Beyond the tropics: forest structure in a temperate forest mapped plot

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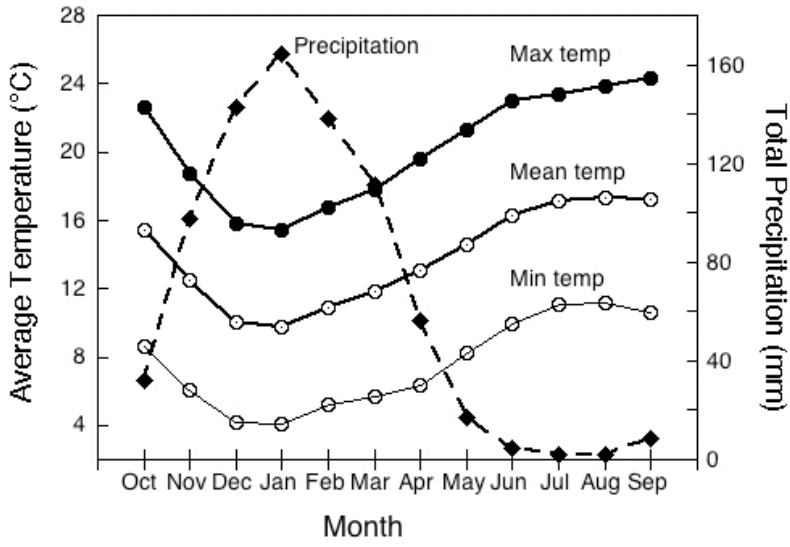
Electronic Appendices



Appendix 1. Weather patterns for Santa Cruz, California (HCND station 047916). Shown are monthly averages (1948-2007) for minimum, average, and maximum daily temperatures, and total precipitation. Data are from the NOAA National Weather Service Cooperative Observer Network Program, available from the Western Regional Climate Center (http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca7916). Precipitation is highly seasonal with 96% of the average yearly total of 776.3 mm precipitation falling between October and April.

Appendix 2. Location (country, latitude, meters above sea level), annual precipitation (mm), number of months with < 100 mm rain, number of species per hectare (S), and Fisher's alpha (α) by minimum stem diameter in 14 published tropical CTFS plots. Data are presented for comparative purposes in the text.

				DBH ≥ 1 cm		DBH ≥ 5 cm		DBH ≥ 10 cm		DBH ≥ 20 cm	
CTFS sites[1]	Location	mm ppt.	Dry mo.	S	α	S	α	S	α	S	α
BCI	Panama, 09°09'N, 125m	2551	3	169	34.6	128	39.0	91	35.6	53	28.5
Bukit Timah	Singapore, 01°15'N, 70m	2473	0	276	60.0			113	51.2		
HKK	Thailand, 15°37'N, 550m	1476	6	96	23.3	81	23.2	65	21.3	44	19.7
Ituri-Mixed	D.R. Congo, 01°33'N, 750m	1785	3	149	26.0	94	23.2	64	20.7	36	17.3
Ituri-Mono	D.R. Congo, 01°19'N, 750m	1674	4	159	29.2	90	24.8	53	17.7	22	7.9
Korup	Cameroon, 05°03'N, 150m	5272	0	236	48.0	134	37.6	87	30.8	54	25.3
Lambir	Malaysia, 04°11'N, 120m	2664	0	618	165.0	387	174.0	247	154.0	120	109.0
Luquillo	Puerto Rico, 18°19'N, 335m	3548	0	73	13.5			42	9.3		
Mudumalai	India, 11°35'N, 980m	1250	4	24	5.9	23	5.9	21	5.5	18	5.1
Nanjenshan	Taiwan, 22°03'N, 300m	3582	0	104	15.6			61	14.0		
Palanan	Philippines, 17°02'N, 85m	3379	0	197	43.4			100	36.5		
Pasoh	Malaysia, 02°58'N, 80m	1788	1	495	124.0	327	136.0	206	125.0	92	86.0
Sinharaja	Sri Lanka 06°24'N, 425m	5016	0	141	24.5	94	22.7	69	19.5	48	16.7
Yasuni	Ecuador, 00°40'N, 230m	3081	0	655	187.0	413	181.0	251	142.0	115	101.0

[1]Data for CTFS sites were taken from Tables 4.3, 7.1, 8.1, 25.3, 32.3,34.4, 35.3 in Losos, E. C. and E. G. Leigh Jr. (Eds.), 2004. Tropical Forest Diversity and Dynamism. Findings from a Large-Scale Plot Network. University of Chicago Press, Chicago.

