Bickelhaupt, D.H., Leaf, A.L. and Richards, N.A. (1973). Effect of branching habit on above-ground dry weight estimates of *Acer saccharum* stands. In: "IUFRO Biomass Studies", pp. 219-230. College of Life Sciences and Agriculture, University of Maine, Orono, U.S.A.

Young, H.E. (1972). Biomass sampling methods for puckerbrush studies. In: "Forest Biomass Studies", pp. 179-190. College of Life Sciences and Agriculture, University of Maine, Orono, U.S.A.

U.S.A.	ca.42°30'N 76°W 500-600 m New York, Alleghany Uplands Heiberg Forest *Acer saccharum* Silt loams with fragipan. (Bickelhaupt *et al.*, 1973)	45-47°N 68-70°W -- Maine *A. saccharum* with *Fagus grandifolia* *et al.* (Young 1972)	
Age (years)	40-45	18	49
Trees/ha	1350		
Tree height (m)	20-22[a]	6.1	
Basal area (m^2/ha)	22.8		
Leaf area index			
Stem volume (m^3/ha)			
Dry biomass (t/ha) Stem wood	29.2[b]	43.4	124.4
Dry biomass (t/ha) Stem bark			
Dry biomass (t/ha) Branches			
Dry biomass (t/ha) Fruits etc.			
Dry biomass (t/ha) Foliage	2.7	3.2	2.9
Dry biomass (t/ha) Root estimate			
CAI (m^3/ha/yr)			
Net production (t/ha/yr) Stem wood			
Net production (t/ha/yr) Stem bark			
Net production (t/ha/yr) Branches			
Net production (t/ha/yr) Fruits etc.			
Net production (t/ha/yr) Foliage			
Net production (t/ha/yr) Root estimate			

Bickelhaupt *et al.* sampled 10 trees in September and derived stand biomass values from regressions on D.
Young (1972) harvested, and determined the fresh weights of all trees within one plot per stand; the plots were at least as long and as wide as the trees were tall; dry weights were estimated from the water contents of subsamples.
a. Height of the dominant trees.
b. Including 15.3 t/ha of stems over 3.8 cm D.

Whittaker, R.H. (1966). Forest dimensions and production in the Great Smoky Mountains. *Ecology* 47, 103-121.

Whittaker, R.H. and Woodwell, G.M. (1971). Measurement of net primary production of forests. In: "Productivity of Forest Ecosystems" (P. Duvigneaud, ed.) pp.159-175. UNESCO, Paris.

35°28-47'N ca.84°W 1310 m U.S.A., Great Smoky Mountains, Trillium Gap.

Aesculus octandra (40%)[a]
Tilia heterophylla (26%)[a]
Prunus serotina (16%)[a]
et al.

Age (years)		222[b]
Trees/ha		1450[c]
Tree height (m)		34.0[b]
Basal area (m^2/ha)		54.2
Leaf area index		6.2
Stem volume (m^3/ha)		720[d]
Dry biomass (t/ha)	Stem wood	387.3
	Stem bark	34.7
	Branches	74.0
	Fruits etc.	0.2
	Foliage	4.0
	Root estimate	78.0
CAI (m^3/ha/yr)		5.5[d]
Net production (t/ha/yr)	Stem wood	4.3[e]
	Stem bark	0.5[e]
	Branches	2.2[e]
	Fruits etc.	0.3
	Foliage	4.0
	Root estimate	1.8

Stand biomass values for a 0.2 ha plot were derived from published regressions of biomass on D and from stem volumes, branch/stem biomass ratios and other relationships.

a. Percentage of the total volume increment; *A. octandra* syn. *flava*.
b. Weighted mean age and height.
c. Stems over 1.9 cm D.
d. Parabolic volumes.
e. Excluding woody litterfall and any mortality.

Cleve, K. van, Viereck, L.A. and Schlentner, R.L. (1971). Accumulation of nitrogen in alder (*Alnus*) ecosystems near Fairbanks, Alaska. *Arctic Alpine Res.* 3, 101-114.

ca.64°45'N 148°15'W -- U.S.A., Alaska, near Fairbanks, Tanana River floodplain.

Alluvial sand and silt. *Alnus incana* subsp. *tenufolia* (83-89%)[a] with *Salix* spp.

Age (years)		5	15	20
Trees/ha		49699[b]	4563[b]	7142[b]
Tree height (m)		3	5-8	6-7
Basal area (m^2/ha)		15.4	19.6	28.9
Leaf area index				
Stem volume (m^3/ha)				
Dry biomass (t/ha)	Stem wood	5.43	20.23	31.41
	Stem bark			
	Branches	1.43	5.81	9.16
	Fruits etc.	0.00	0.14	0.03
	Foliage	1.89	1.63	2.14
	Root estimate	5.90	15.20	24.73
CAI (m^3/ha/yr)				
Net production (t/ha/yr)	Stem wood			2.24
	Stem bark			
	Branches			0.67
	Fruits etc.			ca.0.10
	Foliage			1.89[d]
	Root estimate			+ 5.93[c]

All trees were sampled within each of the above 100 m^2 plots, and roots were excavated in one 9 m^2 area at each site. There was 10.5 and 16.4 t/ha of dead stems and branches in the 15- and 20-year-old stands, respectively. Nitrogen contents were determined.

a. Percentage of the above-ground biomass.
b. Number of *A. incana* stems; there were also 54768, 1091 and 99 *Salix* stems per hectare in columns left to right.
c. Mortality and branch death.
d. Mean foliage biomass.

Zavitkovski, J. and Stevens, R.D. (1972). Primary productivity of red alder ecosystems. *Ecology* 53, 235-242.

Zavitkovski, J., Isebrands, J.G. and Crow, T.R. (1976). "Application of Growth Analysis in Forest Biomass Studies." Proc. 3rd N. Am. For. Biol. Workshop (C.P.P. Reid and C.H. Fechner, eds) pp.196-226. Colorado State University, Fort Collins, Colorado, U.S.A.

44-46°N ca.124°W 50-300 m U.S.A., Oregon, coastal range.

Latosolic and alluvial soils.

Alnus rubra

Age (years)		5	10	20	30	40	50
Trees/ha		22490[a]	6503[a]	1881[a]	910[a]	544[a]	365[a]
Tree height (m)		5	11	20	25	27	29
Basal area (m^2/ha)		ca.12	ca.26	ca.36	ca.40	ca.35	ca.30
Leaf area index			6.5				
Stem volume (m^3/ha)							
Dry biomass (t/ha)	Stem wood, Stem bark, Branches	20.0	50.0	140.0	180.0	200.0	205.0
	Fruits etc.						
	Foliage	5.4	5.5	5.0	4.2	3.5	3.0
	Root estimate			32.0[b]	40.0[b]	45.0[b]	50.0[b]
CAI (m^3/ha/yr)							
Net production (t/ha/yr)	Stem wood, Stem bark, Branches	10.0[c]	10.6+3.3[d]+2.8[e]	10.0[c]	7.0[c]	5.0[c]	4.0[c]
	Fruits etc.						
	Foliage	5.4	5.5	5.0	4.2	3.5	3.0
	Root estimate		2.9				

In all, 119 trees were sampled in 22 stands, and 28 root systems were excavated. Stand biomass values for plots of 1 to 809 m^2 in 50 stands were derived from regressions on D^2H. The production values refer to years 5-10, 10-15, 15-25, 25-35, 35-45 and 45-50 in columns left to right, estimated from graphs of cumulative biomass plus mortality with age. The values for ages 10-15 (second column from the left) were taken from Zavitkovski and Stevens (1972, their Table 2).

a. Estimated from a power curve relating tree numbers per hectare to stand age.
b. Extractable roots plus 10%.
c. Including estimated mortality and litterfall.
d. Mortality.
e. Woody litterfall.

Turner, J., Cole, D.W. and Gessel, S.P. (1976). Mineral nutrient accumulation and cycling in a stand of red alder (*Alnus rubra*). *J. Ecol.* 64, 965-974.

47°24'N 122°15'W 210 m	U.S.A., Washington, Cedar River, Thompson Research Center.	
Compacted coarse till soils.	*Alnus rubra*	
Age (years)	31-37	
Trees/ha	716	
Tree height (m)	22.4[a]	
Basal area (m^2/ha)	23.3	
Leaf area index		
Stem volume (m^3/ha)		
Dry biomass (t/ha) Stem wood	128.0	+ 9.5[b]
Stem bark	23.6	
Branches	19.4	
Fruits etc.		
Foliage	4.1	
Root estimate	35.2	
CAI (m^3/ha/yr)		
Net production (t/ha/yr) Stem wood	7.6 + 8.1[c]	
Stem bark		
Branches	2.1 + 4.4[d]	
Fruits etc.		
Foliage	4.1[e]	
Root estimate		

Above-ground biomass values were estimated by harvesting all trees within a 45 m^2 plot in July. Root biomass was estimated using regressions calculated by Zavitkovski and Stevens (1972) (see p.252). Nutrient contents were determined.

a. Height of the dominant trees.
b. Understorey shrubs.
c. Mortality.
d. Woody litterfall.
e. New foliage biomass; foliage litterfall was 3.4 t/ha/yr.

Parker, G.R. and Schneider, G. (1975). Biomass and productivity of an alder swamp in northern Michigan. *Can. J. For. Res.* 5, 403-409.

Parker, G.R. and Schneider, G. (1974). Structure and edaphic factors of an alder swamp in northern Michigan. *Can. J. For. Res.* 4, 499-508.

Voigt, G.K. and Steucek, G.L. (1969). Nitrogen distribution and accretion in an alder ecosystem. *Proc. Soil Sci. Soc. Am.* 33, 946-949.

U.S.A.	46°31'N 84°21'W 200-400 m Michigan, nr Sault Ste Marie, Dunbar Experimental Forest		42°00'N 72°09'W ca.250 m Connecticut, nr Union
	Alnus rugosa, *Fraxinus nigra*, *Populus balsamifera et al.*		*A. rugosa*
	Impeded drainage (21% 36% 20%)[a]	Sandy loam (60% 25% 9%)[a]	Old mill pond. (Voigt and Steucek 1969)
Age (years)			7-22
Trees/ha			
Tree height (m)			
Basal area (m^2/ha)			
Leaf area index			
Stem volume (m^3/ha)			
Dry biomass (t/ha) Stem wood	34.2	18.0	
Stem bark	2.8	2.2	
Branches	10.9	5.9	
	+ 0.6[b]	+ 1.1[b]	16.9
Fruits etc.			
Foliage	3.5[c] + 0.2[bc]	2.9[c] + 0.2[bc]	0.7
Root estimate			4.7
CAI (m^3/ha/yr)			
Net production (t/ha/yr) Stem wood	1.33[d]	1.25[d]	
Stem bark			
Branches	0.58[d]	0.48[d]	
Fruits etc.			
Foliage	3.49[c]	2.86[c]	
Root estimate			

At Dunbar, Parker and Schneider (1974, 1975) sampled 39 *A. rugosa* and 38 *F. nigra* in late summer, and derived biomass values for ten 16 m^2 plots per stand from regressions on D.

Voigt and Steucek (1969) sampled 6 'clumps' of *A. rugosa* in the autumn, including the roots. Nitrogen contents were determined.

a. Percentage of the total biomass accounted for by *A. rugosa*, *F. nigra* and *P. balsamifera* (left to right within the brackets).

b. Understorey shrubs.

c. Including the current year's twigs.

d. Excluding woody litterfall.

Young, H.E. (1972). Biomass sampling methods for puckerbrush studies. In: "Forest Biomass Studies", pp.179-190. College of Life Sciences and Agriculture, University of Maine, Orono, U.S.A.

45-47°N 68-70°W -- U.S.A., Maine.

Alnus serrulata et al.

'Puckerbrush' stands.

Age (years)		4	5	6	20
Trees/ha					
Tree height (m)		2	2.7	3	5.5
Basal area (m^2/ha)					
Leaf area index					
Stem volume (m^3/ha)					
Dry biomass (t/ha)	Stem wood	7.0	19.0	17.3	31.3
	Stem bark				
	Branches				
	Fruits etc.				
	Foliage	3.8	4.3	6.3	2.3
	Root estimate	3.2		9.0	
CAI (m^3/ha/yr)					
Net production (t/ha/yr)	Stem wood				
	Stem bark				
	Branches				
	Fruits etc.				
	Foliage				
	Root estimate				

All trees were harvested within one plot per stand and their fresh weights were measured. Dry weights were estimated from the water contents of subsamples. The plots were at least as long and as wide as the trees were tall. Roots were excavated in the 4- and 6-year-old stands.

Weaver, G.T. and DeSelm, H.R. (1973). Biomass distributional patterns in adjacent coniferous and deciduous forest ecosystems. In: "IUFRO Biomass Studies", pp. 415-427. College of Life Sciences and Agriculture, University of Maine, Orono, U.S.A.

35°15-25'N 82°55' to 83°03'W 1524-1954 m U.S.A., North Carolina, Balsam Mountains.

Sandy acid loams, high in organic matter, low in exchangeable cations.

Betula lutea syn. *alleghaniensis* with understorey shrubs.

Age (years)		40-60	ca.110
Trees/ha			
Tree height (m)			
Basal area (m^2/ha)			
Leaf area index			
Stem volume (m^3/ha)			
Dry biomass (t/ha)	Stem wood	75[a]	113[a]
	Stem bark		
	Branches	25[a]	42[a]
	Fruits etc.		
	Foliage	4[a]	3[a]
	Root estimate		
CAI (m^3/ha/yr)			
Net production (t/ha/yr)	Stem wood		
	Stem bark		
	Branches		
	Fruits etc.		
	Foliage		
	Root estimate		

Over 50 trees were sampled from four 40-60 year-old and two 110-year-old stands, and biomass values for several 400 m^2 plots within each stand were derived from regressions on D.

a. Including the understorey shrubs.

Young, H.E. (1972). Biomass sampling methods for puckerbrush studies. In: "Forest Biomass Studies", pp.179-190. College of Life Sciences and Agriculture, University of Maine, Orono, U.S.A.

Young, H.E. (1973). Biomass variation in apparently homogeneous puckerbrush stands. In: "IUFRO Biomass Studies", pp.197-206. College of Life Sciences and Agriculture, University of Maine, Orono, U.S.A.

45-47°N 68-70°W -- U.S.A., Maine.

'Puckerbrush' stands.	*Betula alleghaniensis* syn. *lutea et al.*	*Betula papyrifera et al.*		*Betula populifolia et al.*		
					Eddington	Old Town
Age (years)	25	22	24	12	27	40
Trees/ha						
Tree height (m)	8.8	6.7	10.4	3 to 4	7.6	
Basal area (m^2/ha)						
Leaf area index						
Stem volume (m^3/ha)						
Dry biomass (t/ha) Stem wood	59.5	30.0	52.0	28.8	47.3	36.3
Dry biomass (t/ha) Stem bark						
Dry biomass (t/ha) Branches					7.6	2.3
Dry biomass (t/ha) Fruits etc.						
Dry biomass (t/ha) Foliage	2.2	1.9	3.5	6.3	2.6	1.7
Dry biomass (t/ha) Root estimate				9.0		
CAI (m^3/ha/yr)						
Net production (t/ha/yr) Stem wood						
Net production (t/ha/yr) Stem bark						
Net production (t/ha/yr) Branches						
Net production (t/ha/yr) Fruits etc.						
Net production (t/ha/yr) Foliage						
Net production (t/ha/yr) Root estimate						

All trees were harvested within one plot per stand and their fresh weights were measured. Dry weights were estimated from the water contents of subsamples. The plots were at least as long and as wide as the trees were tall. Roots were excavated in the 12-year-old stand.

Whittaker, R.H. and Niering, W.A. (1975). Vegetation of the Santa Catalina mountains, Arizona. V Biomass, production and diversity along the elevation gradient. *Ecology* 56, 771-790.

Whittaker, R.H. and Niering, W.A. (1968). Vegetation of the Santa Catalina mountains, Arizona. IV Limestone and acid soils. *J. Ecol.* 56, 523-544.

ca.32°20'N 110°50'W (alt. given below) U.S.A., Arizona, Santa Catalina Mtns.

Small trees and shrubs.

	Carnegiea gigantea, Cercidium microphyllum, Fouquieria splendens, et al. 1020 m	*C. microphyllum Franseria deltoides F. splendens, et al.* 870 m	*Cercocarpus breviflorus et al.* 1810 m
Age (years)			
Trees/ha	3870	1460	3930
Tree height (m)	3.4[a]	3.1[a]	3.7[a]
Basal area (m^2/ha)	10.9	3.0	2.7
Leaf area index	0.9	0.6	1.4
Stem volume (m^3/ha)	18.5[b]	4.5[b]	5.0[b]
Dry biomass (t/ha): Stem wood	8.0 + 0.1[c]	2.4 + 0.2[c]	4.9
Dry biomass (t/ha): Stem bark			
Dry biomass (t/ha): Branches	4.0 + 0.6[c]	1.4 + 0.9[c]	1.8 + 0.1[c]
Dry biomass (t/ha): Fruits etc.			
Dry biomass (t/ha): Foliage	0.2 + 0.1[c]	0.1 + 0.1[c]	0.5 + 0.3[c]
Dry biomass (t/ha): Root estimate			
CAI (m^3/ha/yr)			
Net production (t/ha/yr): Stem wood	0.25[d]	0.12[d]	0.32[d]
Net production (t/ha/yr): Stem bark	0.04[d]	0.04[d]	0.06[d]
Net production (t/ha/yr): Branches	0.30[d] + 0.13[cd]	0.20[d] + 0.26[cd]	0.37[d] + 0.02[cd]
Net production (t/ha/yr): Fruits etc.	0.02 + 0.03[c]	0.02 + 0.05[c]	0.04 + 0.03[c]
Net production (t/ha/yr): Foliage	0.23 + 0.17[c]	0.14 + 0.22[c]	0.46 + 0.10[c]
Net production (t/ha/yr): Root estimate			

Small trees and shrubs were sampled in one 0.1 ha plot per stand, and stand biomass values were derived from regressions on D, wood volumes and surface areas, and from other relationships. All trees and shrubs over 1 cm D were included.

a. Weighted mean heights.
b. Parabolic volumes.
c. Understorey shrubs.
d. Excluding woody litterfall and mortality.

Whittaker, R.H., Bormann, F.H., Likens, G.E. and Siccama, T.G. (1974). The Hubbard Brook ecosystem study: forest biomass and production. *Ecol. Monogr.* 44, 233-252.
Bormann, F.H., Siccama, T.G., Likens, G.E. and Whittaker, R.H. (1970). The Hubbard Brook ecosystem study: composition and dynamics of the tree stratum. *Ecol. Monogr.* 40, 373-388.
Gosz, J.R., Likens, G.E. and Bormann, F.H. (1972). Nutrient content of litterfall in the Hubbard Brook Experimental Forest, New Hampshire. *Ecology* 53, 769-784.
Whittaker, R.H. and 4 others. (1979). *Ecology* 60, 203-220.

43°55'N 71°40'W (alt. given below) U.S.A., New Hampshire, Hubbard Brook.

