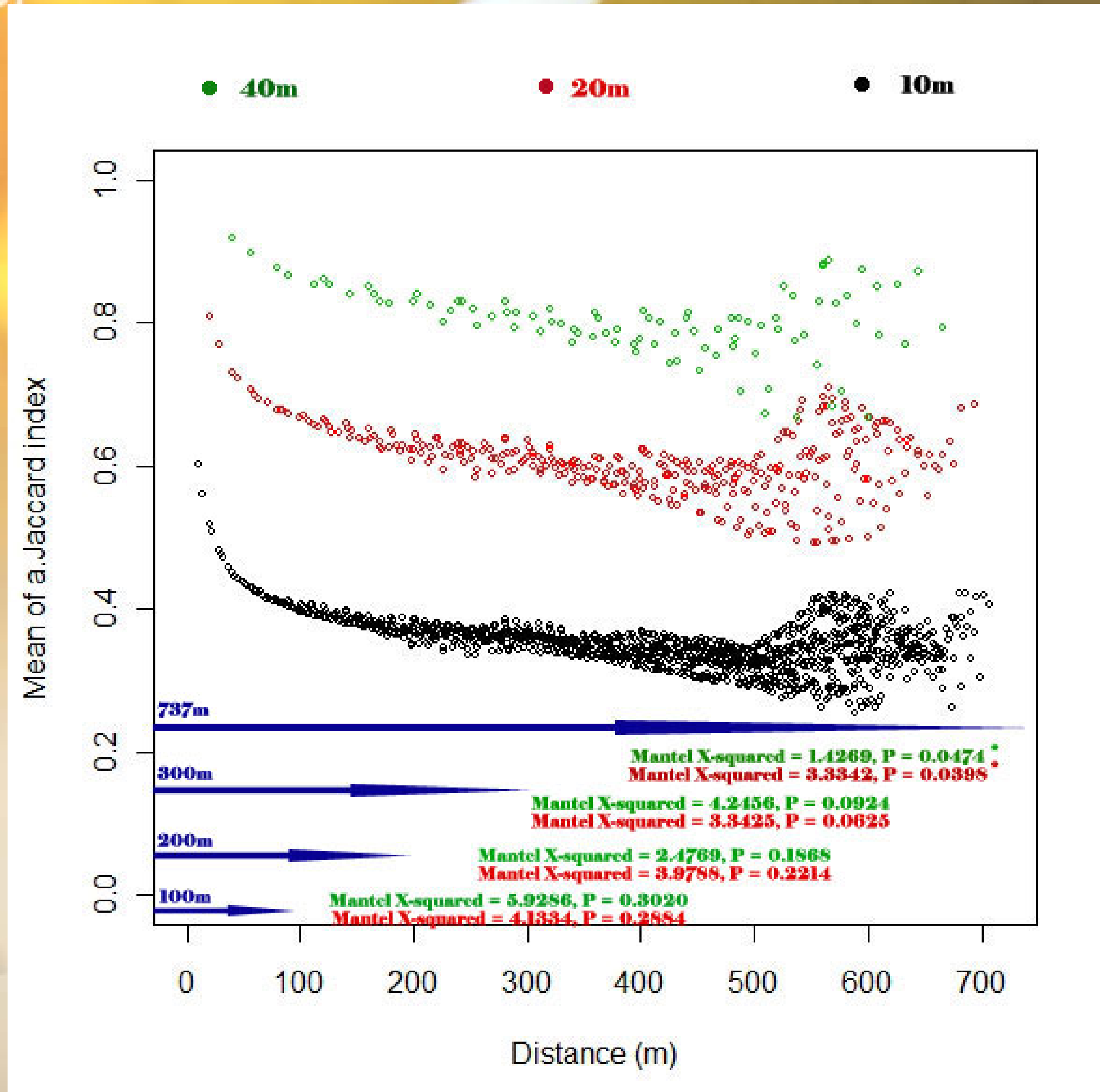
Result

Beta diversity

Elevation

Mantel test



Discussion

- **Beta diversity decay along distance gradient**
- **Association between beta diversity and elevation**
- **Different distance scales**

Next step

- Association with plant beta diversity and other topography variations
- Modeling
- Non-phylogenetic based classifications ：

  traits / functional types

Thanks Fangliang He (University of Alberta, Canada) for his valuable advice

Thanks for your attention !