Appendix 3. Stem density (N) and basal area (m^2) per hectare from (A) 14 Center for Tropical Forest Science mapped forest plots and (B) published temperate forest plots. (C) Location, climate, and forest types for each of the temperate plots. These data are used in Figure 3.

(A) Density and Basal Area for tropical forest plots. Plot locations are as given in Appendix 2.

	DBH ≥ 1 cm		DBH ≥ 2 cm		DBH ≥ 5 cm		DBH ≥ 10 cm		DBH ≥ 20 cm		DBH ≥ 30 cm		DBH ≥ 60 cm	
CTFS site	N	m^2	N	m^2	N	m^2	N	m^2	N	m^2	N	m^2	N	m^2
BCI	4581	32.1	2790	31.8	1024	30.4	429	27.8	156	23.2	82	19.7	17	10.8
Bukit Timah	5959	34.6	3283	34.2	1005	32.5	422	30.3	185	26.7	102	22.8	20	11.5
HKK	353	30.8	340	30.8	315	30.4	281	29.2	180	24.8	102	20.7	13	12.1
Ituri-Mixed	8112	33.2	4592	32.6	1301	29.9	438	26.3	127	21.8	77	19.4	22	11.4
Ituri-Mono	6843	37.5	3524	36.9	940	34.8	358	32.6	151	29.5	98	27.0	33	17.5
Korup	6581	32.0	3996	31.6	1319	29.3	492	26.1	192	21.3	84	16.1	11	6.8
Lambir	6119	43.4	4034	43.0	1469	41.1	636	37.8	234	31.6	119	26.3	26	13.9
Luquillo	4198	38.2	2646	37.9	1440	36.7	874	34.3	218	23.3	109	18.1	11	5.2
Mudumalai	1450	24.9	1130	24.9	738	24.8	438	24.7	171	22.7	82	18.8	19	5.8
Nanjenshan	12209	36.3	7978	35.7	3203	32.2	1052	23.9	187	11.4	46	5.2	1	0.3
Palanan	4124	39.8	2816	39.6	1075	38.2	537	36.1	221	31.0	110	26.0	28	15.6
Pasoh	6707	31.0	3884	30.7	1375	28.9	531	25.7	169	20.2	76	15.9	15	7.8
Sinharaja	8214	46.1	4498	45.5	1427	43.1	677	40.1	284	33.8	143	27.1	23	10.7
Yasuni	6094	33.0	3883	32.6	1611	30.8	702	27.3	219	19.5	81	13.4	8	4.1

[1] Data are taken from Tables 6.1 and 6.2 in Losos, E.C. and E. G. Leigh Jr. (Eds.), 2004. Tropical Forest Diversity and Dynamism. Findings from a Large-Scale Plot Network. University of Chicago Press, Chicago.

(B) Available data on stem density (stems ha^{-1}) and Basal Area (m^2 ha^{-1}) temperate forest plots larger than 1 ha. Note that available size-class data vary, and differ from those available from the tropical CTFS plots. Data are used in Figure 3.

Plot name and location	Size (ha)	Stems per Ha	Basal Area	Min DBH	Reference[2]
Aya, Japan	4	976	48.3	5	Tanouchi & Yamamoto 1995
Wind River, WA, USA[1]	12	438	71.9	5	Chen et al. 2004, Table 1
Wind River, WA, USA	12	188	69.2	20	Chen et al. 2004, Table 1
Wind River, WA, USA	12	117	64.6	40	Chen et al. 2004, Table 1
Wind River, WA, USA	12	83	58.1	60	Chen et al. 2004, Table 1
Teakettle, CA, USA	8.4	520	68.5	5	North et al. 2004, Fig. 3
Teakettle, CA, USA	8.4	182		25	North et al. 2004, Fig. 3
Teakettle, CA, USA	8.4	85		50	North et al. 2004, Fig. 3
Uholka, Ukraine	10	211		10	Commarmot et al. 2005, Fig. 2
Uholka, Ukraine	10	122		22	Commarmot et al. 2005, Fig. 2
Uholka, Ukraine	10	108		173	Commarmot et al. 2005, Fig. 2
Uholka, Ukraine	10	63		58	Commarmot et al. 2005, Fig. 2
Uholka, Ukraine	10		38.5	8	Commarmot et al. 2005, Fig. 2
Tatera, Japan	4	1124	63.5	5	Miura et al. 2001, Fig. 3
Tatera, Japan	4	621		10	Miura et al. 2001, Fig. 3
Tatera, Japan	4	173		30	Miura et al. 2001, Fig. 3
Tatera, Japan	4	74		50	Miura et al. 2001, Fig. 3
Big Thicket, TX, USA	4	933	35.9	5	Harcombe et al. 2002, Fig. 3
Big Thicket, TX, USA	4	468		10	Harcombe et al. 2002, Fig. 3
Big Thicket, TX, USA	4	248		20	Harcombe et al. 2002, Fig. 3
Big Thicket, TX, USA	4	160		30	Harcombe et al. 2002, Fig. 3
Big Thicket, TX, USA	4	12		60	Harcombe et al. 2002, Fig. 3
Smoky RF1, NC, USA	1	898	47.8	2	Busing 1998, Table 2
Smoky RF2, NC, USA	1	972	55.3	2	Busing 1998, Table 2
Smoky RF3, NC, USA	1	763	54.2	2	Busing 1998, Table 2
Smoky RF1, NC, USA	1	490		5	Busing 1998, Fig. 1
Smoky RF1, NC, USA	1	299		15	Busing 1998, Fig. 1
Smoky RF1, NC, USA	1	184		25	Busing 1998, Fig. 1
Smoky RF1, NC, USA	1	122		35	Busing 1998, Fig. 1