Bouldery, glacial till podzolic soils.	*Fagus grandifolia*, *Acer saccharum*, *Betula lutea* syn. *alleghaniensis*, *et al.* (46% 32% 20%)[a] 500-630 m	(26% 43% 29%)[a] 630-710 m	(27% 26% 25%)[a] 710-785 m
Age (years)	83[b]	95[b]	124[b]
Trees/ha	2420	1290	1290
Tree height (m)	10.8[b]	16.7[b]	16.9[b]
Basal area (m^2/ha)	22.0	23.7	26.3
Leaf area index	5.5[c]	5.7[c]	6.2[c]
Stem volume (m^3/ha)	121[d]	172[d]	194[d]
Dry biomass (t/ha) Stem wood	60.1	92.8	104.2
Stem bark	6.9	9.4	10.9
Branches	26.9	41.9	40.3
Fruits etc.	0.2	0.1	0.2
Foliage	3.5	2.8	3.0
Root estimate	23.5	20.6	30.6
CAI (m^3/ha/yr)	2.2[d]	3.7[d]	3.8[d]
Net production (t/ha/yr) Stem wood	2.02	2.94	3.15
Stem bark	0.24 + ca.2.1[e]	0.32 + ca.2.1[e]	0.35 + ca.2.1[e]
Branches	2.23	3.16	3.49
Fruits etc.	0.18	0.16	0.21
Foliage	2.85	3.53	3.74
Root estimate	1.39[f]	2.02[f]	2.23[f]

Ninety-three trees were sampled, 81 roots were excavated, and stand biomass values were derived from regressions on D, wood volumes, and surface areas, and from other relationships. There was about 2.7 t/ha of dead branches in each stand. Nutrient contents were determined.

a. Percentage of the total biomass accounted for by *F. grandifolia*, *A. saccharum* and *B. lutea* (written left to right within the brackets).
b. Weighted mean ages and heights. *c*. Including all-sided leaf areas of a few conifers. *d*. Parabolic volumes. *e*. Estimated woody litterfall and mortality; measured foliage litterfall was 2.55, 2.82 and 2.88 t/ha/yr in columns left to right, or 2.65, 3.06 and 3.22 t/ha/yr including consumption losses.
f. Assuming that roots grew at the same relative rates as above-ground woody parts.

Whittaker, R.H. (1966). Forest dimensions and production in the Great Smoky Mountains. *Ecology* 47, 103-121.
Whittaker, R.H. and Woodwell, G.M. (1971). Measurement of net primary production of forests. In: "Productivity of Forest Ecosystems" (P. Duvigneaud, ed.) pp.159-175. UNESCO, Paris.
Young, H.E. (1972). Biomass sampling methods for puckerbush studies. In: "Forest Biomass Studies", pp.179-190. College of Life Sciences and Agriculture, University of Maine, Orono, U.S.A.

U.S.A.		35°28-47'N ca.84°W 1580 m Great Smoky Mountains, Newfoundland Gap.		45-47°N 68-70°W -- Maine
		Fagus grandifolia (73%)[a] *Picea rubens* (24%)[a] *et al.*	*F. grandifolia* (80%)[a] *Acer saccharum* (6%)[a] *et al.*	*F. grandifolia et al.* (Young 1972)
Age (years)		135[b]	84[b]	26
Trees/ha		2140[c]	2170[c]	
Tree height (m)		15.6[b]	13.4[b]	7.9
Basal area (m^2/ha)		27.7	22.0	
Leaf area index		5.2[d]	4.4	
Stem volume (m^3/ha)		185[e]	120[e]	
Dry biomass (t/ha)	Stem wood	118	87	78.5
	Stem bark	8	6	
	Branches	40	35	
	Fruits etc.			
	Foliage	5	3	1.8
	Root estimate			
CAI (m^3/ha/yr)		2.8[e]	1.6[e]	
Net production (t/ha/yr)	Stem wood	2.6[f]	3.3[f]	
	Stem bark	0.2[f]		
	Branches	1.8[f]		
	Fruits etc.			
	Foliage	4.2	2.7	
	Root estimate			

Whittaker (1966) derived stand biomass values for plots of at least 0.1 ha from published regressions on D and from stem volumes, branch/stem biomass ratios and other relationships.
Young (1972) harvested all trees within one plot of at least 64 m^2, measured their fresh weights and estimated dry weights from the water contents of subsamples.
a. Percentage of the total volume increment.
b. Weighted mean ages and heights.
c. Stems over 1.9 cm D.
d. All-sided LAI was 14.8.
e. Parabolic volumes.
f. Excluding woody litterfall and mortality.

Whittaker, R.H. and Niering, W.A. (1975). Vegetation of the Santa Catalina mountains, Arizona. V Biomass, production and diversity along the elevation gradient. *Ecology* 56, 771-790.

Whittaker, R.H. and Niering, W.A. (1968). Vegetation of the Santa Catalina mountains, Arizona. IV Limestone and acid soils. *J. Ecol.* 56, 523-544.

ca.32°20'N 110°50'W 1220 m U.S.A., Arizona, Santa Catalina Mountains, near Tucson.

Fouquieria splendens, *Prosopis juliflora* syn. *glandulosa* syn. *velutina*, *et al.* with understorey shrubs.

Age (years)		
Trees/ha		20 + 640[c]
Tree height (m)		2.5[a]
Basal area (m^2/ha)		0.2
Leaf area index		1.6
Stem volume (m^3/ha)		0.3[b]
Dry biomass (t/ha)	Stem wood	0.56 + 0.22[c]
	Stem bark	
	Branches	0.04 + 0.87[c]
	Fruits etc.	
	Foliage	0.04 + 0.42[c]
	Root estimate	
CAI (m^3/ha/yr)		
Net production (t/ha/yr)	Stem wood	0.04[d] + 0.25[cd]
	Stem bark	0.04[d]
	Branches	0.01[d]
	Fruits etc.	0.01 + 0.04[c]
	Foliage	0.06 + 0.33[c]
	Root estimate	

Ten to 15 trees were sampled of each of the major species and stand biomass values for a 0.1 ha plot were derived from regressions on D, wood volumes and surface areas, and from other relationships. All trees and shrubs over 1 cm D were included.

a. Weighted mean height.
b. Parabolic volume.
c. Understorey shrubs.
d. Excluding woody litterfall and mortality.

Chew, R.M. and Chew, A.E. (1965). The primary productivity of a desert-shrub (*Larrea tridentata*) community. *Ecol. Monogr.* 35, 355-375.

Whittaker, R.H. and Niering, W.A. (1975). Vegetation of the Santa Catalina mountains, Arizona. V Biomass, production and diversity along the elevation gradient. *Ecology* 56, 771-790.

U.S.A.	31°55'N 109°09'W 1370 m Arizona, San Simon valley. *Larrea tridentata* (72%)[a] *Flourensia cernua* (9%)[a] Shallow soil over gravel alluvium. (Chew and Chew 1965)	ca.32°20'N 110°50'W 760 m Arizona, Santa Catalina Mtns. *Larrea divaricata* *et al.* (Whittaker and Niering 1975)
Age (years)	17 (5 to 65)	
Trees/ha	6140	49500
Tree height (m)		1.7[b]
Basal area (m^2/ha)		4.2
Leaf area index	0.9	0.6
Stem volume (m^3/ha)		3.5[c]
Dry biomass (t/ha): Stem wood	4.6	2.5
Dry biomass (t/ha): Stem bark		
Dry biomass (t/ha): Branches		1.3
Dry biomass (t/ha): Fruits etc.		
Dry biomass (t/ha): Foliage		0.4
Dry biomass (t/ha): Root estimate		
CAI (m^3/ha/yr)		
Net production (t/ha/yr): Stem wood	1.4[d]	0.17[e]
Net production (t/ha/yr): Stem bark		0.02[e]
Net production (t/ha/yr): Branches		0.19[e]
Net production (t/ha/yr): Fruits etc.		0.00
Net production (t/ha/yr): Foliage		0.54
Net production (t/ha/yr): Root estimate		

Chew and Chew (1965) sampled 61 shrubs in summer, excavated 17 root systems, and derived stand biomass values from weight-volume and volume-age relationships; stand production was estimated from age-cumulative biomass relationships and age-frequency distributions.
Whittaker and Niering (1975) sampled shrubs within a 0.1 ha plot and derived stand biomass values from regressions on D, wood volumes and surface areas, and other relationships; all shrubs over 1 cm D were included.

a. Percentage of the vegetation area covered. *b*. Weighted mean height.
c. Parabolic volume. *d*. Including litterfall; about 65%, i.e. 0.9 t/ha/yr, of this total production, was leaves or leaved stems.
e. Excluding woody litterfall and mortality.

Whittaker, R.H. (1966). Forest dimensions and production in the Great Smoky Mountains. *Ecology* 47, 103-121.

ca.35°30'N 84°W 700 m U.S.A., Great Smoky Mountains.

Liriodendron tulipifera (77%)[a], *Acer rubrum* (8%)[a], *Robinia pseudoacacia, et al.*

Vigorous successional stand on abandoned farmland.

Age (years)		29[b]
Trees/ha		1820[c]
Tree height (m)		22.4[b]
Basal area (m^2/ha)		34.2
Leaf area index		7.4
Stem volume (m^3/ha)		310[d]
Dry biomass (t/ha)	Stem wood	150
	Stem bark	17
	Branches	49
	Fruits etc.	
	Foliage	4.7
	Root estimate	
CAI (m^3/ha/yr)		14.4[d]
Net production (t/ha/yr)	Stem wood	19.9[e]
	Stem bark	
	Branches	
	Fruits etc.	
	Foliage	4.1
	Root estimate	

Stand biomass values for a 0.1 ha plot were derived from published regressions on D and from stem volumes, branch/stem biomass ratios and other relationships.

a. Percentage of the total volume increment.
b. Weighted mean age and height.
c. Stems over 1.9 cm diameter.
d. Parabolic volume.
e. Excluding woody litterfall and mortality.

Sollins, P., Reichle, D.E. and Olson, J.S. (1973). "Organic Matter Budget and Model for a Southern Appalachian *Liriodendron* Forest." EDFP-IBP-73/2. Oak Ridge National Laboratory, Tennessee, U.S.A.
Harris, W.F., Kinerson, R.S. and Edwards, N.T. (1977). Comparison of below-ground biomass of natural deciduous forest and loblolly pine plantations. *Pedobiologia* 17, 369-381. Edwards, N.T. and Harris, W.F. (1977). *Ecology* 58, 431-437.
Reichle, D.E., Edwards, N.T., Harris, W.F. and Sollins, P. (1981). In: "Dynamic Properties of Forest Ecosystems" (D.E. Reichle, ed.), p.657. Cambridge Univ. Press.

35°55'N 84°17'W 290 m U.S.A., Tennessee, Oak Ridge Reservation.

Colluvial cherty silt loams, high in organic matter, pH 5.8.

Liriodendron tulipifera (78%)[a] with *Quercus* spp., *Pinus echinata*, *Carya tomentosa* and understorey trees.

Age (years)		40[b]	48[b]
Trees/ha			
Tree height (m)			
Basal area (m²/ha)		19.2[c]	22.1[c]
Leaf area index		5.6 + 1.4[d]	6.0 + 1.1[d]
Stem volume (m³/ha)			
Dry biomass (t/ha)	Stem wood	76.2 + 5.4[d]	94.4 + 5.9[d]
	Stem bark		
	Branches	19.6 + 2.0[d]	27.1 + 2.1[d]
	Fruits etc.		0.2
	Foliage	2.9 + 0.5[d]	3.2 + 0.5[d]
	Root estimate	31.5 + 3.6[d]	38.9 + 4.0[d]
CAI (m³/ha/yr)			
Net production (t/ha/yr)	Stem wood		1.11 + 0.39[e] + 0.59[d] + 0.52[de]
	Stem bark		
	Branches		0.57 + 0.46[e] + 0.02[d] + 0.04[de]
	Fruits etc.		0.20 + 0.02[d]
	Foliage		3.09 + 0.50[d] + 0.10[f]
	Root estimate		2.55 + 0.37[d] (or ca.9.0)[g]

About 250 trees were sampled and stand biomass values for several 500 m² plots were derived from regressions on D. Root values include the stumps. Values given above were taken from Sollins *et al.* (1973); Reichle *et al.* (1981) gave overstorey and understorey stem increment values of 2.25 and 0.06 t/ha/yr, respectively.

a. Percentage of the total above-ground biomass.
b. Mean age of the dominant and co-dominant trees.
c. Trees at least 2.54 cm D.
d. Understorey shrubs and saplings.
e. Woody litterfall and mortality.
f. Consumption.
g. Updated value from Harris *et al.* (1977).

Harris, W.F., Goldstein, R.A. and Henderson, G.S. (1973). Analysis of forest biomass pools, annual primary production and turnover of biomass for a mixed deciduous forest watershed. In: "IUFRO Biomass Studies", pp.43-64. College of Life Sciences and Agriculture, University of Maine, Orono, U.S.A.

Harris, W.F. and Henderson, G.S. (1981). In: "Dynamic Properties of Forest Ecosystems" (D.E. Reichle, ed.) pp.658-661. Cambridge University Press, Cambridge, London, New York, Melbourne.

35°58'N 84°17'W 265-360 m U.S.A., Tennessee, Walker Branch Site.

Red-yellow podzols, pH 4.0-6.5. Ultisols.

Liriodendron tulipifera with *Carya* spp., *Quercus alba*, *Quercus rubra*, *et al.*

Age (years)		30-80
Trees/ha		
Tree height (m)		12-25
Basal area (m^2/ha)		19.0
Leaf area index		
Stem volume (m^3/ha)		
Dry biomass (t/ha)	Stem wood	83.5
	Stem bark	
	Branches	21.2
	Fruits etc.	
	Foliage	3.9
	Root estimate	30.6[a]
CAI (m^3/ha/yr)		
Net production (t/ha/yr)	Stem wood	3.55 + 1.18[b] + 0.63[c]
	Stem bark	
	Branches	
	Fruits etc.	
	Foliage	3.90[d]
	Root estimate	2.0

Many trees were sampled (about 150 at all four Walker Branch sites), roots were excavated in 2-3 pits, and stand biomass values for 50-100 circular plots were derived from regressions on D.

a. Including stumps, which represented about half the 'root' biomass.
b. Mortality.
c. Woody litterfall.
d. Leaf production; leaf litterfall was 3.70 t/ha/yr.

Carter, M.C. and White, E.H. (1971). "Dry Weight and Nutrient Accumulation in Youn; Stands of Cottonwood (*Populus deltoides* Bartr.)." Agr. Exp. Stn, Auburn University, Circular 190. Alabama, U.S.A.

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ca.31°10'N 88°00'W 20-100 m U.S.A., Alabama, near Mobile.

Alluvial soils of various quality.

Populus deltoides

Age (years)		6	7	7	7	8	8	8	9
Trees/ha		17347	964	2446	8056	1161	2693	2199	1507
Tree height (m)		9.9	21.9	17.7	14.9	20.0	18.3	17.1	18.5
Basal area (m^2/ha)		18.8	23.9	23.4	20.2	20.4	23.6	18.4	18.4
Leaf area index									
Stem volume (m^3/ha)		61	180	148	131	142	170	111	126
Dry biomass (t/ha)	Stem wood	26.1	56.5	39.8	47.0	56.0	56.3	36.9	45.2
	Stem bark	7.2	9.5	7.9	8.6	8.6	7.9	8.3	8.3
	Branches	3.4	12.2	14.6	7.2	10.8	14.9	7.7	10.6
	Fruits etc.								
	Foliage	2.5	3.8	2.7	3.6	3.6	2.7	2.5	2.0
	Root estimate								
CAI (m^3/ha/yr)									
Net production (t/ha/yr)	Stem wood								
	Stem bark								
	Branches								
	Fruits etc.								
	Foliage								
	Root estimate								

One tree was sampled in each of three size classes from each stand in August. Biomass values for two 200 m^2 plots per stand were derived from regressions on D. Nutrient contents were determined.

Blackmon, B.G., Baker, J.B. and Cooper, D.T. (1979). Nutrient use by three geographic sources of eastern cottonwood. *Can. J. For. Res.* 9, 532-534.

33°35'N 89-90°W 50-150 m U.S.A., Mississippi, near Stoneville.

Plantations. Fine, silty loam.

Populus deltoides

All stands thinned at age 3.

		S. Illinois provenance	Mississippi provenance	Louisiana provenance
Age (years)		11	11	11
Trees/ha		452	476	487
Tree height (m)		22	22	22
Basal area (m^2/ha)				
Leaf area index				
Stem volume (m^3/ha)				
Dry biomass (t/ha)	Stem wood	63.0	68.8	70.8
	Stem bark			
	Branches	5.4	4.9	8.7
	Fruits etc.			
	Foliage	1.1	1.3	2.0
	Root estimate			
CAI (m^3/ha/yr)				
Net production (t/ha/yr)	Stem wood			
	Stem bark			
	Branches			
	Fruits etc.			
	Foliage	1.1	1.3	2.0
	Root estimate			

One average-sized tree was sampled of each provenance in each of 4 blocks, and stand values were obtained by multiplying mean tree values by the numbers of trees per hectare. Nutrient contents were determined.

Koerper, G.J. and Richardson, C.J. (1980). Biomass and net annual primary production regressions for *Populus grandidentata* on three sites in northern lower Michigan. *Can. J. For. Res.* 10, 92-101.

45°34'N 84°30'W 230-270 m U.S.A., Michigan, Cheboygan County.

		Populus grandidentata		
		82%[a]	79%[a]	48%[a]
		Good loamy sand	Intermediate quality loamy sand	Infertile Rubicon sand
Age (years)		52	52	60
Trees/ha				
Tree height (m)		26.5	23.1	15.6
Basal area (m^2/ha)		30.5	27.3	11.4
Leaf area index				
Stem volume (m^3/ha)				
Dry biomass (t/ha)	Stem wood	126.5	95.6	27.2
	Stem bark	24.6	21.1	6.3
	Branches	18.0	10.3	4.0
	Fruits etc.			
	Foliage	2.4	1.8	1.0
	Root estimate			
CAI (m^3/ha/yr)				
Net production (t/ha/yr)	Stem wood	4.90[b]	3.09[b]	1.08[b]
	Stem bark	0.97[b]	0.73[b]	0.28[b]
	Branches	2.75[b]	1.68[b]	0.61[b]
	Fruits etc.			
	Foliage	2.41	1.76	0.96
	Root estimate			

Ten or eleven trees were sampled per site and stand biomass values for fifteen 100 m^2 plots per site were derived from regressions on D. There was 5.5, 3.6 and 1.3 t/ha of dead branches in columns left to right. Values given above are for *P. grandidentata* only; other species (*Acer*, *Quercus* etc.) were ignored.

a. Percentage of total basal area accounted for by *P. grandidentata*.

b. Excluding woody litterfall and any mortality.

Gosz, J.R. (1980). Biomass distribution and production budget for a non-aggrading forest ecosystem. *Ecology* 61, 507-514.

Bray, J.R. and Dudkiewicz, L.A. (1963). The composition, biomass and productivity of two *Populus* forests. *Bull. Torrey Bot. Club* 90, 298-308.

U.S.A.	35°50'N 105°50'W 3109-3231 m New Mexico Sangre de Cristo Range, Tesuque watershed. *Populus tremuloides* Deep gravelly, stoney loams pH 6.0-6.4 (Gosz 1980)	ca.47°N 95°W 200-400 m Minnesota, Itasca *P. tremuloides* Fertile silty, sandy uplands (Bray and Dudkiewicz 1963)
Age (years)	ca.80	41
Trees/ha	2270	1600
Tree height (m)		16-17
Basal area (m^2/ha)	36.4	30.9
Leaf area index		6.6
Stem volume (m^3/ha)		
Dry biomass (t/ha) — Stem wood	116.2	181.9
Dry biomass (t/ha) — Stem bark	20.5	
Dry biomass (t/ha) — Branches	7.1	20.9
Dry biomass (t/ha) — Fruits etc.		
Dry biomass (t/ha) — Foliage	2.0	3.7
Dry biomass (t/ha) — Root estimate		
CAI (m^3/ha/yr)		
Net production (t/ha/yr) — Stem wood	0.40 + 0.85[a] + 0.62[b]	>4.4[d]
Net production (t/ha/yr) — Stem bark		
Net production (t/ha/yr) — Branches		>0.8[e]
Net production (t/ha/yr) — Fruits etc.		
Net production (t/ha/yr) — Foliage	1.77[a] + 0.42[c]	3.8[f]
Net production (t/ha/yr) — Root estimate		

Gosz (1980) sampled 14 trees and derived stand values for fifty-five 100 m^2 plots from regressions on D; there were 1740 dead trees per hectare (7.0 m^2/ha basal area) weighing 13.8 t/ha, plus 3.1 t/ha of dead branches, and 1.2 t/ha of root sprouts, none of which is included above.
Bray and Dudkiewicz (1963) sampled 6 trees during July-September, and derived stand values by assigning biomass in proportion to the 'effective canopy area' per tree for 4 trees at each of 40 random points.

a. Litterfall, measured over 3 years. *b*. Mortality.
c. Consumption, decay and other losses. *d*. Mean (not current) annual increment.
e. New twigs, plus old wood divided by its age (41) and excluding any woody litterfall. *f*. Foliage biomass plus consumption.

Whittaker, R.H. and Niering, W.A. (1975). Vegetation of the Santa Catalina mountains, Arizona. V Biomass, production and diversity along the elevation gradient. *Ecology* 56, 771-790.

Alban, D.H., Perala, D.A. and Schlaegel, B.E. (1978). Biomass and nutrient distribution in aspen, pine and spruce stands on the same soil type in Minnesota. *Can. J. For. Res.* 8, 290-299.

U.S.A.	ca.32°20'N 110°50'W 2250 m Arizona Santa Catalina Mtns *Populus tremuloides* (72%)[a] *Robinia neomexicana* (7%)[a] *et al.* (Whittaker and Niering 1975)	47°20'N 94°30'W 400 m Minnesota Pike Bay Expt. Forest *P. tremuloides*, *Populus grandidentata* with *Acer saccharum*, *Acer rubrum et al.* (Alban *et al.* 1978)
Age (years)	34[b]	40
Trees/ha	2350 710[c]	1334 + 1655[f]
Tree height (m)	16.1[b]	20.3 11.0[f]
Basal area (m^2/ha)	31.6 + 0.4[c]	34.7 + 7.0[f]
Leaf area index	6.4	
Stem volume (m^3/ha)	218[d]	286[g] + 39[fg]
Dry biomass (t/ha) Stem wood	103 + 0.7[c]	119.4
Dry biomass (t/ha) Stem bark		28.3
Dry biomass (t/ha) Branches	16 + 0.2[c]	17.0
Dry biomass (t/ha) Fruits etc.		
Dry biomass (t/ha) Foliage	5.2 + 0.0[c]	3.8
Dry biomass (t/ha) Root estimate		38
CAI (m^3/ha/yr)	5.4[d]	
Net production (t/ha/yr) Stem wood	3.25[e] + 0.06[ce]	
Net production (t/ha/yr) Stem bark	0.68[e]	
Net production (t/ha/yr) Branches	2.17[e] + 0.06[ce]	
Net production (t/ha/yr) Fruits etc.	0.45	
Net production (t/ha/yr) Foliage	3.75 + 0.07[c]	
Net production (t/ha/yr) Root estimate		

Whittaker and Niering (1975) sampled 10-15 trees of each species and derived stand biomass values for a 0.1 ha plot from regressions on D, wood volumes and surface areas, and from other relationships; all trees and shrubs over 1 cm D were included. Alban *et al.* (1978) sampled 10 trees in spring, and felled two trees in August to estimate foliage biomass and to extract roots; stand biomass values for ten 80 m^2 plots were derived from regressions on D^2H; nutrient contents were determined.

a. Percentage of the total stem volume. *b*. Weighted mean age and height.
c. Understorey shrubs. *d*. Parabolic volumes.
e. Excluding woody litterfall and any mortality.
f. Values for trees other than *Populus* spp. (all species are included in the biomass values). *g*. Volumes inside bark.

Young, H.E. (1972). Biomass sampling methods for puckerbrush studies. In: "Forest Biomass Studies", pp. 179-190. College of Life Sciences and Agriculture, University of Maine, Orono, U.S.A.

Young, H.E. (1973). Biomass variation in apparently homogeneous puckerbrush stands. In: "IUFRO Biomass Studies", pp. 197-206. College of Life Sciences and Agriculture, University of Maine, Orono, U.S.A.

45-47°N 68-70°W -- U.S.A., Maine.

Populus tremuloides, *Populus grandidentata*, with *Betula populifolia*, *Acer rubrum et al.*

'Puckerbrush' stands

nr Old Town

Age (years)	6	7	20	40	41
Trees/ha		-			
Tree height (m)	4.9	5.0	10.7		13.7
Basal area (m^2/ha)					
Leaf area index					
Stem volume (m^3/ha)					
Dry biomass (t/ha) Stem wood	} 21.6	} 23.8	} 74.5	} 49.8	} 117.9
Dry biomass (t/ha) Stem bark					
Dry biomass (t/ha) Branches				3.3	
Dry biomass (t/ha) Fruits etc.					
Dry biomass (t/ha) Foliage	3.7	3.9	1.9	2.7	2.1
Dry biomass (t/ha) Root estimate		5.7			
CAI (m^3/ha/yr)					
Net production (t/ha/yr) Stem wood					
Net production (t/ha/yr) Stem bark					
Net production (t/ha/yr) Branches					
Net production (t/ha/yr) Fruits etc.					
Net production (t/ha/yr) Foliage					
Net production (t/ha/yr) Root estimate					

All trees were harvested within one plot per stand and their fresh weights were measured. Dry weights were estimated from the water contents of subsamples. The plots were at least as long and as wide as the trees were tall. Roots were excavated in the 7-year-old stand.

Cooper, A.W. (1980). Above-ground biomass accumulation and net primary production during the first 70 years of succession in *Populus grandidentata* Michx. stands on poor sites in northern lower Michigan. In: "Proceedings of Workshop on Forest Succession", Mountain Lake, Va, U.S.A.

45°35'N 84°45'W 235 m **U.S.A., Michigan, Cheboygan County, Douglas Lake.**

Infertile, freely-drained, weakly podzolized, Rubicon sands.

Populus tremuloides*, *Populus grandidentata*, with *Acer rubrum*, *Quercus rubra*, *Pinus strobus et al.

Regeneration after fire.

Age (years)	20	30	40	50	60	70
Trees/ha						
Tree height (m)						
Basal area (m^2/ha)				15.7		
Leaf area index						
Stem volume (m^3/ha)						
Dry biomass (t/ha): Stem wood / Stem bark	8 + 3	20 + 6	32 + 11	43 + 16	52 + 24	56 + 36
Dry biomass (t/ha): Branches	1.4+0.5	2.6+1.1	3.5+1.9	4.0+2.6	4.3+3.3	4.3+4.2
Dry biomass (t/ha): Fruits etc.						
Dry biomass (t/ha): Foliage	0.8+0.2	1.0+0.3	1.2+0.5	1.2+0.6	1.1+0.8	0.9+1.1
Dry biomass (t/ha): Root estimate						
CAI (m^3/ha/yr)						
Net production (t/ha/yr): Stem wood / Stem bark	(0.6+0.3)[a]	(1.1+0.3)[a]	(1.4+0.4)[a]	(1.5+0.4)[a]	(1.1+0.5)[a]	(0.2+0.8)[a]
Net production (t/ha/yr): Branches	0.8+0.3	1.3+0.4	1.5+0.5	1.4+0.6	1.4+0.7	1.2+0.9
Net production (t/ha/yr): Fruits etc.						
Net production (t/ha/yr): Foliage						
Net production (t/ha/yr): Root estimate						

Fifty-two *Populus*, and 79 trees of the other species, were sampled in July-August. Stand biomass values for plots of 200-400 m^2 were derived from regressions on D, and equations were calculated relating biomass and production to age. Values are given above for *Populus* spp. plus other species (left and right, respectively, in each column). There was about 0.4, 0.6, 0.9, 1.1, 1.2 and 1.4 t/ha of dead branches in columns left to right.

a. Including woody litterfall, but excluding any mortality.

Pastor, J. and Bockheim, J.G. (1981). Biomass and production of an aspen-mixed hardwood-spodosol ecosystem in northern Wisconsin. *Can. J. For. Res.* 11, 132-138.

45°50'N 89°40'W ca.300 m U.S.A., Wisconsin.

Acid, glacial-outwash, sandy loams.

Populus tremuloides (58%)[a], *Acer saccharum* (19%)[a], *Populus grandidentata* (10%)[a], *Acer rubrum*, *et al.*

Age (years)		39-63
Trees/ha		1341
Tree height (m)		31.6
Basal area (m^2/ha)		
Leaf area index		
Stem volume (m^3/ha)		
Dry biomass (t/ha)	Stem wood	124.0
	Stem bark	24.0
	Branches	23.3
	Fruits etc.	2.4
	Foliage	
	Root estimate	20.2
CAI (m^3/ha/yr)		
Net production (t/ha/yr)	Stem wood	3.80[b]
	Stem bark	0.80[b]
	Branches	3.32[b]
	Fruits etc.	
	Foliage	2.36
	Root estimate	1.20

Nine trees were sampled of *P. tremuloides* and 9 of *A. saccharum*. Stand biomass values for three 400 m^2 plots were derived from regressions on D. There was 3.5 t/ha of dead branches. Roots were assumed to grow at the same relative rates as above-ground parts.

a. Percentage of the total basal area.

b. Excluding woody litterfall and any mortality.

Crow, T.R. (1978). Biomass and production in three contiguous forests in northwest Wisconsin. *Ecology* 59, 265-273.

45°30'N 89°20'W 600 m U.S.A., Wisconsin, 30 km SE of Rhinelander.

Well-drained acidic sandy loams.

Populus tremuloides, *Acer rubrum*, *Betula papyrifera*, *Acer saccharum* with understorey shrubs.

		(53% 13% 11% 3%)[a]	(33% 21% 17% 6%)[a]	(12% 26% 18% 11%)[a]
Age (years)		ca.50	ca.50	ca.50
Trees/ha		2842	2080	1868
Tree height (m)		14.4	14.4	14.7
Basal area (m^2/ha)		18.0	16.5	18.8
Leaf area index		5.0	4.9	5.5
Stem volume (m^3/ha)				
Dry biomass (t/ha)	Stem wood	66.1	65.6	78.8
	Stem bark	11.3	10.3	11.1
	Branches	13.5 + 1.7[c]	16.8 + 0.8[c]	25.7 + 0.4[c]
	Fruits etc.			
	Foliage	2.4[b]	2.8[b]	3.7[b]
	Root estimate			
CAI (m^3/ha/yr)				
Net production (t/ha/yr)	Stem wood	4.37	3.35	2.61
	Stem bark	0.72	0.49	0.32
	Branches	0.82 + 0.42[c]	0.83 + 0.21[c]	0.90 + 0.08[c]
	Fruits etc.			
	Foliage	2.41[b]	2.77[b]	3.73[b]
	Root estimate			

Trees in several diameter classes of all the main species were sampled. Biomass values for about eighty 4 m^2 plots per stand were derived by proportional basal area allocation.

a. Percentage of the total basal area accounted for by *P. tremuloides*, *A. rubrum*, *B. papyrifera* and *A. saccharum* (written left to right within the brackets).

b. Including current year's twigs.

c. Understorey shrubs.

Safford, L.O. and Filip, S.M. (1974). Biomass and nutrient content of 4-year-old fertilized and unfertilized northern hardwood stands. *Can. J. For. Res.* 4, 549-554.

ca.44°00'N 71°20'W -- U.S.A., New Hampshire, Barlett Experimental Forest.

	Prunus pensylvanica (53%)[a] *Betula alleghaniensis* syn. *lutea* (11%)[a] *Betula papyrifera, et al.* Clearfelled and scarified	*P. pensylvanica* (94%)[a] *Betula* spp. *et al.* Clearfelled, scarified and fertilized (4.5 t/ha limestone, 1165 kg/ha NPK)
Age (years)	4	4
Trees/ha		
Tree height (m)	1.2-2.2	1.2-2.9
Basal area (m^2/ha)		
Leaf area index		
Stem volume (m^3/ha)		
Dry biomass (t/ha) Stem wood	3.9	18.9
Stem bark		
Branches	0.6 + 1.6[b]	2.5 + 1.1[b]
Fruits etc.		
Foliage	1.0	1.8
Root estimate		
CAI (m^3/ha/yr)		
Net production (t/ha/yr) Stem wood		
Stem bark		
Branches		
Fruits etc.		
Foliage		
Root estimate		

All woody vegetation was sampled in nine 1 m^2 plots in late September at each of the two sites. Nutrient contents were determined.

a. Percentage of the total woody plant biomass.

b. Understorey shrubs.

Lawson, G.J., Cottam, G. and Loucks, O.L. (1981). In: "Dynamic Properties of Forest Ecosystems" (D.E. Reichle, ed.), pp. 663-664. Cambridge University Press, Cambridge, London, New York, Melbourne.

43°02'N 89°24'W 274 m U.S.A., Wisconsin.

		Noe Woods	Nakoma
		Quercus alba, *Quercus velutina*, *Prunus serotina*	*Q. alba* and *Q. velutina*
		Silt loam, pH 5.8.	Urban oak remnant.
Age (years)		130	130
Trees/ha		422	
Tree height (m)		23.7	27.4
Basal area (m^2/ha)		33.2	
Leaf area index		4.4	2.9
Stem volume (m^3/ha)			
Dry biomass (t/ha)	Stem wood	209.2	99.0
	Stem bark		
	Branches	50.8	26.0
	Fruits etc.	0.1	
	Foliage	3.9	2.6
	Root estimate	66.0	
CAI (m^3/ha/yr)			
Net production (t/ha/yr)	Stem wood	2.71 + 3.49[a] + 1.49[b]	2.23[c]
	Stem bark		
	Branches	0.73 + 0.90[b]	0.59[c]
	Fruits etc.	0.08[b]	
	Foliage	4.29[b]	2.59
	Root estimate	6.60	

There was 20.6 t/ha of standing dead wood at Noe Woods.

a. Mortality.

b. Litterfall.

c. Excluding woody litterfall and any mortality.

Rochow, J.J. (1974a). Estimates of above-ground biomass and primary productivity in a Missouri forest. *J. Ecol.* 62, 567-577.
Rochow, J.J. (1974b). Litterfall relations in a Missouri forest. *Oikos* 25, 80-85.
Rochow, J.J. (1975). Mineral nutrient pool and cycling in a Missouri forest. *J. Ecol.* 63, 985-994.
Whittaker, R.H. (1966). Forest dimensions and production in the Great Smoky Mountains. *Ecology* 47, 103-121.

U.S.A.	38°48'N 92°12'W 175-245 m Missouri, SE Boone County. *Quercus alba* (30%)[a] other *Quercus* spp. (28%)[a] *Acer saccharum* (11%)[a] *et al.* Loess covered uplands (Rochow 1974 a, b, 1975)	35°28-47'N ca.84°W 300 m Great Smoky Mountains, Oak Ridge. *Q. alba* (57%)[d] *Quercus velutina* (28%)[d] *et al.* (Whittaker 1966)
Age (years)	35-92	Mature
Trees/ha	522	660[e]
Tree height (m)		29[f]
Basal area (m^2/ha)		31.4
Leaf area index		
Stem volume (m^3/ha)		350[g]
Dry biomass (t/ha) Stem wood, Stem bark, Branches	94.8 + 3.3[b]	366.5
Dry biomass (t/ha) Fruits etc.		
Dry biomass (t/ha) Foliage		3.5
Dry biomass (t/ha) Root estimate		
CAI (m^3/ha/yr)		4.6[g]
Net production (t/ha/yr) Stem wood, Stem bark, Branches	1.7 + 1.1[c] + 0.5[b]	12.0[h]
Net production (t/ha/yr) Fruits etc.		
Net production (t/ha/yr) Foliage	3.5[c]	3.5
Net production (t/ha/yr) Root estimate		

Rochow (1974a) estimated the biomass of trees over 4 cm D in eighteen 800 m^2 plots from their parabolic wood volumes, wood specific gravities, and litterfall; nutrient contents were determined.
Whittaker (1966) derived stand biomass values for a 0.1 ha plot from published regressions on D, from stem volumes, branch/stem biomass ratios, and other relationships.
a. Percentage of the total basal area. *b*. Saplings.
c. Litterfall, measured over 3 years.
d. Percentage of the total volume increment.
e. Stems over 1.9 cm D. *f*. Canopy height.
g. Parabolic volume. *h*. Excluding woody litterfall and any mortality.

Ovington, J.D., Heitkamp, D. and Lawrence, D.B. (1963). Plant biomass and productivity of prairie, savanna, oakwood and maize field ecosystems in central Minnesota. *Ecology* 44, 52-63.

Whittaker, R.H. (1963). Net production of heath balds and forest heaths in the Great Smoky Mountains. *Ecology* 46, 176-182.

Whittaker, R.H. (1966). Forest dimensions and production in the Great Smoky Mountains. *Ecology* 47, 103-121.

U.S.A.	45°24'N 93°10'W 400 m Minnesota, 50 km N of Minneapolis *Quercus borealis*, with *Pinus banksiana*, *Pinus strobus*, *Quercus* spp. *et al.* Infertile sands and peats	35°28-47'N ca.84°W Great Smoky Mountains 1450 m Gregory Bald *Q. borealis* (80%)[b] *Magnolia acuminata* *et al.* (Whittaker 1963, 1966)	1390 m Parson Bald *Q. borealis* (51%)[b] *Quercus alba* (29%)[b] *et al.*
Age (years)	up to 90	Mature	146[c]
Trees/ha	over 800[a]	2660[d]	2600[d]
Tree height (m)	16	14[e]	7.5[c]
Basal area (m^2/ha)	ca.25	24.6	22.0
Leaf area index			3.5
Stem volume (m^3/ha)		137[f]	65[f]
Dry biomass (t/ha) Stem wood	111	132.2	46
Dry biomass (t/ha) Stem bark			6
Dry biomass (t/ha) Branches	49		31
Dry biomass (t/ha) Fruits etc.			
Dry biomass (t/ha) Foliage	4	2.8	3
Dry biomass (t/ha) Root estimate	16		
CAI (m^3/ha/yr)		2.3[f]	1.2[f]
Net production (t/ha/yr) Stem wood		4.7[g]	1.0[g]
Net production (t/ha/yr) Stem bark			0.2[g]
Net production (t/ha/yr) Branches			1.5[g]
Net production (t/ha/yr) Fruits etc.			
Net production (t/ha/yr) Foliage		2.8	2.3
Net production (t/ha/yr) Root estimate			

Ovington *et al.* (1963) sampled 3 trees and took soil core samples of the roots; stand biomass values for a 900 m^2 plot were obtained by multiplying mean tree values by the numbers of trees per hectare.
Whittaker (1963, 1966) estimated stand values for plots of at least 0.1 ha from the weight of clippings of current year's twigs, from published regressions, from stem volumes, branch/stem biomass ratios and other relationships.

a. Number of *Q. borealis*.
b. Percentage of the total volume increment.
c. Weighted mean age and height.
d. Stems over 1.9 cm D.
e. Canopy height.
f. Parabolic volumes.
g. Excluding woody litterfall and mortality.