Smoky RF1, NC, USA	1	88		45	Busing 1998, Fig. 1
Smoky RF1, NC, USA	1	54		55	Busing 1998, Fig. 1
Smoky RF2, NC, USA	1	581		5	Busing 1998, Fig. 1
Smoky RF2, NC, USA	1	307		15	Busing 1998, Fig. 1
Smoky RF2, NC, USA	1	180		25	Busing 1998, Fig. 1
Smoky RF2, NC, USA	1	129		35	Busing 1998, Fig. 1
Smoky RF2, NC, USA	1	97		45	Busing 1998, Fig. 1
Smoky RF2, NC, USA	1	68		55	Busing 1998, Fig. 1
Smoky RF3, NC, USA	1	452		5	Busing 1998, Fig. 1
Smoky RF3, NC, USA	1	261		15	Busing 1998, Fig. 1
Smoky RF3, NC, USA	1	184		25	Busing 1998, Fig. 1
Smoky RF3, NC, USA	1	140		35	Busing 1998, Fig. 1
Smoky RF3, NC, USA	1	100		45	Busing 1998, Fig. 1
Smoky RF3, NC, USA	1	64		55	Busing 1998, Fig. 1
Changbaishan, China	2	1316	50.2	8	Chen & Bradshaw 1999, Fig. 1
Changbaishan, China	2	933		12	Chen & Bradshaw 1999, Fig. 1
Changbaishan, China	2	663		16	Chen & Bradshaw 1999, Fig. 1
Changbaishan, China	2	479		20	Chen & Bradshaw 1999, Fig. 1
Changbaishan, China	2	352		24	Chen & Bradshaw 1999, Fig. 1
Changbaishan, China	2	263		28	Chen & Bradshaw 1999, Fig. 1
Changbaishan, China	2	202		32	Chen & Bradshaw 1999, Fig. 1
Changbaishan, China	2	153		36	Chen & Bradshaw 1999, Fig. 1
Changbaishan, China	2	119		40	Chen & Bradshaw 1999, Fig. 1
Changbaishan, China	2	94		44	Chen & Bradshaw 1999, Fig. 1
Changbaishan, China	2	63		48	Chen & Bradshaw 1999, Fig. 1
Changbaishan, China	2	44		52	Chen & Bradshaw 1999, Fig. 1
Changbaishan, China	2	27		56	Chen & Bradshaw 1999, Fig. 1
Changbaishan, China	2	19		60	Chen & Bradshaw 1999, Fig. 1
Sequoia, CA, USA	1.44	168	329.5	10	Busing & Fujimori 2002,Table 1
Ogawa, Japan	6	864.2	32.4	5	Masaki et al. 1992, Table 1

[1]Note that we did not use the data on Wind River presented in North et al. 2004, because there seems to be a typographic problem with the data in that publication, tallying exactly 1000 more stems than indicated for the site in Chen et al. 2004 and in the data base made available to us by the authors

[2]Data are taken from the following sources:

Busing, R.T., 1998. Composition, structure and diversity of cove forest stands in the Great Smoky Mountains: a patch dynamics perspective. *Journal of Vegetation Science* 9: 881-890.

Busing, R.T. & Fujimori, T. 2002. Dynamics of composition and structure in an old *Sequoia sempervirens* forest. *Journal of Vegetation Science* 13: 785-792.

Chen, J. & Bradshaw, G.A. 1999. Forest structure in space: a case study of an old growth spruce-fir forest in Changbaishan Natural Reserve, PR China. *Forest Ecology and Management* 120: 219-233.