Whittaker, R.H. and Woodwell, G.M. (1968). Dimension and production relations of trees and shrubs in the Brookhaven forest, New York. *J. Ecol.* 56, 1-25.

Whittaker, R.H. and Woodwell, G.M. (1969). Structure, production and diversity of the oak-pine forest at Brookhaven, New York. *J. Ecol.* 57, 155-174.

Woodwell, G.M., Whittaker, R.H. and Houghton, R.A. (1975). Nutrient concentrations in plants in the Brookhaven oak-pine forest. *Ecology* 56, 318-332.

40°40'N 73°10'W 25 m U.S.A., New York, Long Island, Brookhaven.

Sandy, well-drained, podzolic soils

Quercus coccinea (31%)[a], *Quercus alba* (18%)[a], *Pinus rigida* (18%)[a], *Quercus velutina* (3%)[a], *et al.* with understorey shrubs.

Age (years)		43[b]
Trees/ha		1854
Tree height (m)		7.6[b]
Basal area (m^2/ha)		15.6
Leaf area index		3.4[c] + 0.4[d]
Stem volume (m^3/ha)		69.9
Dry biomass (t/ha)	Stem wood	35.1 + 0.5[d]
	Stem bark	8.1 + 0.2[d]
	Branches	14.7 + 0.4[d]
	Fruits etc.	0.2 + 0.0[d]
	Foliage	4.1 + 0.3[d]
	Root estimate	33.3 + 3.0[d]
CAI (m^3/ha/yr)		1.59
Net production (t/ha/yr)	Stem wood	1.49 + 0.05[d]
	Stem bark	0.27 + 0.01[d]
	Branches	2.47 + 0.21[d] } + 0.60[e]
	Fruits etc.	(0.22 + 0.02[d])[f]
	Foliage	(3.51 + 0.31[d])[g]
	Root estimate	2.60 + 0.73[d]

Fifteen trees were sampled of each major species and roots were excavated. Stand values for several 0.1 ha plots were derived from regressions on D, stem volumes and surface areas, and from other relationships. All trees and shrubs over 1 cm D were included. Roots were assumed to grow at the same relative rates as the above-ground parts. Nutrient contents were determined.

a. Percentage of the total stem volume.

b. Weighted mean age and height (*Quercus* spp. were 38-45 years old, *P. rigida* was 84-100 years). *c*. Including all-sided LAI of *P. rigida*. *d*. Understorey shrubs.

e. Mean woody litterfall measured over 3 years; the increment values include estimated mortality. *f*. Including litterfall of 0.16 t/ha/yr of seeds etc. and miscellaneous matter. *g*. Including foliage litterfall of 2.61 t/ha/yr.

Reiners, W.A. (1972). Structure and energetics of three Minnesota forests. *Ecol. Monogr.* 42, 71-94.

Reiners, W.A. and Reiners, N.M. (1970). Energy and nutrient dynamics of forest floors in three Minnesota forests. *J. Ecol.* 58, 497-519.

Whittaker, R.H. and Niering, W.A. (1975). Vegetation of the Santa Catalina Mountains, Arizona. V Biomass, production and diversity along the elevation gradient. *Ecology* 56, 771-790.

U.S.A.		45°30'N 193°20'W 400 m Minnesota, N of Minneapolis *Quercus ellipsoidalis* (75%)[a] *Acer rubrum* (8%)[a] *et al.* (Reiners 1972)	ca.32°20'N 110°50'W 1310 m Arizona, Santa Catalina Mtns *Quercus oblongifolia* (56%)[b] *Quercus emoryi* (44%)[b] with understorey shrubs. (Whittaker and Niering 1975)
Age (years)		45-50	117[c]
Trees/ha		1788	190
Tree height (m)		ca.15	5.3[c]
Basal area (m^2/ha)		26.5	4.0
Leaf area index			1.8
Stem volume (m^3/ha)			10.7[d]
Dry biomass (t/ha)	Stem wood	92.4	6.1
	Stem bark	12.2	
	Branches	16.2	2.9
	Fruits etc.	0.0	
	Foliage	3.4	0.4 + 1.5[e]
	Root estimate		
CAI (m^3/ha/yr)			6.3[d]
Net production (t/ha/yr)	Stem wood	3.56	0.14[g] + 0.01[eg]
	Stem bark	0.48	0.03[g] + 0.01[eg]
	Branches	1.22 + 1.12[f]	0.22 + 0.02[e]
	Fruits etc.	0.01	0.05 + 0.12[e]
	Foliage	3.44	0.28 + 0.33[e]
	Root estimate		

Reiners (1972) derived stand biomass values for sixteen 100 m^2 plots from regressions on D and from the stem volumes of sample trees; increment values refer to the previous year's growth.
Whittaker and Niering (1975) sampled 10-15 trees per species and derived stand biomass values for a 0.1 ha plot from regressions on D, wood volumes and surface areas, and from other relationships; all trees over 1 cm D were included.

a. Percentage of the total biomass. *b*. Percentage of the total stem volume.
c. Weighted mean age and height. *d*. Parabolic volumes.
e. Understorey shrubs.
f. Woody litterfall; total litterfall was 4.57 t/ha/yr (Reiners and Reiners 1970).
g. Excluding woody litterfall and any mortality.

Whittaker, R.H. (1963). Net production of heath balds and forest heaths in the Great Smoky Mountains. *Ecology* 46, 176-182.

Whittaker, R.H. (1966). Forest dimensions and production in the Great Smoky Mountains. *Ecology* 47, 103-121.

35°28-47'N ca.84°W	(alt. given below) 970 m Mt LeConte		U.S.A., Great Smoky Mountains. 820 m Greenbrier Cove	820 m Cherokee Orchard
	Quercus prinus (19%)[a] *Nyssa sylvatica* (15%)[a] *et al.* with understorey shrubs		*Q. prinus* (56%)[a] *Quercus borealis* (12%)[a] *Acer rubrum* (18%)[a] *et al.*	*Q. prinus* (17%)[a] *Q. borealis* (16%)[a] *Liriodendron tulipifera* (18%)[a] *et al.*
Age (years)			Mature	Mature
Trees/ha	1410[b]	+ 17290[c]	2130[b]	2240[b]
Tree height (m)	10	3.5[c]	30[d]	21[d]
Basal area (m^2/ha)	10.3	+ 9.6[c]	35.6	26.9
Leaf area index		3.0[c]	6.3	
Stem volume (m^3/ha)	44.1[e]	+ 15.9[ce]	402[e]	203[e]
Dry biomass (t/ha): Stem wood, Stem bark, Branches, Fruits etc.	40.0	+ 24.3[c]	415.8	166.4
Dry biomass (t/ha): Foliage			4.2	3.6
Dry biomass (t/ha): Root estimate				
CAI (m^3/ha/yr)	0.6[e]	+ 0.6[ce]	6.2[e]	9.0[e]
Net production (t/ha/yr): Stem wood, Stem bark, Branches, Fruits etc.	2.2[f]	+ 3.2[cf]	14.0[f]	19.0[f]
Net production (t/ha/yr): Foliage			4.2	3.6
Net production (t/ha/yr): Root estimate				

Stand values for plots of at least 0.1 ha were estimated from the weights of clippings of current year's twigs, from published regressions, from stem volumes, branch/stem biomass ratios and other relationships.

a. Percentage of the total volume increment.
b. Stems over 1.9 cm D.
c. Understorey shrubs.
d. Canopy height.
e. Parabolic volumes.
f. Excluding woody litterfall and mortality; foliage production of trees and shrubs at Mt LeConte (left column) was 2.3 t/ha/yr.

Harris, W.F., Goldstein, R.A. and Henderson, G.S. (1973). Analysis of forest biomass pools, annual primary production and turnover of biomass for a mixed deciduous forest watershed. In: "IUFRO Biomass Studies", p.43-64. College of Life Sciences and Agriculture, University of Maine, Orono, U.S.A.

Harris, W.F. and Henderson, G.S. (1981). In: "Dynamic Properties of Forest Ecosystems", (D.E. Reichle, ed.), pp. 658-661. Cambridge University Press, Cambridge, London, New York and Melbourne.

35°58'N 84°17'W 265-360 m U.S.A., Tennessee, Walker Branch Sites.

Red-yellow podzols pH 4.0-6.5. Ultisols.	*Quercus prinus*, with *Carya* spp., *Quercus alba*, *Quercus rubra*, *Quercus velutina*, *et al.*	*Carya* spp., *Q. alba*, *Q. prinus*, *Q. velutina*, *et al.*
Age (years)	30-80	30-80
Trees/ha		
Tree height (m)	12-25	25
Basal area (m^2/ha)	25.8	20
Leaf area index		
Stem volume (m^3/ha)		
Dry biomass (t/ha): Stem wood	102.9	90.5
Stem bark		
Branches	30.3	26.9
Fruits etc.		
Foliage	4.7	4.2
Root estimate	38.0[a]	32.2[a]
CAI (m^3/ha/yr)		
Net production (t/ha/yr): Stem wood	5.40 + 0.55[b] + 0.55[c]	4.83 + 1.18[b] + 0.70[c]
Stem bark		
Branches		
Fruits etc.		
Foliage	4.70[d]	4.20[d]
Root estimate		

Many trees were sampled per site (about 150 at all four Walker Branch sites), roots were excavated in 2 or 3 pits per site, and stand values for 50-100 circular plots per site were derived from regressions on D. There was 1.2 t/ha of standing dead wood in the right column.

a. Including stumps which represented about half the 'root' biomass.
b. Mortality.
c. Woody litterfall.
d. Leaf biomass; leaf litterfall was 3.9 and 4.1 t/ha/yr in columns left and right, respectively.

Day, F.P. and Monk, C.D. (1977a). Net primary production and phenology on a southern Appalachian watershed. *Am. J. Bot.* 64, 1117-1125.

Day, F.P. and Monk, C.D. (1974). Vegetation patterns on a southern Appalachian watershed. *Ecology* 55, 1064-1074.

Day, F.P. and Monk, C.D. (1977b). Seasonal nutrient dynamics in the vegetation on a southern Appalachian watershed. *Am. J. Bot.* 64, 1126-1139.

35°03'N 83°26'W 726-993 m U.S.A., North Carolina, Nantahala Mountains.

Porter loams, pH 5.2 on 53° slope.

Quercus prinus (21%)[a], *Acer rubrum* (9%)[a], *Quercus coccinea* (8%)[a], *et al.*, with understorey shrubs including *Rhododendron* spp.

Age (years)		60-200
Trees/ha		3044
Tree height (m)		25
Basal area (m^2/ha)		25.6
Leaf area index		
Stem volume (m^3/ha)		
Dry biomass (t/ha)	Stem wood, Stem bark	97.1 + 11.0[b]
	Branches	22.1 + 4.2[b]
	Fruits etc.	0.4
	Foliage	3.5 + 2.1[b]
	Root estimate	30.7
CAI (m^3/ha/yr)		
Net production (t/ha/yr)	Stem wood, Stem bark, Branches	3.77 + 1.34[c]
	Fruits etc.	0.42[c]
	Foliage	4.19[d]
	Root estimate	

Stand biomass values for twenty-five 0.125 ha plots were derived from published regressions on D. There was 9.6 t/ha of standing dead trees. Nutrient contents were determined.

a. Percentage of the total basal area (*Quercus* species accounted for 43%).
b. Understorey shrubs; shrubs are included in the production values.
c. Litterfall.
d. New foliage biomass; leaf litterfall was 3.20 t/ha/yr.

Johnson, F.L. and Risser, P.G. (1974). Biomass, annual net primary production, and dynamics of six mineral elements in a Post oak - Blackjack oak forest. *Ecology* 55, 1246-1258.

35°15'N 97°20'W ca.250 m U.S.A., Oklahoma, 17 km E of Norman, Lake Thunderbird.

Sandy, red-yellow podzols

Quercus stellata and *Quercus marilandica* (98.6%)[a], with understorey shrubs.

Age (years)		to 80
Trees/ha		2600[b]
Tree height (m)		
Basal area (m^2/ha)		18.3
Leaf area index		4.8[c]
Stem volume (m^3/ha)		
Dry biomass (t/ha)	Stem wood	109.5
	Stem bark	
	Branches	64.9 + 1.4[d]
	Fruits etc.	
	Foliage	4.8
	Root estimate	39.0
CAI (m^3/ha/yr)		
Net production (t/ha/yr)	Stem wood	3.69
	Stem bark	
	Branches	3.64 + 0.53[e] + 0.30[d]
	Fruits etc.	
	Foliage	4.76
	Root estimate	2.24

Five trees of each of the two *Quercus* species were sampled in June and roots were core sampled. Stand values for two 100 m^2 plots were derived from regressions on D. Roots were assumed to grow at the same relative rates as above-ground parts. There was 14.3 t/ha of dead branches. Nutrient contents were determined.

a. Percentage of the total basal area accounted for by the two *Quercus* species.
b. Including 1420 *Quercus* trees.
c. Peak value, attained in June.
d. Understorey shrubs.
e. Woody litterfall measured over one year.

Monk, C.D., Child, G.I. and Nicholson, S.A. (1970). Biomass, litter and leaf surface area estimates of an oak - hickory forest. *Oikos* 21, 138-141.

Rolfe, G.L., Akhtar, M.A. and Arnold, L.E. (1978). Nutrient distribution and flux in a mature oak - hickory forest. *Forest Sci.* 24, 122-130.

U.S.A.	33°57'N 83°24'W ca.300 m Georgia, Athens. *Quercus* spp., *Carya pallida*, *et al.* (Monk *et al.* 1970)	37°30'N 88-89°W 200-400 m Illinois, Shawnee Hills, Pope County. *Quercus* spp. (85%)[d], *Acer saccharum*, *Carya glabra*, *et al.* Silty loams	
		Mesic site	Xeric site
Age (years)	>50	150[e]	150[e]
Trees/ha		2130[f]	1905[f]
Tree height (m)			
Basal area (m^2/ha)			
Leaf area index	ca.4		
Stem volume (m^3/ha)			
Dry biomass (t/ha): Stem wood	137.2 + 0.2[a]	130.6	127.3
Dry biomass (t/ha): Stem bark			
Dry biomass (t/ha): Branches		53.6	51.9
Dry biomass (t/ha): Fruits etc.			
Dry biomass (t/ha): Foliage	4.4 + 0.03[a]	5.6	5.2
Dry biomass (t/ha): Root estimate		48.8	46.8
CAI (m^3/ha/yr)			
Net production (t/ha/yr): Stem wood	>0.8[b]	7.1[g]	6.2[g]
Net production (t/ha/yr): Stem bark			
Net production (t/ha/yr): Branches			
Net production (t/ha/yr): Fruits etc.			
Net production (t/ha/yr): Foliage	4.6[c]		
Net production (t/ha/yr): Root estimate			

Monk *et al.* (1970) sampled 23 trees and estimated stand values for the tree layer in twenty 10 m^2 plots from regressions on D.
Rolfe *et al.* (1978) sampled 11 trees (in Pope County), excavated 4 root systems, and derived stand values for three 400 m^2 plots per site from regressions on D; nutrient contents were determined.

a. Understorey shrubs.
b. Stem increment plus new twigs, excluding the increment of large branches and any woody litterfall.
c. New foliage biomass plus estimated consumption.
d. Percentage of the total biomass. *e*. Average age of *Quercus* dominants.
f. Trees over 3.8 cm D. *g*. Total litterfall only, measured over 2½ years.

Whittaker, R.H. (1963). Net production of heath balds and forest heaths in the Great Smoky Mountains. *Ecology* 44, 176-182.

Whittaker, R.H. (1962). Net production relations of shrubs in the Great Smoky Mountains. *Ecology* 43, 357-377.

ca.35°40'N 83°30'W (alt. given below) U.S.A., Tennessee, Great Smoky Mountains, Mount LeConte.

Leached acid podzols with a low nutrient status, on 15-40° slopes.

Rhododendron carolinianum, *Rhododendron catawbiense*, *Kalmia latifolia*, *Vaccinium constablaei*, *Pyrus melanocarpa*, *et al.*

	2010 m[a]	2010 m[b]	1500 m	1430 m	1500 m	1560 m	1490 m
Age (years)							Mature
Trees/ha							42700
Tree height (m)	1.3[c]	2.5[c]	0.7[c]	1.5[c]	1.8[c]	1.7[c]	3.8[d]
Basal area (m^2/ha)							35.0
Leaf area index	2.0	2.8	2.0	2.6	4.5	4.8	6.1
Stem volume (m^3/ha)							60.1[e]
Dry biomass (t/ha): Stem wood, Stem bark, Branches, Fruits etc., Foliage, Root estimate	17.6	25.0	8.3	19.8	27.7	37.2	107.8
CAI (m^3/ha/yr)							2.3[e]
Net production (t/ha/yr): Stem wood, Stem bark, Branches, Fruits etc., Foliage, Root estimate	4.1[f]	4.9[f]	2.3[f]	3.8[f]	5.9[f]	6.3[f]	9.8[f]

Stand values were estimated for ten 1 m^2 plots per stand from the weight of clippings of current year's twigs, from published regressions, from stem volumes, branch/stem biomass ratios, and other relationships.

a. Values in this column refer to a plot of almost pure *R. carolinianum*.
b. Values in this column refer to a plot of almost pure *R. catawbiense*.
c. Canopy heights.
d. Weighted mean height.
e. Parabolic volume.
f. Excluding woody litterfall and mortality.

Schlesinger, W.H. (1978). Community structure, dynamic and nutrient cycling in the Okefenokee cypress swamp forest. *Ecol. Monogr.* 48, 43-65.

30°31'-31°08'N 82°08-38'W 32-40 m U.S.A., Georgia, Okefenokee.

Peat bog. *Taxodium distichum* var. *nutans* (81%)[a], *Ilex cassine*, *Nyssa sylvatica* var. *biflora*, with understorey shrubs.

Age (years)		
Trees/ha		1430 + 500[b]
Tree height (m)		13.9
Basal area (m^2/ha)		51.9 + 12.3[b]
Leaf area index		1.1[c] + 0.3[cb]
Stem volume (m^3/ha)		
Dry biomass (t/ha)	Stem wood	253.3
	Stem bark	36.7
	Branches	8.2 + 5.3[b]
	Fruits etc.	0.1
	Foliage	2.3[d]
	Root estimate	
CAI (m^3/ha/yr)		
Net production (t/ha/yr)	Stem wood	2.32
	Stem bark	0.35 + 0.43[e]
	Branches	0.63
	Fruits etc.	0.07 + 0.34[e] + 1.06[b] + 0.10[be]
	Foliage	2.33[de]
	Root estimate	

Twenty-three trees were sampled in July and stand biomass values for two 0.1 ha plots were derived from regressions on D. There was 49 t/ha of standing dead trees, 2.7 t/ha of dead branches and 0.7 t/ha of *Tillandsia usneoides* (Spanish moss), none of which is included above. Nutrient contents were determined.

a. Percentage of the total basal area.
b. Understorey shrubs.
c. All-sided LAI values were 2.4 for trees and 0.5 for shrubs.
d. Including current year's twigs.
e. Litterfall, measured over one year; there was also 0.08 t/ha/yr of litterfall from *T. usneoides*.

Connor, W.H. and Day, J.W. (1976). Productivity and composition of a baldcypress water tulepo site and a bottomland hardwood site in a Louisiana swamp. *Am. J. Bot.* 63, 1354-1364.

29°45'N 90°30'W 1 to 2 m U.S.A., Louisiana, near New Orleans, Barataria Bay.