Chen, J., Song, B., Rudnicki, M., Moeur, M., Bible, K., North, M., Shaw, D.C., Franklin, J.F., & Braun, D.M. 2004. Spatial relationship of biomass and species distribution in an old-growth *Pseudotsuga-Tsuga* forest. *Forest Science* 50: 364-375.

Harcombe, P.A., Bill, C.J., Fulton, M., Glitzenstein, J.S., Marks, P.L., & Elsik, I.S. 2002. Stand dynamics over 18 years in a southern mixed hardwood forest, Texas, USA. *Journal of Ecology* 90, 947-957.

Masaki, T., Suzuki, W., Niiyama, K., Iida, S., Tanaka, H., Nakashizuka, T. 1992. Community structure of a species-rich temperate forest, Ogawa Forest Reserve, central Japan. *Vegetatio* 98: 97-111.

Miura, M., Manabe, T., Nishimura, N., Yamamoto, S.I., 2001. Forest canopy and community dynamics in a temperate old-growth evergreen broad-leaved forest, south western Japan: a 7-year study of a 4-ha plot. *Journal of Ecology* 89: 841-849.

North, M., Chen, J., Oakley, B., Song, B., Rudnicki, M., Gray, A., Innes, J., 2004. Forest stand structure and pattern of old-growth western hemlock / Douglas-fir and mixed-conifer forests. *Forest Science* 50: 299-311.

Tanouchi, H., Yamamoto, S., 1995. Structure and regeneration of canopy species in an old-growth evergreen broad-leaved forest in Aya District, southwestern Japan. *Vegetatio* 117: 51-60.

(C) Location, climate (mean annual precipitation and mean annual temperature), and forest type information for each of the twelve temperate forest plots given in (B). Most data come from the publications cited in (B). Where climate data were not presented in publications on the plots, proxy data from the nearest NOAA weather station was substituted (from http://cdo.ncdc.noaa.gov/cgi-bin/climatenormals/).

Site	Latitude	Elev. (masl)	Precip. (mm)	Temp (°C)	Forest type and disturbance
UCSC-FERP	37°01'N	314	776	13.8	Coastal mixed evergreen (selective disturbance early 1900s)
Aya, Japan	32°04'N	1109	2829	15.7	Old-growth evergreen broadleaf forest
Wind River, WA, USA	45°49'N	371	2223	8.7	Old-growth western hemlock/Douglas-fir forest
Teakettle, CA, USA	36°57'N	2000	1250	7.7[1]	Old-growth Sierra mixed conifer
Uholka, Ukraine	48°14'N	700	950	7.0	Old-growth beech
Tatera, Japan	34°25'N	120	2150	15.1	Old-growth evergreen broad-leaved forest (major typhoon 1987)
Big Thicket, TX, USA	30°16'N	4	1440	20.3[2]	Southern mixed hardwood forest (selectively logged 1917)
Smoky RF1, NC, USA	35°40'N	960	1464[3]	12.9[3]	Old-growth *Tsuga*-mixed-deciduous forest
Smoky RF3, NC, USA	35°40'N	990	1464[3]	12.9[3]	Old-growth *Tsuga*-mixed-deciduous forest
Smoky RF3, NC, USA	35°40'N	1140	1464[3]	12.9[3]	Old-growth *Tsuga*-mixed-deciduous forest
Changbaishan, China	42°01'N	1800	700	2.9	Broadleaved Korean pine mixed forest
Sequoia, CA, USA	40°21'N	70	975	11.6	Old-growth *Sequoia* forest
Ogawa, Japan	37°00'N	670	1200	12.4	Old-growth oak-beech forest