Swamp.	*Taxodium distichum* (46%)[a], *Nyssa aquatica* (48%)[a], *et al.*	*N. aquatica* (35%)[a], *Populus heterophylla* (14%)[a], *Acer rubrum* (10%)[a], *T. distichum, et al.*
	Soft clay and peat.	Organic matter over grey clay.
Age (years)	50-95	< 30
Trees/ha	1730	2970
Tree height (m)		
Basal area (m^2/ha)		
Leaf area index		
Stem volume (m^3/ha)		
Dry biomass (t/ha): Stem wood, Stem bark, Branches	372.0	165.3
Dry biomass (t/ha): Fruits etc.		
Dry biomass (t/ha): Foliage		
Dry biomass (t/ha): Root estimate		
CAI (m^3/ha/yr)		
Net production (t/ha/yr): Stem wood, Stem bark, Branches	5.00	8.00
Net production (t/ha/yr): Fruits etc., Foliage	6.20[b]	5.74[b]
Net production (t/ha/yr): Root estimate		

Stand biomass values for the above two 0.1 ha plots were derived from regressions on D published by Monk *et al.* (1970) (see p.285).

a. Percentage of the total basal area.

b. Total litterfall measured over one year.

Grier, C.C., Vogt, K.A., Keyes, M.R. and Edmonds, R.L. (1981). Biomass distribution and above- and below-ground production in young and mature *Abies amabilis* zone ecosystems of the Washington Cascades. *Can. J. For. Res.* 11, 155-167.
Grier, C.C. and Milne, W.A. (1981). Regression equations for calculating component biomass of young *Abies amabilis* (Dougl.) Forbes. *Can. J. For. Res.* 11, 184-187.
Gholz, H.L., Grier, C.C., Campbell, A.G. and Brown, A.T. (1979). "Equations for Estimating Biomass and Leaf Area of Plants in the Pacific Northwest." Forest Research Laboratory, Oregon State University, Corvallis, USA. Research Paper 41.

47°19'N 121°35'W 1140 m U.S.A., Washington, Findley Lake.

Sandy to gravelly clay loams overlying morainal deposits.

Abies amabilis with some *Abies procera*, *Tsuga heterophylla*, *Tsuga mertensiana* and understorey shrubs.

Age (years)		23	180
Trees/ha		110500	510
Tree height (m)		1.4 (0.3 to 2.6)	22.1 (3.1 to 39.0)
Basal area (m^2/ha)		45.7	74.3
Leaf area index			
Stem volume (m^3/ha)			
Dry biomass (t/ha)	Stem wood	25.0 + 2.2[a]	293.9
	Stem bark	2.7 + 2.2[a]	62.2
	Branches	7.8 + 2.2[a]	67.8
	Fruits etc.		
	Foliage	13.6 + 0.3[a]	21.7
	Root estimate	24.7	137.7
CAI (m^3/ha/yr)			
Net production (t/ha/yr)	Stem wood	2.85 + 0.30[b] + 0.06[a] + 0.47[c]	1.58
	Stem bark	0.29 + 0.30[b] + 0.06[a] + 0.47[c]	0.36
	Branches	0.90 + 0.30[b] + 0.06[a] + 0.47[c]	0.38 + 1.15[c]
	Fruits etc.		
	Foliage	0.22 + 1.04[c]	0.00 + 1.03[c]
	Root estimate	1.78 + 10.04[d]	0.70 + 11.53[d]

Fifty-six trees were sampled from the 23-year-old stand in November, and stand biomass values were derived from regressions on D. Regressions published by Gholz *et al.* (1979) were used to estimate the biomass of the older stand and the biomass of the thick roots. Roots over 5 mm diameter weighed 15.5 and 124.9 t/ha in columns left and right, respectively. There was 2.0 and 7.9 t/ha of dead branches, and 60.5 and 157.0 t/ha of standing dead trees in columns left and right, respectively.

a. Understorey shrubs.
b. Mortality, estimated only in this 23-year-old stand.
c. Litterfall.
d. Estimated root turnover of trees and shrubs.

Turner, J. and Singer, M.J. (1976). Nutrient distribution and cycling in a sub-alpine coniferous forest ecosystem. *J. appl. Ecol.* 13, 295-301.

Fujimori, T., Kawanabe, S., Saito, H., Grier, C.C. and Shidei, T. (1976). Biomass and primary production in forests of three major vegetation zones of the north-western United States. *J. Jap. For. Soc.* 58, 360-373.

U.S.A.	47°52'N 123°00'W 1200 m Washington, Findley Lake. *Abies amabilis* (93%)[a], *Tsuga mertensiana* with understorey shrubs. Unthinned. Coarse sandy loam. (Turner and Singer 1976)	44°00'N 122°40'W 1300 m Oregon, Wildcat Mtn Reserve. *Abies procera* (56%)[a], *Pseudotsuga menziesii* (40%)[a], *Abies amabilis* (4%)[a]. Brown podzolic sandy loam. (Fujimori *et al.* 1976)
Age (years)	up to 170	100-130
Trees/ha	620	350
Tree height (m)		49.9[b]
Basal area (m^2/ha)	96.7	98.1
Leaf area index		
Stem volume (m^3/ha)		1989
Dry biomass (t/ha) Stem wood	265.0	683.1
Stem bark	38.7	111.9
Branches	17.7 + 17.7[c]	67.8
Fruits etc.		
Foliage	15.7	17.5
Root estimate		
CAI (m^3/ha/yr)		19.3
Net production (t/ha/yr) Stem wood		6.7[d]
Stem bark		1.0[d]
Branches	0.94[f]	2.0[d] (or 5.6)[de]
Fruits etc.		
Foliage	2.08[f]	3.2
Root estimate		

Turner and Singer (1976) derived stand values for a 450 m^2 plot from regressions calculated by Dice (1970) (see p.329), and from a sample of 6 trees; there were 490 dead trees per hectare weighing 127.7 t/ha; nutrient contents were determined. Fujimori *et al.* (1976) derived stand values for a 0.34 ha plot from regressions on D^2H for the main species, and by proportional basal area allocation for the minor species; foliage litterfall was similar to the foliage increment given above.

a. Percentage of the total basal area.
b. Mean height of the dominant trees. *c.* Understorey shrubs.
d. Excluding woody litterfall and mortality.
e. Alternative value derived by branch ring analysis.
f. Litterfall only.

Whittaker, R.H. (1966). Forest dimensions and production in the Great Smoky Mountains. *Ecology* 47, 103-121.

35°28-47'N ca.84°W (alt. given below) U.S.A., Great Smoky Mountains.

Abies fraseri, *Picea rubens*, *et al.*

	(69% 28%)[a]	(67% 31%)[a]	(96% 3%)[a]	(77% 18%)[a]
	1620 m	1620 m	1920 m	1900 m
Age (years)	Mature	45-55	Mature	Mature
Trees/ha	1410[b]	1470[b]	710[b]	5580[b]
Tree height (m)	26[c]	21[c]	17[c]	10[c]
Basal area (m^2/ha)	50.2	59.7	40.0	56.3
Leaf area index			5.3[d]	
Stem volume (m^3/ha)	488[e]	472[e]	276[e]	209[e]
Dry biomass (t/ha): Stem wood, Stem bark, Branches, Fruits etc., Foliage	310	300	210	200
Dry biomass (t/ha): Root estimate				
CAI (m^3/ha/yr)	5.3[e]	8.5[e]	2.4[e]	2.7[e]
Net production (t/ha/yr): Stem wood, Stem bark, Branches, Fruits etc.	6.4[f]	10.6[f]	2.9[f]	4.1[f]
Net production (t/ha/yr): Foliage	2.8	3.4	1.8	2.4
Net production (t/ha/yr): Root estimate				

Stand biomass values for plots of at least 0.1 ha were derived from published regressions on D, from stem volumes, branch/stem biomass ratios, and other relationships.

a. Percentage of the total volume increment accounted for by *A. fraseri* and *P. rubens*, written left and right, respectively, within the brackets.
b. Stems over 1.9 cm D.
c. Weighted mean heights.
d. All-sided LAI was 12.3.
e. Parabolic volumes.
f. Excluding woody litterfall and mortality.

Whittaker, R.H. and Niering, W.A. (1975). Vegetation of the Santa Catalina Mountains, Arizona. V Biomass, production and diversity along the elevation gradient. *Ecology* 56, 771-790.

Whittaker, R.H. and Niering, W.A. (1968). Vegetation of the Santa Catalina Mountains, Arizona. IV Limestone and acid soils. *J. Ecol.* 56, 523-544.

ca.32°20'N 110°50'W (alt. given below)		N facing slope of Mt Lemmon. *Abies lasiocarpa* (85%)[a], *Pseudotsuga menziesii* (10%)[a], *et al.* with understorey of *Jamesia americana*, *et al.*	U.S.A., Arizona, Santa Catalina Mountains, near Tucson. Marshall Gulch. *Abies concolor* (55%)[a], *P. menziesii* (20%)[a], *Pinus strobiformis*, *et al.*
		2720 m	2340 m
Age (years)		106[b]	124[b] (50-145)
Trees/ha		590 160[c]	1510
Tree height (m)		33.5[b]	25.5[b]
Basal area (m^2/ha)		57.8 + 0.3[c]	58.6
Leaf area index		6.4[d]	6.7[d]
Stem volume (m^3/ha)		837[e]	746[e]
Dry biomass (t/ha)	Stem wood	290 + 0.40[c]	270
	Stem bark		
	Branches	50 + 0.20[c]	74
	Fruits etc.		
	Foliage	16.2 + 0.04[c]	16.7
	Root estimate		
CAI (m^3/ha/yr)		5.7[e]	5.6[e]
Net production (t/ha/yr)	Stem wood	2.75[f] + 0.02[cf]	3.95[f]
	Stem bark	0.48[f]	0.85[f]
	Branches	1.30[f] + 0.02[cf]	1.64[f]
	Fruits etc.	0.42 + 0.00[c]	0.54
	Foliage	3.65 + 0.04[c]	4.12
	Root estimate		

Ten to fifteen trees were sampled of each of the major species, and stand values for the above two 0.1 ha plots were derived from regressions on D, wood volumes and surface areas, and from other relationships. All trees and shrubs over 1 cm D were included.

a. Percentage of the total stem volume.
b. Weighted mean ages and heights.
c. Understorey shrubs.
d. All-sided LAI values were 14.7 and 15.5 in columns left and right, respectively.
e. Parabolic volumes.
f. Excluding woody litterfall and mortality.

Westman, W.E. and Whittaker, R.H. (1975). The pygmy forest region of northern California: studies on biomass and primary productivity. *J. Ecol.* 63, 493-520.

Jenny, H., Arkley, R.J. and Schultz, A.M. (1969). The pygmy forest podsol ecosystem and its dune associates of the Mendocino coast. *Madroño* 20, 60-74.

ca.39°20'N 123°45'W 146 m U.S.A., California, Mendocino, near Fort Bragg.

Podzols. *Cupressus pygmaea* (68%)[a], *Vaccinium ovatum* (17%)[a], *Pinus contorta* subsp. *bolanderi* (9%)[a].

Age (years)		up to 136
Trees/ha		>150000
Tree height (m)		1.2[b] 2.6[b]
Basal area (m²/ha)		1.7[c]
Leaf area index		2.1[d]
Stem volume (m³/ha)		2.0[e]
Dry biomass (t/ha)	Stem wood	12.1
	Stem bark	7.0
	Branches	2.8
	Fruits etc.	1.4
	Foliage	3.3[f]
	Root estimate	8.3
CAI (m³/ha/yr)		0.07[e]
Net production (t/ha/yr)	Stem wood	0.22[g]
	Stem bark	0.11[g]
	Branches	1.02 } [h]
	Fruits etc.	0.53 } [h]
	Foliage	1.19[f] } [h]
	Root estimate	0.96

Extensive sampling was done and roots were excavated. Stand values were derived from regressions on various dimensions following Whittaker *et al.* (1974) (see p.259).
Values given above are the means of five 100 m² plots.

a. Percentage of the total biomass; *C. pygmaea* is also known as *C. goveniana* var. *pigmaea*.
b. Weighted mean heights of *C. pygmaea* (1.2 m) and *P. contorta* (2.6 m).
c. 'Basal area' of *P. contorta* only, measured 10 cm from the ground.
d. Including all-sided foliage area of *P. contorta*.
e. Parabolic volume.
f. Including the current year's twigs.
g. Excluding mortality.
h. Including total litterfall of 0.60 t/ha/yr.

Gholz, H.L. (1981). Environmental limits on aboveground net primary production, leaf area and biomass in vegetation zones of the Pacific Northwest. *Ecology* (in press).
Gholz, H.L., Grier, C.C., Campbell, A.G. and Brown, A.T. (1979). "Equations for Estimating Biomass and Leaf Area of Plants in the Pacific Northwest." Forest Research Laboratory, Oregon State University, Corvallis, USA. Research Paper No.41.
Gholz, H.L., Fitz, F. and Waring, R.H. (1976). Leaf area differences associated with old-growth forest communities in the western Oregon Cascades. *Can. J. For. Res.* 6, 49-57.

44-45°N ca.121°W 1356 m U.S.A., Oregon, Cascade Mountains.

High lava plain.

Juniperus occidentalis

Age (years)		up to 350
Trees/ha		199[a]
Tree height (m)		1
Basal area (m^2/ha)		27.8
Leaf area index		0.9[b]
Stem volume (m^3/ha)		
Dry biomass (t/ha)	Stem wood	9
	Stem bark	
	Branches	7
	Fruits etc.	
	Foliage	4
	Root estimate	
CAI (m^3/ha/yr)		
Net production (t/ha/yr)	Stem wood	0.2[c]
	Stem bark	
	Branches	ca.0.1[c]
	Fruits etc.	
	Foliage	1.0
	Root estimate	

Stand biomass values for a plot of over 0.25 ha were derived from regressions on D.
a. Trees over 10 cm D; there were 470 trees/ha less than 10 cm D.
b. All-sided LAI was 2.0.
c. Excluding woody litterfall and mortality.

Landis, T.D. and Mogren, E.W. (1975). Tree strata biomass of subalpine spruce-fir stands in southwestern Colorado. *Forest Sci.* 21, 9-12.

ca.37°30'N 107°W 3100-3500 m U.S.A., Colorado, San Juan National Forest.

Picea engelmannii (85%)[a] and *Abies lasiocarpa*.

		Near Durango		Wolf Creek Pass	
Age (years)		15-250	15-250	15-250	15-250
Trees/ha					
Tree height (m)					
Basal area (m^2/ha)					
Leaf area index					
Stem volume (m^3/ha)					
Dry biomass (t/ha)	Stem wood	120	135	95	120
	Stem bark	30	30	25	25
	Branches	28	30	20	28
	Fruits etc.				
	Foliage	18	18	15	17
	Root estimate				
CAI (m^3/ha/yr)					
Net production (t/ha/yr)	Stem wood				
	Stem bark				
	Branches				
	Fruits etc.				
	Foliage				
	Root estimate				

A total of 29 *P. engelmanii* were sampled over two years, and stand values for the above four 800 m^2 plots were derived from regressions on D.

a. Approximate percentage of the total biomass.

Singer, F.P. and Hutnik, R.J. (1966). Accumulation of organic matter in red pine and Norway spruce plantations of various spacings. *Penn. State Univ. Res. Briefs* 1, 22-28.

Alban, D.H., Perala, D.A. and Schlaegel, B.E. (1978). Biomass and nutrient distribution in aspen, pine and spruce stands on the same soil type in Minnesota. *Can. J. For. Res.* 8, 290-299.

U.S.A.	ca.41°N 78°W -- Central Pennsylvania			47°20'N 94°30'W 400 m Minnesota Pike Bay Expt. Forest
Plantations.	*Picea abies*			*Picea glauca*
	(Singer and Hutnik 1966)			Fine sandy loams. (Alban *et al.* 1978)
Age (years)	42	42	42	40
Trees/ha	1076	2242	2990	2187
Tree height (m)				14.4
Basal area (m^2/ha)				41.1
Leaf area index				
Stem volume (m^3/ha)				256[a]
Dry biomass (t/ha) Stem wood	106.4	139.2	135.2	88.6
Stem bark				11.1
Branches	36.9	39.3	27.9	35.1 + 0.1[b]
Fruits etc.				
Foliage	15.5	18.4	15.8	17.9
Root estimate				34
CAI (m^3/ha/yr)				
Net production (t/ha/yr) Stem wood				
Stem bark				
Branches				
Fruits etc.				
Foliage				
Root estimate				

Singer and Hutnik (1966) sampled 9 trees and derived stand values for the above three 400 m^2 plots from regressions on D and H; there was 0.0, 6.2 and 3.7 t/ha of dead branches in columns left to right.
Alban *et al.* (1978) sampled 10 trees in spring and excavated the roots of two further trees in August; stand values for ten 80 m^2 plots were derived from regressions on D^2H; nutrient contents were determined.
a. Volume inside bark.
b. Understorey shrubs.

Cleve, K. van (1981). In: "Dynamic Properties of Forest Ecosystems" (D.E. Reichle, ed.), pp. 648-650. Cambridge University Press, Cambridge, London, New York, and Melbourne.

Barney, R.J. and Cleve, K. van (1973). Black spruce fuel weights and biomass in two interior Alaska stands. *Can. J. For. Res.* 3, 304-311.

64°45'N 148°15'W (alt. given below) U.S.A., Alaska, near Fairbanks, Bonanza Creek Experimental Forest.

Picea mariana with understorey shrubs.

		--	167 m	470 m
		'Moss' site, pH 5.4-6.4.	Poorly drained alluvial muskeg with permafrost, pH 5.3.	Silt loam muskeg, pH 4.6-5.6.
Age (years)		130	51	55
Trees/ha		5000	27335	14820
Tree height (m)		13.7	2.9	3.1
Basal area (m^2/ha)		34.7	18.2	22.0
Leaf area index				
Stem volume (m^3/ha)				
Dry biomass (t/ha)	Stem wood	86.1 + 4.7[a]	8.00 + 0.71[a]	14.02 + 0.95[a]
	Stem bark			
	Branches	13.0	3.59	4.69
	Fruits etc.	5.3	1.25	0.72
	Foliage	8.9 + 0.4[a]	3.76 + 0.45[a]	4.59 + 0.54[a]
	Root estimate	51.7	12.5	10.4
CAI (m^3/ha/yr)				
Net production (t/ha/yr)	Stem wood	1.18 + 0.07[b]	0.29	0.70
	Stem bark			
	Branches	0.26 + 0.17[b]	0.11	0.22
	Fruits etc.	0.07 + 0.07[b]	0.02	0.02
	Foliage	0.07 + 0.23[b]	0.09	0.17
	Root estimate		[c]	[c]

The fresh weights of all trees were measured within three 40 m^2 plots in each stand, and dry weights were estimated from the water contents of subsamples. There was 31.1, 4.3 and 2.6 t/ha of standing dead wood in columns left to right, according to van Cleve (1981) but only 2.2 and 0.6 t/ha in the centre and right columns, respectively, according to Barney and van Cleve (1973).

a. Understorey shrubs.
b. Litterfall.
c. Excluding woody, foliage and all other litterfall.

Whittaker, R.H. (1963). Net production of heath balds and forest heaths in the Great Smoky Mountains. *Ecology* 46, 176-182.

Whittaker, R.H. (1966). Forest dimensions and production in the Great Smoky Mountains. *Ecology* 47, 103-121.

Weaver, G.T. and DeSelm, H.R. (1973). Biomass distribution patterns in adjacent coniferous and deciduous forest ecosystems. In: "IUFRO Biomass Studies", pp.415-427. College of Life Sciences and Agriculture, University of Maine, Orono, U.S.A.