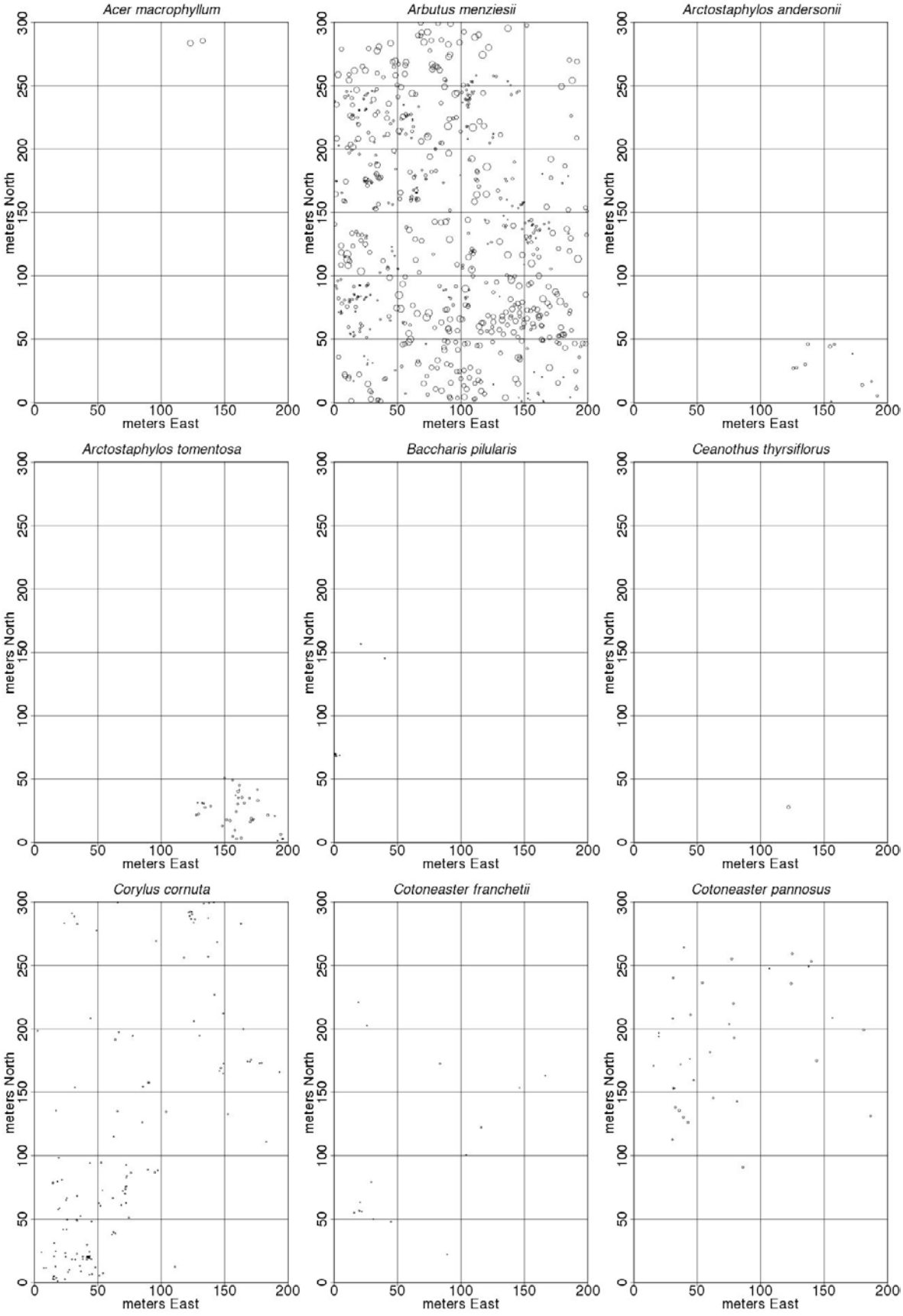
[1]Data from Huntington Lake, CA at 2139 m. Data from Port Arthur AP Beaumont, TX. [3]Data from Gatlinburg, TN at 443 m.

Appendix 4. Indices of aggregation for all individuals on the UCSC Forest Ecology Research Plot, for the annulus from 0 to 10 m around each stem. *Umbellularia californica* and *Morella californica* had no individuals within this distance, and so were excluded. These data are presented in Figure 4. $\Omega_{0\text{-}10m}$ and the 95% confidence interval were calculated as described in the text[1].

Species	Stems ha^{-1}	$\Omega_{0\text{-}10m}$	CI_{95}
Hedera helix	1.1667	90.946	0.0000
Baccharis pilularis	1.6667	12.732	0.9448
Heteromeles arbutifolia	1.8333	14.882	1.2678
Ilex aquifolium	1.8333	3.157	0.3244
Arctostaphylos andersonii	1.8333	19.292	0.5905
Cotoneaster franchetii	2.6667	14.921	0.7105
Pinus ponderosa	2.8333	50.225	1.5681
Cotoneaster pannosus	6.1667	2.790	0.0897
Arctostaphylos tomentosa	6.3333	21.277	0.2764
Corylus cornuta	24.333	7.073	0.0949
Sequoia sempervirens	31.000	8.785	0.0972
Lonicera hispidula	36.167	1.735	0.0162
Vaccinium ovatum	42.167	8.754	0.0588
Rhamnus californica	49.167	5.019	0.0499
Toxicodendron diversilobum	112.67	1.027	0.0061
Arbutus menziesii	114.500	0.523	0.0044
Quercus agrifolia	153.33	0.276	0.0024
Quercus parvula var. *shrevei*	198.83	0.234	0.0013
Lithocarpus densiflorus	208.00	0.365	0.0024
Pseudotsuga menziesii	360.00	0.151	0.0009

[1]Calculations based on the methods presented in Condit, R., Ashton, P.S., Baker, P., Bunyavejchewin, S., Gunatilleke, S., Gunatilleke, N., Hubbell, S.P., Foster, R.B., Itoh, A., LaFrankie, J.V., Lee, H.S., Losos, E., Manokaran, N., Sukumar, R. & Yamakura, T., 2000. Spatial patterns in the distribution of tropical tree species. *Science* 288: 1414-1418.