U.S.A.	ca.35°40'N 83°30'W 1740 m Tennessee, Great Smoky Mtns. *Picea rubens* (83%)[a] *et al.* with understorey of *Rhododendron catawbiense* (11%)[a], *et al.* (Whittaker 1963, 1966)	ca.35°20'N 83°00'W 1524-1954 m North Carolina, Balsam Mtns. *P. rubens*, with *Abies fraseri*, and understorey shrubs. Sandy acid loams. (Weaver and DeSelm 1973)
Age (years)		40-60
Trees/ha	640 + 3720[b]	
Tree height (m)	23 4.5[b] (20.2)[c]	
Basal area (m^2/ha)	50.5 + 5.4[b]	
Leaf area index	2.1[b]	
Stem volume (m^3/ha)	514[d] + 10.5[bd]	
Dry biomass (t/ha) Stem wood	300.0 + 21.0[b]	138[f]
Dry biomass (t/ha) Stem bark		25[f]
Dry biomass (t/ha) Branches		
Dry biomass (t/ha) Fruits etc.		
Dry biomass (t/ha) Foliage		16[f]
Dry biomass (t/ha) Root estimate		
CAI (m^3/ha/yr)	3.4[d] + 0.5[bd]	
Net production (t/ha/yr) Stem wood	6.1[e] + 2.0[be]	
Net production (t/ha/yr) Stem bark		
Net production (t/ha/yr) Branches		
Net production (t/ha/yr) Fruits etc.		
Net production (t/ha/yr) Foliage		
Net production (t/ha/yr) Root estimate		

Whittaker (1963, 1966) estimated stand values for a plot of at least 0.1 ha from the weight of clippings of current year's twigs, from published regressions, from stem volumes, branch/stem biomass ratios, and other relationships.
Weaver and DeSelm (1973) sampled over 50 trees and derived stand values for fourteen 400 m^2 plots from regressions on D.

a. Percentage of the total volume increment.
b. Understorey shrubs.
c. Weighted mean height.
d. Parabolic volumes.
e. Excluding woody litterfall and mortality; total foliage production of trees and shrubs was 2.6 t/ha/yr.
f. Mean of all 14 plots, and including shrubs.

Adams, W.R. (1928). Studies in tolerance of New England forest trees. VIII Effect of spacing in a jack pine plantation. *Vermont Agric. Exp. Stn Bull.* 282, 49 pp.

Alban, D.H., Perala, D.A. and Schlaegel, B.E. (1978). Biomass and nutrient distribution in aspen, pine and spruce stands on the same soil type in Minnesota. *Can. J. For. Res.* 8, 290-299.

U.S.A.	ca.44°28'N 73°12'W 50-100 m Vermont, near Burlington.				47°20'N 94°30'W 400 m Minnesota Pike Bay Expt. Forest
Plantations.	*Pinus banksiana* Spacing experiment on deep glacial sands. (Adams 1928)				*P. banksiana* with understorey shrubs. Fine sandy loams. (Alban *et al.* 1978)
Age (years)	10	10	10	10	40
Trees/ha	25057	6726	2990	1680	1580
Tree height (m)	3.7	4.2	4.1	4.2	18.4
Basal area (m^2/ha)	29.3	18.3	11.7	8.1	35.1
Leaf area index					
Stem volume (m^3/ha)					263[a]
Dry biomass (t/ha) Stem wood	21.6	12.9	3.6	4.7	106.6
Stem bark					12.5
Branches	6.9	8.7	5.3	8.2	23.6 + 2.9[b]
Fruits etc.					
Foliage	5.7	5.8	4.5	4.2	5.6
Root estimate	7.1	3.9	4.1	3.1	28
CAI (m^3/ha/yr)					
Net production (t/ha/yr) Stem wood					
Stem bark					
Branches					
Fruits etc.					
Foliage					
Root estimate					

Adams (1928) sampled one average-sized tree, including the roots, in each spacing treatment, and obtained stand values for one 550 m^2 plot per treatment by multiplying mean tree values by the numbers of trees per hectare; nutrient contents were determined.
Alban *et al.* (1978) sampled 10 trees in spring, and the roots of 2 further trees were excavated in August; stand values for ten 80 m^2 plots were derived from regressions on D^2H; nutrient contents were determined.
a. Volume inside bark.
b. Understorey shrubs.

Ohmann, L.F. and Grigal, D.F. (1979). Early revegetation and nutrient dynamics following the 1971 Little Sioux forest fire in northeastern Minnesota. *Forest Sci. Monogr.* 21, 80 pp.

ca.48°N 92°W 390-470 m U.S.A., Minnesota, Little Sioux.

Loamy glacial sands and gravels.

Pinus banksiana (40%)[a], *Populus tremuloides* (33%)[a], *Betula papyrifera*, *Populus grandidentata et al.* with understorey shrubs.

Regeneration after fire in May 1971.

	1971	1972	1973	1974	1975
Age (years)	1	2	3	4	5
Trees/ha	98414	71757	56700	42500	39843
Tree height (m)					
Basal area (m^2/ha)					
Leaf area index					
Stem volume (m^3/ha)					
Dry biomass (t/ha): Stem wood, Stem bark, Branches, Fruits etc., Foliage	0.4 + 0.2[b]	1.7 + 0.8[b]	2.1 + 1.0[b]	2.6 + 1.7[b]	8.0 + 2.8[b]
Dry biomass (t/ha): Root estimate					
CAI (m^3/ha/yr)					
Net production (t/ha/yr): Stem wood, Stem bark, Branches	0.30	1.23	0.95	0.47	5.19
Net production (t/ha/yr): Fruits etc.					
Net production (t/ha/yr): Foliage	0.38[c]	0.89[c]	1.11[c]	1.28[c]	2.51[c]
Net production (t/ha/yr): Root estimate					

All vegetation was sampled in August in ten 0.6 m^2 plots at seven sites in each year. Wood production values were derived from regressions of cumulative biomass against time. Nutrient contents were determined.

a. Mean percentage of the total tree number at seven sites over the five years.

b. Understorey shrubs; the production values include the shrubs.

c. Biomass of deciduous leaves, plus conifer needle litterfall assuming that the needles were retained for three years.

Green, D.C. and Grigal, D.F. (1979). Jack pine biomass accretion on shallow and deep soils in Minnesota. *Proc. Soil Sci. Soc. Am.* 43, 1233-1237.

Green, D.C. and Grigal, D.F. (1978). "Generalized Biomass Estimation Equations for Jack Pine (*Pinus banksiana* Lamb.)." Minn. For. Res. Notes 268.

Green, D.C. and Grigal, D.F. (1980). Nutrient accumulations in Jack pine stands on deep and shallow soils over bedrock. *Forest Sci.* 26, 325-333.

47°50'N 91°50'W 410-550 m U.S.A., Minnesota, near Ely.

Sandy loams, pH 3.9-4.5 derived from four rock types, namely:

Pinus banksiana (over 80%)[a] *et al.*

		till		gabbro	granite	greenstone
Age (years)		>50		>50	>50	>50
Trees/ha		>400		>400	>400	>400
Tree height (m)		14.3		9.3	10.2	11.2
Basal area (m^2/ha)						
Leaf area index						
Stem volume (m^3/ha)						
Dry biomass (t/ha)	Stem wood	106.5	+ 3.0[b]	61.7	56.0	59.5
	Stem bark	11.5		7.1	6.6	6.8
	Branches	19.3		10.9	9.9	10.7
	Fruits etc.					
	Foliage	7.4		4.8	4.5	4.8
	Root estimate					
CAI (m^3/ha/yr)						
Net production (t/ha/yr)	Stem wood					
	Stem bark					
	Branches					
	Fruits etc.					
	Foliage					
	Root estimate					

Stand biomass values for *P. banksiana* were estimated from regressions on D, and biomass values for other species were estimated using published regressions. Nutrient contents were determined.

a. Percentage of the total basal area.

b. Tall shrubs; the other three stands had less than 1 t/ha of shrubs.

Zavitkovski, J., Jeffers, R.M., Nienstaedt, H. and Strong, T.F. (1981). Biomass production of several Jack pine provenances at three Lake States locations. *Can. J. For. Res.* 11, 441-447.

U.S.A.	45°38'N 87°59'W ca.300 m Pembine, Wisconsin				48°18'N 89°10'W ca.300 m Watersmeet, Michigan.	47°36'N 91°21'W ca.300 m Isabella, Minnesota.
Plantations.	*Pinus banksiana*					
	Four provenances					
	46°48'[a]	45°48'[a]	46°12'[a]	44°12'[a]	*b*	*b*
Age (years)	24	24	24	24	25	25
Trees/ha	3660	3703	3574	3617	2852	3069
Tree height (m)	10-12	10-12	10-12	10-12	10-12	8-11
Basal area (m^2/ha)						
Leaf area index						
Stem volume (m^3/ha)						
Dry biomass (t/ha): Stem wood	87.0	90.6	86.8	100.2	78.3	53.0
Dry biomass (t/ha): Stem bark						
Dry biomass (t/ha): Branches	21.8	22.7	22.0	26.7	21.3	19.2
Dry biomass (t/ha): Fruits etc.						
Dry biomass (t/ha): Foliage						
Dry biomass (t/ha): Root estimate						
CAI (m^3/ha/yr)						
Net production (t/ha/yr): Stem wood						
Net production (t/ha/yr): Stem bark						
Net production (t/ha/yr): Branches						
Net production (t/ha/yr): Fruits etc.						
Net production (t/ha/yr): Foliage						
Net production (t/ha/yr): Root estimate						

Thirty-four trees were sampled, and stand biomass values for four 20 m^2 plots per provenance were derived from regressions on D and D^2H.

a. Latitude of the seed origin in the U.S.A.

b. Values in these columns are the means of the four provenances; the authors gave individual provenance values.

Whittaker, R.H. and Niering, W.A. (1975). Vegetation of the Santa Catalina Mountains, Arizona. V Biomass, production and diversity along the elevation gradient. *Ecology* 56, 771-790.

Harris, W.F., Goldstein, R.A. and Henderson, G.S. (1973). Analysis of forest biomass pools, annual primary production and turnover of biomass for a mixed deciduous forest watershed. In: "IUFRO Biomass Studies", pp.43-64. Univ. of Maine, U.S.A.

Harris, W.F. and Henderson, G.S. (1981). In: "Dynamic Properties of Forest Ecosystems" (D.E. Reichle, ed.), pp.658-661. Cambridge University Press, Cambridge.

U.S.A.		ca.32°20'N 110°50'W 2040 m Arizona, Santa Catalina Mtns	35°58'N 84°17'W 265-360 m Tennessee, Walker Branch Site
		Pinus cembroides (69%)[a] *Juniperus deppeana* (16%)[a] *et al.*	*Pinus echinata*, with *Liriodendron tulipifera* *et al.*
			Red-yellow podzols, pH 4.0-6.5
		(Whittaker and Niering 1975)	(Harris *et al.* 1973, 1981)
Age (years)		115[b]	30
Trees/ha		570 + 160[c]	
Tree height (m)		2.7[b]	12-25
Basal area (m^2/ha)		4.3 + 0.6[c]	21.3
Leaf area index		0.7[d]	
Stem volume (m^3/ha)		6.6[e]	
Dry biomass (t/ha)	Stem wood	9.1 + 1.0[c]	89.6
	Stem bark		
	Branches	4.8 + 0.9[c]	27.6
	Fruits etc.		
	Foliage	1.4 + 1.5[c]	4.6
	Root estimate		34.0[g]
CAI (m^3/ha/yr)		5.5[e]	
Net production (t/ha/yr)	Stem wood	0.07[f] + 0.12[cf]	4.16 + 1.90[h] + 0.73[i]
	Stem bark	0.02[f]	
	Branches	0.13[f] + 0.20[cf]	
	Fruits etc.	0.04 + 0.05[c]	
	Foliage	0.40 + 0.80[c]	4.60[j]
	Root estimate		

Whittaker and Niering (1975) sampled 10-15 trees per species and derived stand biomass values for a 0.1 ha plot from regressions on D, wood volumes and surface areas, and from other relationships; all trees and shrubs over 1 cm D were included. Harris *et al.* (1973, 1981) sampled many trees (about 150 at all 4 Walker Branch sites), excavated roots in 3 pits, and derived stand biomass values for 50-100 circular plots from regressions on D.

a. Percentage of the total stem volume. *b*. Weighted mean age and height.
c. Understorey shrubs. *d*. All-sided LAI was 2.0. *e*. Parabolic volumes.
f. Excluding woody litterfall and any mortality.
g. Including stumps, which represented about half the 'root' biomass. *h*. Mortality.
i. Woody litterfall. *j*. Foliage production; foliage litterfall was 3.4 t/ha/yr.

McKee, W.H. and Shoulders, E. (1974). Slash pine biomass response to site preparation and soil properties. *Proc. Soil Sci. Soc. Am.* 38, 144-148.

ca.31°N 92-93°W 50 m U.S.A., Louisiana

Plantations.
Fine silty loam soils, saturated in winter, unless drained.

		Pinus elliottii		
		Untreated	Disked	Ploughed with drainage furrows
Age (years)		7	7	7
Trees/ha		ca.2000	ca.2000	ca.2000
Tree height (m)		7.6[a]	7.4[a]	8.3[a]
Basal area (m^2/ha)		16.6	15.8	19.8
Leaf area index				
Stem volume (m^3/ha)				
Dry biomass (t/ha)	Stem wood	16.6	13.7	21.8
	Stem bark	6.2	5.5	8.6
	Branches	6.9	7.5	10.1
	Fruits etc.	0.0	0.0	0.0
	Foliage	8.9	7.5	10.1
	Root estimate			
CAI (m^3/ha/yr)				
Net production (t/ha/yr)	Stem wood			
	Stem bark			
	Branches			
	Fruits etc.			
	Foliage			
	Root estimate			

Four trees were sampled per treatment in September, and stand biomass values for plots of 0.14 ha per treatment were derived by proportional basal area allocation. Nutrient contents were determined.
a. Mean heights of sample trees.

Hanley, D.P. (1976). "Tree Biomass and Productivity Estimated for Three Habit Types of Northern Idaho." Bulletin 14. College of Forestry, Wildlife and Range Sciences, University of Idaho, Moscow, U.S.A.

48°20'N 116°50'W over 500 m U.S.A., Idaho, Priest River (and see below).					47°45'N 116°30'W Deception Creek	
	Pinus monticola, Larix occidentalis, Thuja plicata, Tsuga heterophylla, Pseudotsuga menziesii, Abies grandis.					
	24% 17% 54% 1% 3% 1%[a]	28% 12% 51% 1% 4% 1%[a]	33% 2% 58% 1% 5% 0%[a]	30% 5% 13% 39% 2% 11%[a]	38% 1% 0% 57% 1% 5%[a]	
Age (years)	105	110	100	over 250	20	
Trees/ha	1056	584	756	105	2728	
Tree height (m)		25.0	23.2	32.9	4.0	
Basal area (m^2/ha)	62.9	51.4	56.2	49.8	11.2	
Leaf area index						
Stem volume (m^3/ha)						
Dry biomass (t/ha) Stem wood	235	205	203	240	8.7	
Stem bark	37	31	23	32	0.8	
Branches	41	31	26	32	0.7	
Fruits etc.						
Foliage	16	10	13	12	3.8	
Root estimate	82	69	58	84	11.2	
CAI (m^3/ha/yr)						
Net production (t/ha/yr) Stem wood	3.0[b]	2.2[b]	3.3[b]	2.15[b]	2.45[b]	
Stem bark	0.4[b]	0.3[b]	0.4[b]	0.26[b]	0.25[b]	
Branches	0.4[b]	0.3[b]	0.4[b]	0.26[b]	0.57[b]	
Fruits etc.						
Foliage	6.2[c]	4.7[c]	4.4[c]	2.86[c]	1.45[c]	
Root estimate	0.8	0.7	0.7	0.98	1.58	

Stand biomass values for 'growth and yield' plots were derived from published regressions on D and H. In most instances, biomass was estimated at the beginning and end of a period of 10 years; the initial biomass values are given above. Increment values refer to the potential production of fully stocked stands as represented by the selected sample plots.

a. Percentage of the total basal area occupied by *P. monticola*, *L. occidentalis*, *T. plicata*, *T. heterophylla*, *P. menziesii* and *A. grandis*, e.g. 24%, 17%, 54%, 1%, 3% and 1%, respectively, in the far left column.

b. Including estimated mortality and new regeneration.

c. Derived from the foliage biomass and mean leaf longevity of each species.

Continued from p.305.

46°35'N 115°37'W over 500 m		U.S.A., Idaho, Clearwater National Forest (and see below).			47°47'N 116°30'W Fernan District
		Pinus monticola, *Abies grandis*, *Pseudotsuga menziesii* and *Larix occidentalis*.			
		$\left\{\begin{matrix}94\% & 5\% \\ 1\% & 0\%\end{matrix}\right\}^a$	$\left\{\begin{matrix}84\% & 11\% \\ 3\% & 0\%\end{matrix}\right\}^a$	$\left\{\begin{matrix}78\% & 16\% \\ 6\% & 0\%\end{matrix}\right\}^a$	$\left\{\begin{matrix}15\% & 43\% \\ 19\% & 21\%\end{matrix}\right\}^a$
Age (years)		103	103	103	105
Trees/ha		803	628	699	1127
Tree height (m)		32.3	33.5	34.4	
Basal area (m^2/ha)		67.7	61.3	62.2	53.5
Leaf area index					
Stem volume (m^3/ha)					
Dry biomass (t/ha)	Stem wood	344	350	381	200
	Stem bark	30	35	44	28
	Branches	34	35	38	41
	Fruits etc.				
	Foliage	15	15	16	21
	Root estimate	69	71	65	55
CAI (m^3/ha/yr)					
Net production (t/ha/yr)	Stem wood	8.1[b]	7.1[b]	8.2[b]	2.9[b]
	Stem bark	0.8[b]	0.7[b]	0.8[b]	0.3[b]
	Branches	0.8[b]	0.7[b]	0.8[b]	0.6[b]
	Fruits etc.				
	Foliage	3.8[c]	3.8[c]	4.6[c]	5.4[c]
	Root estimate	1.8	1.7	1.6	0.7

Same as p.305, except:

a. Percentage of the total basal area occupied by *P. monticola*, *A. grandis*, *P. menziesii* and *L. occidentalis*, e.g. 94%, 5%, 1% and 0%, respectively, in the far left column.

Continued from p.306.

46°35'N 115°37'W over 500 m U.S.A., Idaho, Clearwater National Forest.

Pinus monticola, Abies grandis, Pseudotsuga menziesii and *Larix occidentalis*.

	{77% 1% 20% 0%}[a]	{62% 3% 22% 3%}[a]	{60% 6% 33% 1%}[a]	{82% 1% 15% 1%}[a]	{71% 5% 22% 2%}[a]
Age (years)	103	103	103	103	103
Trees/ha	309	390	242	295	332
Tree height (m)	27.4	29.0	36.6	31.4	31.4
Basal area (m^2/ha)	56.9	88.4	63.8	60.6	62.2
Leaf area index					
Stem volume (m^3/ha)					
Dry biomass (t/ha): Stem wood	337	539	441	350	365
Dry biomass (t/ha): Stem bark	29	56	41	30	37
Dry biomass (t/ha): Branches	34	56	43	35	37
Dry biomass (t/ha): Fruits etc.					
Dry biomass (t/ha): Foliage	15	24	19	15	16
Dry biomass (t/ha): Root estimate	73	119	74	70	74
CAI (m^3/ha/yr)					
Net production (t/ha/yr): Stem wood	6.6[b]	9.8[b]	7.5[b]	8.2[b]	7.2[b]
Net production (t/ha/yr): Stem bark	0.7[b]	1.0[b]	0.8[b]	0.8[b]	0.7[b]
Net production (t/ha/yr): Branches	0.7[b]	1.0[b]	0.8[b]	0.8[b]	0.7[b]
Net production (t/ha/yr): Fruits etc.					
Net production (t/ha/yr): Foliage	3.4[c]	5.8[c]	4.8[c]	4.2[c]	3.5[c]
Net production (t/ha/yr): Root estimate	1.7	2.4	1.7	1.7	1.5

Same as p.306.