Appendix 5. Maps of the 31 woody species found on the UCSC Forest Ecology Research Plot. Shown are all individuals with DBH≥10 mm. Symbol size is proportional to tree diameter. On fourth page of graphs, the distribution of all species combined is shown for individuals with DBH≥10mm, DBH≥300mm, and DBH≥600mm. The contour of the plot is shown with exaggerated scale for meters above sea level.


Acer macrophyllum
Arbutus menziesii
Arctostaphylos andersonii
Arctostaphylos tomentosa
Baccharis pilularis
Ceanothus thyrsiflorus
Corylus cornuta
Cotoneaster franchetii
Cotoneaster pannosus
meters North
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0
50
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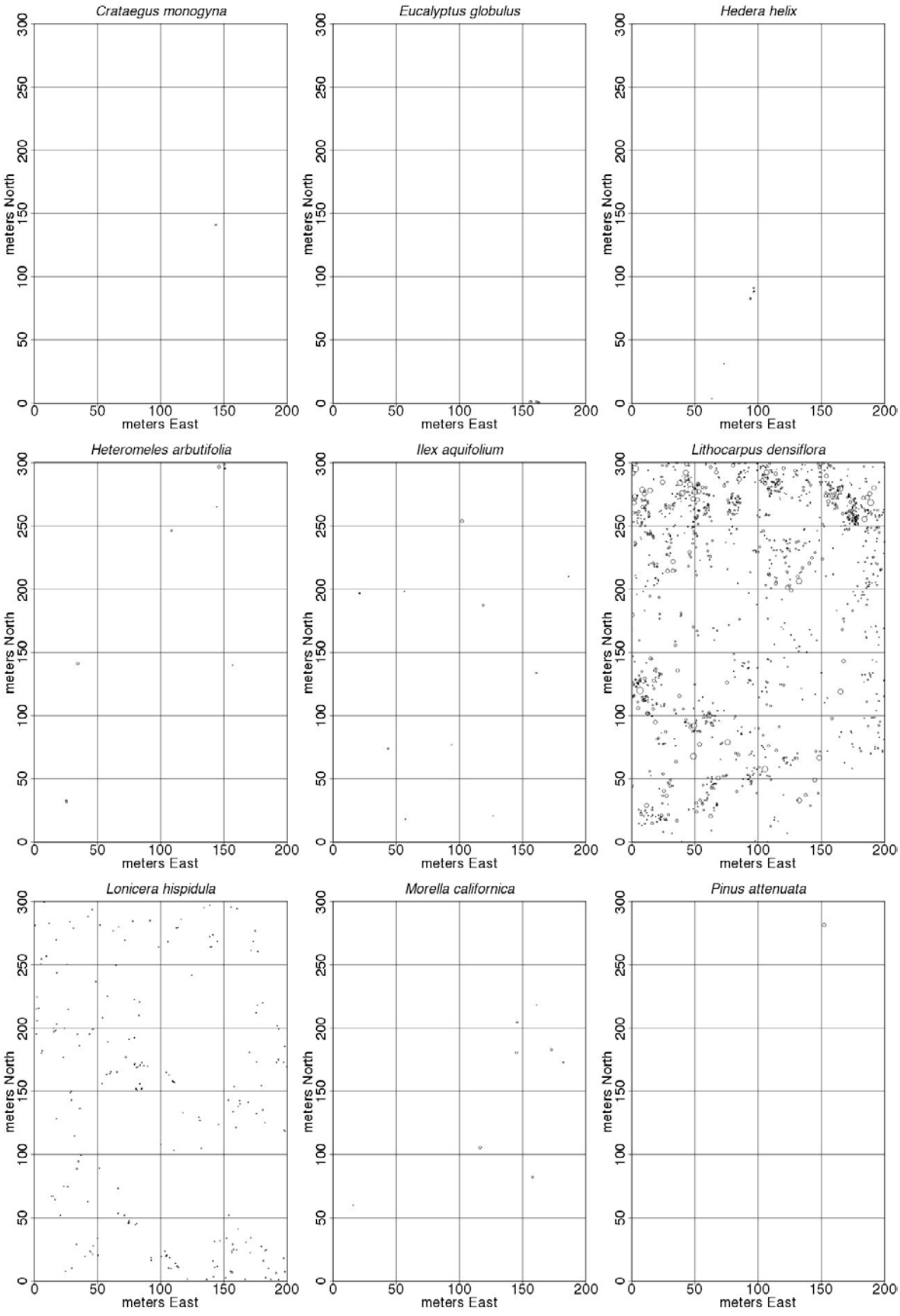
200
250
300


Crataegus monogyna
Eucalyptus globulus
Hedera helix
Heteromeles arbutifolia
Ilex aquifolium
Lithocarpus densiflora
Lonicera hispidula
Morella californica
Pinus attenuata
meters North
meters East
0
50
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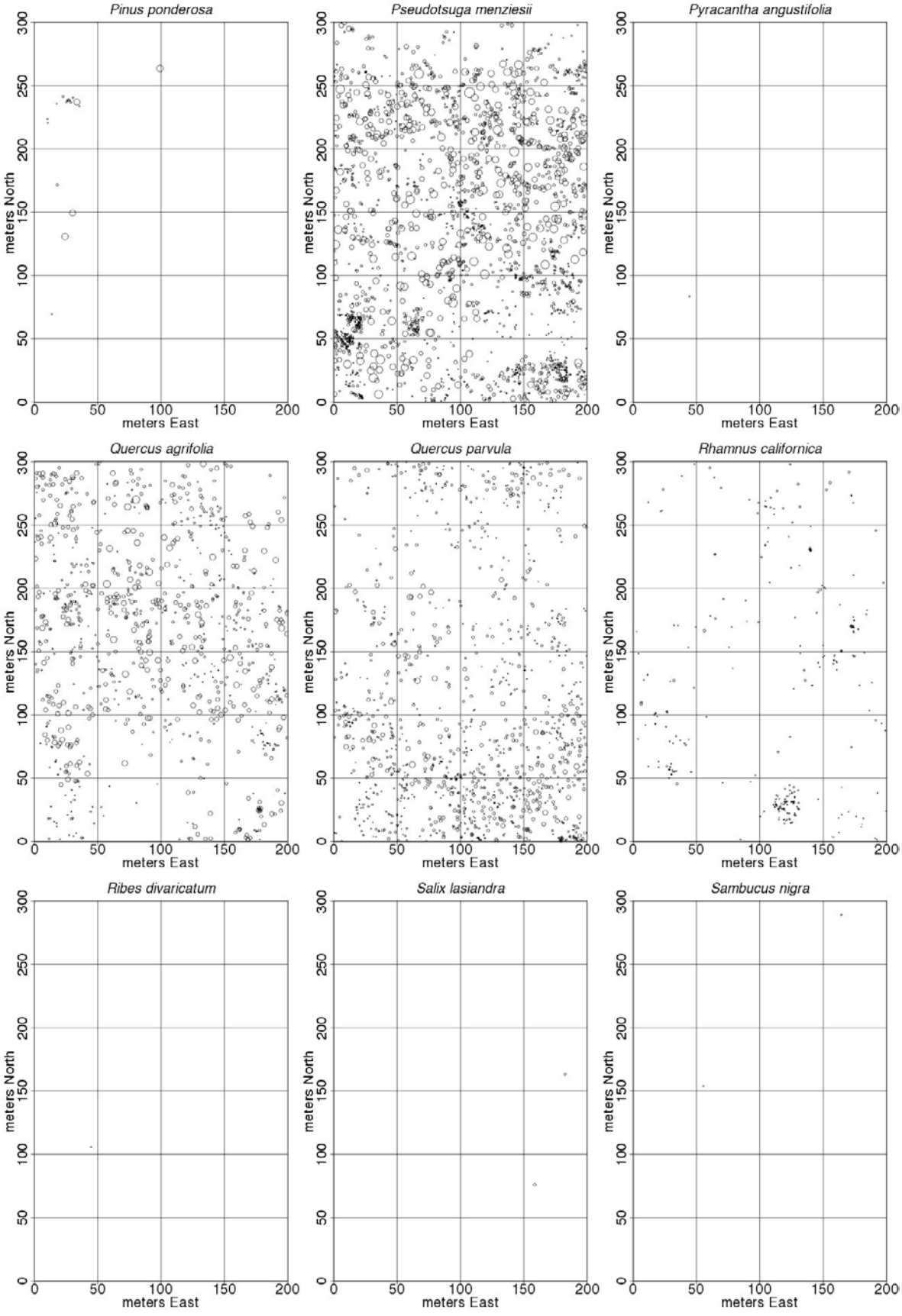
Pinus ponderosa
Pseudotsuga menziesii
Pyracantha angustifolia
Quercus agrifolia
Quercus parvula
Rhamnus californica
Ribes divaricatum
Salix lasiandra