Westman, W.E. and Whittaker, R.H. (1975). The pygmy forest region of northern California: studies on biomass and primary productivity. *J. Ecol.* 63, 493-520.

39°20'N 123°45'W (alt. given below) U.S.A., California, Mendocino, near Fort Bragg.

Noyo and Noyo-Blacklock podzols

Pinus muricata (89%)[a], *Pseudotsuga menziesii*, *Sequoia sempervirens*, *Myrica californica*.

	80 m	90 m	100 m	170 m	75 m
Age (years)	84[d]	94[d]	89[d]	94[d]	62[d]
Trees/ha	520[b]+5440[c]	500[b]+3520[c]	480[b]+7000[c]	400[b]+6800[c]	740[b]+10720[c]
Tree height (m)	11[d]	18[d]	24[d]	28[d]	24[d]
Basal area (m^2/ha)	53.4	53.9	64.3	102.3	99.3
Leaf area index					
Stem volume (m^3/ha)	349[e]	485[e]	786[e]	1409[e]	1187[e]
Dry biomass (t/ha): Stem wood, Stem bark, Branches, Fruits etc., Foliage	167	232	382	692	575
Dry biomass (t/ha): Root estimate					
CAI (m^3/ha/yr)	0.8[e]	2.1[e]	4.6[e]	6.8[e]	8.6[e]
Net production (t/ha/yr): Stem wood, Stem bark, Branches, Fruits etc., Foliage	2.7[f]	5.4[f]	10.5[f]	13.7[f]	16.1[f]
Net production (t/ha/yr): Root estimate					

Stand biomass values for the above 250 to 500 m^2 plots were derived from regressions on various dimensions following extensive sampling and using the methods of Whittaker *et al.* (1974) (see p.259).

a. Mean percentage of the total basal area.
b. Number of *P. muricata* trees.
c. Number of trees of other species.
d. Weighted mean ages and heights.
e. Parabolic volumes.
f. Including foliage production, but excluding woody litterfall and any mortality; total litterfall was estimated to be up to 4.3 t/ha/yr.

Wiegert, R.G. and Monk, C.D. (1972). Litter production and energy accumulation in three plantations of longleaf pine (*Pinus palustris* Mill.). *Ecology* 53, 949-953.

ca.33°35'N 81°45'W 150 m U.S.A., South Carolina, near Aiken.

Plantations.

Pinus palustris

Age (years)		7	11	13
Trees/ha		924	1412	1680
Tree height (m)				
Basal area (m^2/ha)				
Leaf area index				
Stem volume (m^3/ha)				
Dry biomass (t/ha)	Stem wood	3.6	23.9	57.8
	Stem bark			
	Branches	0.9	6.2	16.7
	Fruits etc.			
	Foliage	2.1	4.0	9.2
	Root estimate			
CAI (m^3/ha/yr)				
Net production (t/ha/yr)	Stem wood			
	Stem bark			
	Branches	0.02[a]	0.08[a]	0.05[a]
	Fruits etc.			
	Foliage	0.60[a]	3.40[a]	5.20[a]
	Root estimate			

Thirteen trees were sampled from the 7-year-old stand, and 5 trees were sampled from each of the other two stands, all in March-April. Stand biomass values for the above three 0.25 ha plots were obtained by multiplying mean tree values by the numbers of trees per hectare. There was 0.0, 2.6 and 6.2 t/ha of dead branches in columns left to right.

a. Litterfall only, measured over 10-12 months.

Klemmedson, J.O. (1975). Nitrogen and carbon regimes in an ecosystem of young dense ponderosa pine in Arizona. *Forest Sci.* 21, 163-168.
Gholz, H.L. (1981). Environmental limits on above-ground net primary production, leaf area, and biomass in vegetation zones of the Pacific Northwest. *Ecology* (in press).
Gholz, H.L., Grier, C.C., Campbell, A.G. and Brown, A.T. (1979). "Equations for Estimating Biomass and Leaf Area of Plants in the Pacific Northwest." Forest Research Laboratory, Oregon State University, Corvallis, USA. Research Paper no.41.

U.S.A.	ca.35°20'N 111°40'W 2500 m Arizona, Flagstaff, Wing Mountain.		44-45°N 121-122°W 870 m Oregon, Cascade Mountains
	Pinus ponderosa		*P. ponderosa*
	Unthinned natural stand on loamy soils derived from basalt.		Typic vitrandept
	(Klemmedson 1975)		(Gholz 1981)
Age (years)	49		Mature
Trees/ha	22500		215[c]
Tree height (m)			8
Basal area (m^2/ha)	67		26.1
Leaf area index			2.5[d]
Stem volume (m^3/ha)			
Dry biomass (t/ha) Stem wood	121.0		99
Stem bark			
Branches	20.2		30
Fruits etc.			
Foliage	10.6		7
Root estimate	38.0[a]		
CAI (m^3/ha/yr)			
Net production (t/ha/yr) Stem wood	3.88[b]		1.0[b]
Stem bark			
Branches			0.2
Fruits etc.			
Foliage			1.8[e]
Root estimate			

Klemmedson (1975) sampled all trees within ten 2 m^2 plots within several even-aged stands, and expressed values per hectare; nitrogen contents were determined.
Gholz (1981) derived stand biomass values for a plot at least 0.25 ha from regressions published by Gholz *et al.* (1979) based on trees sampled in northern Arizona.
a. Assumed to be 20% of the total biomass.
b. Excluding woody litterfall and mortality.
c. Trees over 10 cm D; there were 490 trees/ha less than 10 cm D.
d. All-sided LAI was 7.0.
e. Assumed to be 25% of the foliage biomass.

Whittaker, R.H. and Niering, W.A. (1975). Vegetation of the Santa Catalina Mountains, Arizona. V Biomass, production and diversity along the elevation gradient. *Ecology* 56, 771-790.

Whittaker, R.H. and Niering, W.A. (1968). Vegetation of the Santa Catalina Mountains, Arizona. IV Limestone and acid soils. *J. Ecol.* 56, 523-544.

ca.32°20'N 110°50'W (alt. given below) U.S.A., Arizona, Santa Catalina Mountains, near Tucson.

Pinus ponderosa, *Pinus strobiformis*, *Pinus chihuahuana*, *Quercus* spp.

	{68% 32% / 0% 0%}[a] 2740 m	{99% 0% / 0% 0%}[a] 2470 m	{95% 0% / 0% 4%}[a] 2180 m	{10% 0% / 45% 43%}[a] 2040 m
Age (years)	93[b]	142[b]	150[b]	101[b]
Trees/ha	2700	1100	1280	2780
Tree height (m)	12.8[b]	18.4[b]	15.2[b]	7.5[b]
Basal area (m^2/ha)	39.4	46.3	34.9	26.0
Leaf area index	2.7[c]	2.1[c]	1.7[c]	1.3[c]
Stem volume (m^3/ha)	253[d]	425[d]	265[d]	98[d]
Dry biomass (t/ha): Stem wood / Stem bark	126	213	134	79
Dry biomass (t/ha): Branches	28	30	23	28
Dry biomass (t/ha): Fruits etc.				
Dry biomass (t/ha): Foliage	7.3	6.8	5.4	6.6
Dry biomass (t/ha): Root estimate				
CAI (m^3/ha/yr)	1.8[d]	1.8[d]	1.0[d]	0.7[d]
Net production (t/ha/yr): Stem wood	1.38[e]	1.36[e]	1.29[e]	0.75[e]
Net production (t/ha/yr): Stem bark	0.35[e]	0.27[e]	0.17[e]	0.20[e]
Net production (t/ha/yr): Branches	1.00[e]	0.97[e]	0.72[e]	0.90[e]
Net production (t/ha/yr): Fruits etc.	0.30	0.25	0.20	0.15
Net production (t/ha/yr): Foliage	3.09	2.90	2.55	2.35
Net production (t/ha/yr): Root estimate				

Ten to fifteen trees were sampled of each of the major species and stand values for the above 0.1 ha plots were derived from regressions on D, wood volumes and surface areas, and from other relationships. All trees and shrubs over 1 cm D were included.

a. Percentage of the total stem volume represented by *P. ponderosa*, *P. strobiformis*, *P. chihuahuana* and *Quercus* spp., e.g. 68%, 32%, 0% and 0%, respectively, in the far left column; *P. chichuahuana* is also known as *P. leiophylla* var. *chihuahuana*.

b. Weighted mean ages and heights.

c. All-sided LAI values were 7.6, 5.9, 4.7 and 3.7 in columns left to right.

d. Parabolic volumes.

e. Excluding woody litterfall and mortality.

Wilde, S.A. (1967). Production of energy material by forest stands as related to supply of soil water. *Silva fenn.* 1, 31-44.
Alban, D.H., Perala, D.A. and Schlaegel, B.E. (1978). Biomass and nutrient distribution in aspen, pine and spruce stands on the same soil type in Minnesota. *Can. J. For. Res.* 8, 290-299.
Singer, F.P. and Hutnik, R.J. (1966). Accumulation of organic matter in red pine and Norway spruce plantations of various spacings. *Penn. State Univ. Res. Briefs* 1, 22-28.

U.S.A.	44°54'N 88°37'W ca.250 m Wisconsin, Keshena	47°20'N 94°30'W 400 m Minnesota, Pike Bay Expt. For.	ca.41°N 78°W -- Central Pennsylvania		
Plantations.	*Pinus resinosa* Sandy non-podzolic soil. (Wilde 1967)	*P. resinosa* Fine sandy loam. (Alban *et al.* 1978)	*P. resinosa* (Singer and Hutnik 1966)		
Age (years)	32	40	42	42	42
Trees/ha	2175	1780	1076	2242	2990
Tree height (m)	14.4	17.6			
Basal area (m^2/ha)	39	51.9			
Leaf area index					
Stem volume (m^3/ha)	243	408[c]			
Dry biomass (t/ha) Stem wood	102.2	147.3	147.8	179.7	144.7
Dry biomass (t/ha) Stem bark		13.5			
Dry biomass (t/ha) Branches	29.1	25.4 + 4.4[d]	31.5	36.7	29.3
Dry biomass (t/ha) Fruits etc.					
Dry biomass (t/ha) Foliage		14.1	13.7	16.7	12.7
Dry biomass (t/ha) Root estimate	35.8[a]	44			
CAI (m^3/ha/yr)	10.2				
Net production (t/ha/yr) Stem wood	4.3				
Net production (t/ha/yr) Stem bark					
Net production (t/ha/yr) Branches	0.9 + 3.3[b]				
Net production (t/ha/yr) Fruits etc.					
Net production (t/ha/yr) Foliage					
Net production (t/ha/yr) Root estimate	1.6				

Wilde (1967) sampled several average-sized trees, including the root systems, and multiplied mean tree values by the numbers of trees per hectare.
Alban *et al.* (1978) sampled 10 trees in spring, excavated two root systems in August, and derived stand biomass values for ten 80 m^2 plots from regressions on D^2H; nutrient contents were determined.
Singer and Hutnik (1966) sampled 9 trees and derived stand biomass values for the above three 400 m^2 plots from regressions on D and H; there was 1.7, 2.9 and 2.8 t/ha of dead branches in columns left to right.
a. Including stumps, weighting 7.8 t/ha.
b. Total litterfall.
c. Volume inside bark.
d. Understorey shrubs.

Leaf, A.L., Leonard, R.E., Wittwer, R.F. and Bickelhaupt, D.H. (1975). Four-year growth responses of plantation red pine to potash fertilization and irrigation in New York. *Forest Sci.* 21, 88-96.

Wittwer, R.F., Leaf, A.L. and Bickelhaupt, D.H. (1975). Biomass and chemical composition of fertilized and/or irrigated *Pinus resinosa* Ait. plantations. *Pl. Soil* 42, 629-651.

43°28'N 73°47'W 260 m U.S.A., New York, Warrensburg.

Pinus resinosa

Plantations. Glacial outwash sandy soils.		Untreated	One application of 448 kg/ha K given 4 years previously. (A)	35 cm of irrigation water applied in each of the previous 4 years. (B)	Received treatments A and B.
Age (years)		35-40	35-40	35-40	35-40
Trees/ha		2638	2103	2106	2287
Tree height (m)		12.7[a]	13.2[a]	13.8[a]	13.8[a]
Basal area (m^2/ha)					
Leaf area index					
Stem volume (m^3/ha)					
Dry biomass (t/ha)	Stem wood	47.7	61.6	54.9	58.1
	Stem bark	8.0	9.3	8.7	8.8
	Branches	14.7	15.0	14.3	18.8
	Fruits etc.				
	Foliage	6.8	11.8	8.8	13.8
	Root estimate				
CAI (m^3/ha/yr)					
Net production (t/ha/yr)	Stem wood				
	Stem bark				
	Branches				
	Fruits etc.				
	Foliage				
	Root estimate				

Five trees were sampled from each treatment in the autumn, and stand values for 800 m^2 plots were derived from regressions on individual tree basal area. Nutrient contents were determined.

a. Height of the dominant trees.

Madgwick, H.A.I. (1962). "Studies in the Growth and Nutrition of *Pinus resinosa* Ait." Ph.D. thesis, State University College of Forestry, Syracuse University, Syracuse, New York, U.S.A.

Madgwick, H.A.I., White, E.H., Xydias, G.K. and Leaf, A.L. (1970). Biomass of *Pinus resinosa* in relation to potassium nutrition. *Forest Sci.* 16, 154-159.

43°28'N 73°47'W 260 m U.S.A., New York, Warrensburg.

Plantations. Brown, podzolic, deep sand.	*Pinus resinosa*				
	Untreated, thinned at age 16.	Slash[a] applied at age 16.	Fertile site	Slash[a] applied at age 14.	
Age (years)	30	30	32	30	30
Trees/ha	4990	7020	1530	6420	5730
Tree height (m)	10.4	9.2	15.2	10.2	9.9
Basal area (m^2/ha)	30.6	37.3	36.4	39.6	44.0
Leaf area index	3.4[b]	3.1[b]	3.8[b]	4.2[b]	4.3[b]
Stem volume (m^3/ha)					
Dry biomass (t/ha) Stem wood	49.5	54.0	80.3	65.6	69.8
Stem bark	9.7	10.4	8.4	12.7	12.4
Branches	10.0	9.7	16.1	11.0	10.6
Fruits etc.					
Foliage	8.4	7.8	10.4	10.7	10.4
Root estimate					
CAI (m^3/ha/yr)					
Net production (t/ha/yr) Stem wood					
Stem bark					
Branches					
Fruits etc.					
Foliage	3.5[c]	3.2[c]	2.4[c]	3.5[c]	3.8[c]
Root estimate					

Five trees were sampled per plot during August-October (apart from the 'fertile' site, where only 3 trees were sampled), and stand values were derived from regressions on D. There was 7.3, 9.5, 14.8, 10.4 and 9.9 t/ha of dead branches in columns left to right. Nutrient contents were determined.

a. Thinnings and prunings from other plots.

b. All-sided LAI values were 9.6, 8.8, 10.7, 12.1 and 12.3 in columns left to right.

c. New foliage biomass.

Continued from p.314.

43°28'N 73°47'W 260 m U.S.A., New York, Warrensburg.

Plantations. Brown, deep, podzolic sand, deficient in potash.

Pinus resinosa

	Unfertilized plots.			Unfertilized spacing experiment.			
Age (years)	29	30	31	32	32	32	32
Trees/ha	6520	6520	6520	1760	3830	6680	10720
Tree height (m)		7.5		10.2	10.1	8.6	7.6
Basal area (m^2/ha)			26.5	24.6	30.4	26.9	25.5
Leaf area index	1.9[a]	2.6[a]	2.5[a]	3.0[a]	2.9[a]	2.3[a]	2.8[a]
Stem volume (m^3/ha)							
Dry biomass (t/ha) Stem wood	27.8	32.5	33.3	43.8	49.7	35.1	32.0
Stem bark	5.2	6.9	7.3	7.0	8.5	7.3	7.1
Branches	7.9	9.9	8.4	14.5	11.7	8.8	9.1
Fruits etc.							
Foliage	5.3	6.2	5.9	7.9	7.4	6.0	6.9
Root estimate							
CAI (m^3/ha/yr)							
Net production (t/ha/yr) Stem wood		2.8[b]					
Stem bark		1.1[b]					
Branches							
Fruits etc.							
Foliage	2.5[c]	2.8[c]	2.8[c]	3.6[c]	3.3[c]	2.3[c]	2.9[c]
Root estimate							

Five trees were sampled per plot during August-October, and stand values were derived from regressions on D. There was 4.8, 6.3, 6.5, 7.3, 7.5, 6.1 and 5.2 t/ha of dead branches in columns left to right. Nutrient contents were determined.

a. All-sided LAI values were 5.3, 7.3, 7.0, 8.5, 8.2, 6.6 and 8.1 in columns left to right.

b. Increments from ages 29 to 31, excluding any mortality.

c. New foliage biomass.

Olsvig-Whittaker, L. (1980). "A Comparative Study of Northeastern Pine Barrens Vegetation." Ph.D. thesis, Cornell University, Ithaca, N.Y., U.S.A.

U.S.A.	ca.40°N 74°30'W 10-100m New Jersey.		ca.41°25'N 74°40'W 200-400 m New York, Shawangunk Mountains.	
	Pinus rigida and *Quercus marilandica*		*Pinus rigida*	
	(48%)[a]	(70%)[a]		
Age (years)	10-20	12-24	20-24	20-23
Trees/ha	40000	45800	10600	19400
Tree height (m)	1.2	1.1	1.7	1.3
Basal area (m^2/ha)	4.1	6.2	14.9	13.8
Leaf area index				
Stem volume (m^3/ha)	2.1	3.1	12.7	9.1
Dry biomass (t/ha) Stem wood	0.94	1.25	4.48	3.21
Stem bark	0.44	0.63	2.22	1.66
Branches	1.34	1.37	2.79	2.15
Fruits etc.				
Foliage	0.82[b]	1.05[b]	1.88[b]	1.70[b]
Root estimate				
CAI (m^3/ha/yr)				
Net production (t/ha/yr) Stem wood	0.17[c]	0.20[c]	0.30[c]	0.24[c]
Stem bark	0.09[c]	0.12[c]	0.14[c]	0.13[c]
Branches	0.42[c]	0.45[c]	0.48[c]	0.37[c]
Fruits etc.				
Foliage	0.55[d]	0.55[d]	0.57[d]	0.49[d]
Root estimate				

Stand values for the above 100 m^2 plots were derived from regressions on D, stem conic surface area, and stem volume, following the methods of Whittaker *et al.* (1974) (see p.259). Nutrient contents were determined.

a. Percentage of the total basal area accounted for by *P. rigida*.
b. Including the current year's twigs.
c. Excluding woody litterfall and mortality.
d. New foliage biomass, corrected for leaf fall and consumption, and including the current year's twigs.