Sambucus nigra
meters North
meters East
0
50
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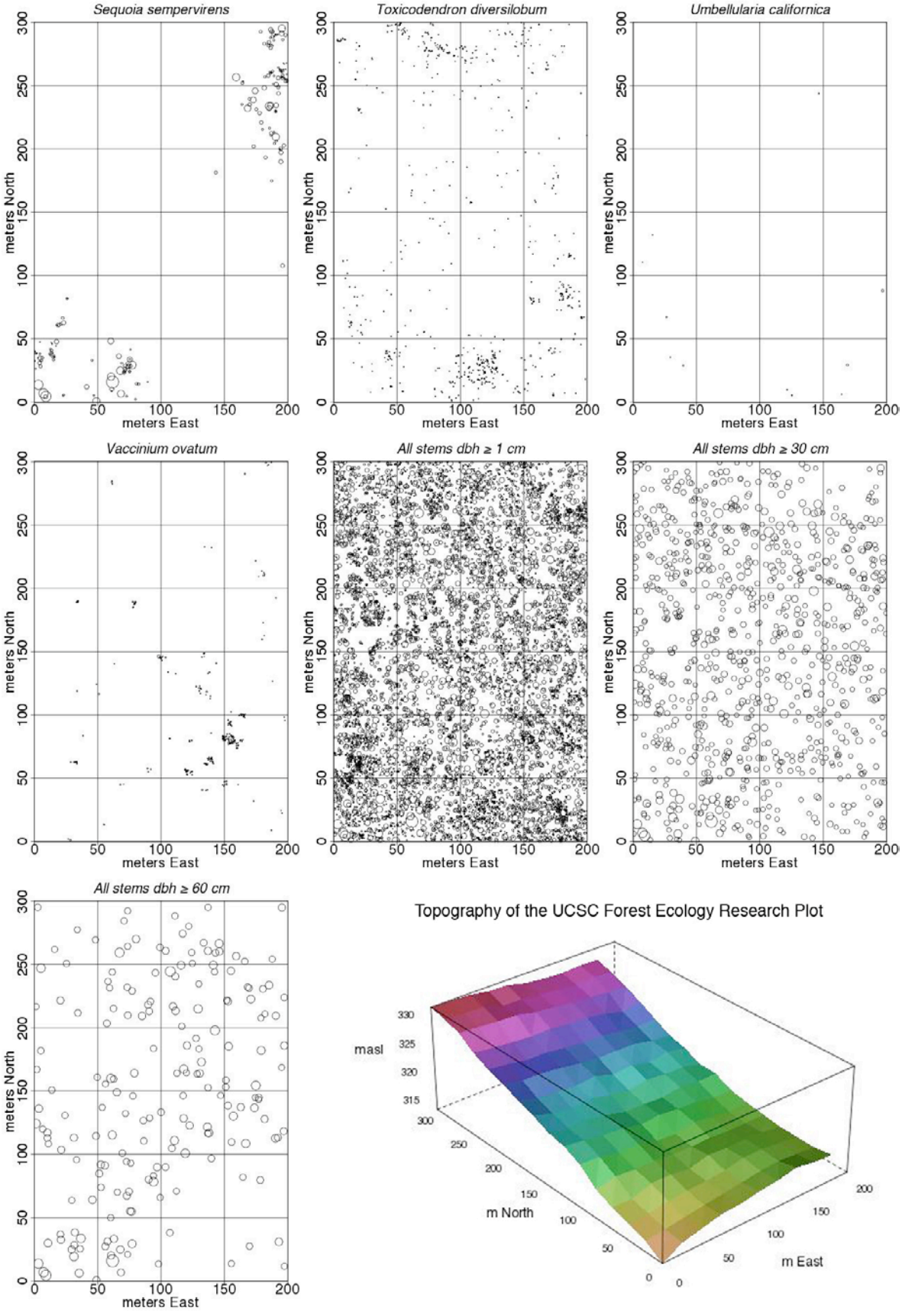
Sequoia sempervirens
Toxicodendron diversilobum
Umbellularia californica
Vaccinium ovatum
All stems dbh ≥ 1 cm
All stems dbh ≥ 30 cm
All stems dbh ≥ 60 cm
meters North
meters East
0
50
100
150
200
250
300

Topography of the UCSC Forest Ecology Research Plot
masl
330
325
320
315
300
m North
m East
0
50
100
150
200
250