Continued from p.316.

ca.40°45'N 73°W 10-100 m U.S.A., New York, Long Island.

		Pinus rigida (83%)[a] *Quercus alba*, *Quercus velutina*, and *Quercus ilicifolia*.	*P. rigida* (92%)[a] *Quercus stellata* and *Q. velutina*.	*P. rigida* (86-88%)[a] and *Q. ilicifolia*. Shrublands on sandy coastal plain.	
Age (years)		60-70	65-80	30-40	30-45
Trees/ha		930 + 450	690 + 340	7000+16400	7800+21400
Tree height (m)		6.2	7.1	1.7	1.6
Basal area (m^2/ha)		13.0 + 2.7	17.3 + 1.5	11.5 + 1.5	10.9 + 1.8
Leaf area index					
Stem volume (m^3/ha)		73.4 + 13.3	118.0 + 8.0	10.4 + 0.7	9.3 + 0.8
Dry biomass (t/ha)	Stem wood	26.9 + 6.5	44.3 + 4.0	3.7 + 0.4	3.3 + 0.4
	Stem bark	6.0 + 1.5	8.9 + 0.9	1.8 + 0.1	1.6 + 0.2
	Branches	10.7 + 2.6	18.7 + 2.3	2.3 + 0.5	2.0 + 0.4
	Fruits etc.				
	Foliage	6.4[b] + 0.6[b]	8.3[b] + 0.5[b]	1.6[b] + 0.1[b]	1.5[b] + 0.2[b]
	Root estimate			4.7 + 2.1	4.2 + 2.0
CAI (m^3/ha/yr)					
Net production (t/ha/yr)	Stem wood	1.42[c]+0.22[c]	1.75[c]+0.16[c]	0.25[c]+0.04[c]	0.24[c]+0.05[c]
	Stem bark	0.29[c]+0.04[c]	0.31[c]+0.03[c]	0.12[c]+0.02[c]	0.12[c]+0.02[c]
	Branches	1.86[c]+0.30[c]	2.32[c]+0.25[c]	0.40[c]+0.05[c]	0.38[c]+0.06[c]
	Fruits etc.				
	Foliage	1.79[d]+1.53[d]	3.43[d]+0.47[d]	0.56[d]+0.13[d]	0.52[d]+0.18[d]
	Root estimate				

Stand values for plots of 0.10 ha (two left-hand columns) or 0.01 ha (two right-hand columns) were derived from regressions on D, stem conic surface area, and stem volume, following the methods of Whittaker *et al.* (1974) (see p.259). Roots were excavated in the two plots on the coastal plain. Values are given above for *P. rigida* plus *Quercus* spp. (left and right in each column). Nutrient contents were determined.

a. Percentage of the total basal area.
b. Including the current year's twigs.
c. Excluding woody litterfall and mortality.
d. New foliage biomass, corrected for leaf fall and consumption, and including the current year's twigs.

Whittaker, R.H. (1963). Net production of heath balds and forest heaths in the Great Smoky Mountains. *Ecology* 46, 176-182.

Whittaker, R.H. (1966). Forest dimensions and production in the Great Smoky Mountains. *Ecology* 47, 103-121.

ca.35°40'N 83°30'W (alt. given below) U.S.A., Tennessee, Great Smoky Mountains, Mount Leconte.

	Pinus rigida, *Pinus strobus*, *Pinus virginiana* (74-78%)[a] *Quercus coccinea*, *et al.*		*Pinus pungens* (96%)[a] *et al.*	*P. pungens* (73%)[a] *Quercus prinus*, *et al.*
	610 m	550 m	1070 m	1340 m
Age (years)	Mature			
Trees/ha	346 + 480[b]	228 + 390[b]	2630 + 500[b]	2310 + 2280[b]
Tree height (m)	20 (15.5)[c]	17 (14.1)[c]	18 (15.0)[c]	12 (5.9)[c]
Basal area (m^2/ha)	34.4 + 0.3[b]	25.4 + 0.2[b]	25.6 + 0.3[b]	19.1 + 1.5[b]
Leaf area index	0.5[b]	0.3[b]	1.4[b]	1.5[b]
Stem volume (m^3/ha)	227^d + 0.5[bd]	162^d + 0.2[bd]	165^d + 0.2[bd]	74.2^d + 1.8[bd]
Dry biomass (t/ha): Stem wood, Stem bark, Branches, Fruits etc., Foliage	180 + 1.5[b]	130 + 1.2[b]	86 + 5.8[b]	52.0 + 5.7[b]
Dry biomass (t/ha): Root estimate				
CAI (m^3/ha/yr)	3.9^d	4.5^d	2.0^d	0.7^d + 0.1[bd]
Net production (t/ha/yr): Stem wood, Stem bark, Branches, Fruits etc., Foliage	8.2 + 0.5[be]	9.5 + 0.4[be]	4.0 + 1.6[be]	2.1 + 1.7[be]
Net production (t/ha/yr): Root estimate				

Stand values were estimated for plots of at least 0.1 ha from the weight of clippings of current year's twigs, from published regressions, from stem volumes, branch/stem biomass ratios, and other relationships.

a. Percentage of the total volume increment; 74-78% refers to the sum of the three *Pinus* species.

b. Understorey shrubs.

c. Weighted mean height (in the brackets).

d. Parabolic volumes.

e. Excluding woody litterfall and mortality; total foliage production of trees plus shrubs was 2.6, 2.7, 1.8 and 1.6 t/ha/yr in columns left to right.

Swank, W.T. and Schreuder, H.T. (1973). Temporal changes in biomass, surface area and net production for a *Pinus strobus* L. forest. In: "IUFRO Biomass Studies", pp.173-182. College of Life Sciences and Agriculture, University of Maine, Orono, U.S.A.

Swank, W.T. and Schreuder, H.T. (1974). Comparison of three methods of estimating surface area and biomass for a forest of young eastern white pine. *Forest Sci.* 20, 91-100.

35°04'N 83°26'W 706-988 m U.S.A., North Carolina, Franklin, Coweeta.

Plantations.

Pinus strobus

Age (years)	10	12	15
Trees/ha	1790	1790	1790
Tree height (m)	ca.6.5	ca.7.5	9.8
Basal area (m^2/ha)	7.3	12.6	23.4
Leaf area index	3.5[a]	6.2[a]	6.4[a]
Stem volume (m^3/ha)			
Dry biomass (t/ha): Stem wood / Stem bark	7.9	23.5	42.1
Dry biomass (t/ha): Branches	7.6	15.3	22.8
Dry biomass (t/ha): Fruits etc.			
Dry biomass (t/ha): Foliage	2.5	4.7	4.7
Dry biomass (t/ha): Root estimate			
CAI (m^3/ha/yr)			
Net production (t/ha/yr): Stem wood / Stem bark		6.84[b]	
Net production (t/ha/yr): Branches		3.04 + 0.02[c]	
Net production (t/ha/yr): Fruits etc.			
Net production (t/ha/yr): Foliage		0.42 + 3.21[c]	
Net production (t/ha/yr): Root estimate			

Twenty trees were sampled at age 10, six at age 12 and thirteen at age 15, all in February. Stand biomass values for twenty 800 m^2 plots were derived from regressions on basal area per tree.

a. All-sided LAI values in February were 5.4, 9.7 and 9.9 at ages 10, 12 and 15, respectively; these values were increased by 80% to give late summer values, and were then divided by 2.8 to give projected areas.

b. Including estimated mortality.

c. Litterfall.

Switzer, G.L., Nelson, L.E. and Smith, W.H. (1966). The characterization of dry matter and nitrogen accumulation by loblolly pine (*Pinus taeda* L.). *Proc. Soil. Sci. Soc. Am.* 30, 114-119.

ca.33°N 89°W -- U.S.A., Mississippi, near Louisville.

Red-yellow podzols.

Pinus taeda. Natural regeneration.

	Poor upland sites.					Good lowland sites.				
Age (years)	20	30	40	50	60	20	30	40	50	60
Trees/ha	2260	1400	880	680	580	1260	810	500	370	300
Tree height (m)	10	15	17	19	21	12	22	26	29	30
Basal area (m^2/ha)	21	29	31	31	31	24	31	33	34	33
Leaf area index										
Stem volume (m^3/ha)	50[a]	160[a]	220[a]	240[a]	260[a]	150[a]	290[a]	380[a]	420[a]	440[a]
Dry biomass (t/ha): Stem wood, Stem bark, Branches, Fruits etc., Foliage	45	101	135	157	174	95	168	219	241	252
Dry biomass (t/ha): Root estimate										
CAI (m^3/ha/yr)										
Net production (t/ha/yr): Stem wood, Stem bark, Branches, Fruits etc., Foliage										
Net production (t/ha/yr): Root estimate										

Five trees were sampled in each of 5 size classes at each site in March-April, and stand biomass values were derived from regressions on stem volume per tree and from stand volume tables. Nitrogen contents were determined.

a. Volume inside the bark.

Baker, J.B., Switzer, G.L. and Nelson, L.E. (1974). Biomass production and nitrogen recovery after fertilization of young loblolly pines. *Proc. Soil Sci. Soc. Am.* 38, 958-961.

ca.34°30'N 89°30'W 100 m U.S.A., Mississippi, Interior Upland Flatwoods.

Plantations. Coarse and fine loams.

Pinus taeda

	No fertilizers applied.				112 kg N applied per hectare at age 3.	224 kg N applied per hectare at age 4.		
								a
Age (years)	3	4	5	6	5	6	5	6
Trees/ha	2421	2421	2376	2376	2408	2870	2964	2655
Tree height (m)	1.0	2.1	3.3	4.3	3.4	4.4	3.3	4.4
Basal area (m^2/ha)				8.0				8.4
Leaf area index								
Stem volume (m^3/ha)								
Dry biomass (t/ha) Stem wood	0.3	1.2	2.1	6.6	2.9	3.1	7.1	6.6
Stem bark			0.7	2.1	0.9	1.0	2.3	2.0
Branches	0.4	0.5	1.6	4.0	2.3	2.7	3.8	4.4
Fruits etc.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Foliage	0.6	1.7	3.0	4.7	4.3	4.7	4.7	5.2
Root estimate								
CAI (m^3/ha/yr)								
Net production (t/ha/yr) Stem wood								
Stem bark								
Branches								
Fruits etc.								
Foliage								
Root estimate								

Three trees were sampled per treatment per year during the autumn, and stand values for 400 m^2 plots were derived from regressions on D and H. Nitrogen contents were determined.

a. Data in this column refer to a plot which received N-fertilizer in two applications.

Demott, T.E. (1979). "Response to and Recovery of Nitrogen Fertilizer in Young Loblolly Pine Plantations." M.Sc. thesis, Mississippi State University, U.S.A.

ca.32°46'N 88°33'W 100 m U.S.A., Mississippi, Interior Upland Flatwoods, near De Kalb.

Plantations.

Pinus taeda

All fertilizer treatments were applied at age 8.

		Untreated	Urea 112 kg/ha	Urea 224 kg/ha	Ammonium nitrate 112 kg/ha	Ammonium nitrate 224 kg/ha
Age (years)		10	10	10	10	10
Trees/ha		1870	1870	1860	1820	1850
Tree height (m)		9.2	9.1	9.2	9.0	8.9
Basal area (m^2/ha)		21.8	22.9	23.1	22.3	24.3
Leaf area index						
Stem volume (m^3/ha)		79.1	82.6	83.3	80.0	87.5
Dry biomass (t/ha)	Stem wood	33.6	34.8	35.2	34.0	36.8
	Stem bark	6.0	6.2	6.1	6.0	6.7
	Branches	11.0	11.8	12.2	11.4	12.8
	Fruits etc.					
	Foliage	5.8	6.1	6.3	5.8	6.5
	Root estimate					
CAI (m^3/ha/yr)						
Net production (t/ha/yr)	Stem wood	8.60[a]	8.85[a]	8.85[a]	8.55[a]	9.90[a]
	Stem bark	0.75[a]	0.85[a]	0.85[a]	0.75[a]	1.10[a]
	Branches	2.45[a]	2.65[a]	2.75[a]	2.45[a]	3.15[a]
	Fruits etc.					
	Foliage	0.20[a]	0.40[a]	0.50[a]	0.25[a]	0.60[a]
	Root estimate					

Stand values were obtained using regression methods. Nitrogen contents were determined.

a. Increments since age 8, excluding all woody and foliage litterfall.

Larsen, H.S., Carter, M.C., Gooding, J.W. and Hyink, D.M. (1976). Biomass and nitrogen distribution in four 13-year-old loblolly pine plantations in the hilly coastal plain of Alabama. *Can. J. For. Res.* 6, 187-194.

Burkhart, H.E. (1977). Biomass and nitrogen distribution in four 13-year-old loblolly pine plantations in the hilly coastal plain of Alabama: discussion. *Can. J. For. Res.* 7, 545-546.

ca.31°N 88°W 50 m U.S.A., Alabama, Wilcox County, hilly coastal plain.

Plantations.
Paleudult soils.

Pinus taeda

		Unthinned stand.
Age (years)		13
Trees/ha		1439
Tree height (m)		11.6
Basal area (m^2/ha)		25.7
Leaf area index		
Stem volume (m^3/ha)		
Dry biomass (t/ha)	Stem wood	50.9 }
	Stem bark	8.1 }
	Branches	12.1 } + 1.2[a]
	Fruits etc.	}
	Foliage	9.5 }
	Root estimate	9.7[b]
CAI (m^3/ha/yr)		
Net production (t/ha/yr)	Stem wood	
	Stem bark	
	Branches	
	Fruits etc.	
	Foliage	
	Root estimate	

Thirty-two trees were sampled in August, and stand biomass values for a 0.62 ha plot in each of four plantations were derived by proportional basal area allocation. There was 7.9 t/ha of dead branches. Nitrogen contents were determined.
a. Understorey shrubs.
b. Stumps only.

Nemeth, J.C. (1973a). Dry matter production in young loblolly (*Pinus taeda* L.) and slash pine (*Pinus elliottii* Engelm.) plantations. *Ecol. Monogr.* 43, 21-41.

Nemeth, J.C. (1973b). Forest biomass estimation: permanent plots and regression techniques. In: "IUFRO Biomass Studies", pp.79-88. College of Life Sciences and Agriculture, University of Maine, Orono, U.S.A.

35°20'N 76°45'W 8 m U.S.A., North Carolina, Beaufort County, near Aurora.

Plantations. Sandy loams. Alfisols and Ultisols.

	Pinus taeda and *Pinus elliottii* (63% 37%)[a]	*Pinus taeda* and *Pinus elliottii* (48% 52%)[a]	*Pinus taeda*			
Age (years)	4-5	6-7	8	9-10	11	12
Trees/ha	1450	2030	900	1220	1400	1400
Tree height (m)	3.4[b]	4.3[b]	5.2	9.4	10.5	11.6
Basal area (m^2/ha)	ca.2.3	ca.7.5	ca.6.3	ca.22.0	ca.24.1	ca.28.0
Leaf area index						
Stem volume (m^3/ha)						
Dry biomass (t/ha) Stem wood	7.0[c]	9.2	7.3	40.0	53.0	65.5
Dry biomass (t/ha) Stem bark						
Dry biomass (t/ha) Branches		6.5[c]	4.6[c]	16.2[c]	17.4[c]	18.6[c]
Dry biomass (t/ha) Fruits etc.		0.0	0.0	0.0	0.0	0.0
Dry biomass (t/ha) Foliage		4.7	4.2	9.2	7.8	6.9
Dry biomass (t/ha) Root estimate	1.3	3.7	2.9	11.9	14.2	16.6
CAI (m^3/ha/yr)						
Net production (t/ha/yr) Stem wood		2.1	4.9	4.3	12.4	11.5
Net production (t/ha/yr) Stem bark		0.6	1.3	0.8	1.3	1.2
Net production (t/ha/yr) Branches		1.3+0.0[d]	2.4+0.0[d]	2.6+0.2[d]	1.2+1.0[d]	0.1+1.6[d]
Net production (t/ha/yr) Fruits etc.		0.0	0.0	0.0	0.0	0.0
Net production (t/ha/yr) Foliage		2.2[e]	4.2[e]	4.0[e]	4.4[e]	3.0[e]
Net production (t/ha/yr) Root estimate		1.0	1.9	1.8	2.9	2.6

A total of 4 *P. taeda* and 15 *P. elliottii* trees were sampled over 2 years during August-September (biomass values given above are the values in the first sampling year). Five root systems were excavated, and fine roots were core sampled. Stand biomass values in a total of twenty-eight 100 m^2 plots were derived from regressions on D and H. The production values given above refer to years 4-6, 6-8, 8-9, 9-10 and 11-12 in columns left to right.

a. Percentage of the total tree number (e.g. *P. taeda* 63%, *P. elliottii* 37% in left column). *b*. Weighted by the proportion of each species. *c*. Including dead branches. *d*. Estimated branch mortality (0.0, 0.0, 2.7, 5.9 and 8.5% of the branch biomass in columns left to right). *e*. New foliage biomass; foliage litterfall was 0.8, 1.4, 2.5, 3.5 and 3.5 t/ha/yr in columns left to right.

Pope, P.E. (1979). The effect of genotype on biomass and nutrient content of 11-year-old loblolly pine plantation. *Can. J. For. Res.* 9, 224-230.

35°45'N 91°39'W 50-200 m U.S.A., Arkansas, Batesville.

Plantations.
Loamy, skeletal, siliceous soils.

Pinus taeda

Unthinned plots of four open-pollinated progenies from parent trees in southern Arkansas.

Age (years)		11	11	11	11
Trees/ha		2990	2990	2990	2990
Tree height (m)		9.9	10.0	9.5	9.9
Basal area (m^2/ha)		52.7	49.2	39.4	51.0
Leaf area index					
Stem volume (m^3/ha)					
Dry biomass (t/ha)	Stem wood	61.1	47.8	41.1	73.3
	Stem bark	7.8	6.9	6.2	9.1
	Branches	20.7	18.9	11.8	25.3
	Fruits etc.				
	Foliage	6.7	3.8	7.5	7.8
	Root estimate				
CAI (m^3/ha/yr)					
Net production (t/ha/yr)	Stem wood				
	Stem bark				
	Branches				
	Fruits etc.				
	Foliage				
	Root estimate				

Twelve trees were sampled of each progeny and stand biomass values for two 0.2 ha plots per progeny were derived from regressions on D and D^2H. Nutrient contents were determined.

Ralston, C.W. (1973). Annual primary productivity in a loblolly pine plantation. In: "IUFRO Biomass Studies", pp.107-117. College of Life Sciences and Agriculture, University of Maine, Orono, U.S.A.
Kinerson, R.S., Ralston, C.W. and Wells, C.G. (1977). Carbon cycling in a loblolly pine plantation. *Oecologia* 29, 1-10.
Harris, W.F., Kinerson, R.S. and Edwards, N.T. (1977). Comparison of belowground biomass of natural deciduous forest and loblolly pine plantations. *Pedobiologia* 17, 369-381.

ca.36°N 79°W 135 m U.S.A., North Carolina, near Saxapahaw, Triangle Site.

Plantation.
Sandy loam,
pH 4.5.

Pinus taeda

The same stand was measured in three successive years.

Age (years)		13	14	15
Trees/ha		1445	1445	1445
Tree height (m)		11.9[a]	12.6[a]	13.9[a]
Basal area (m^2/ha)		31.8	33.5	34.5
Leaf area index				
Stem volume (m^3/ha)			3.9-6.6	
Dry biomass (t/ha)	Stem wood	54.4	65.3	74.8
	Stem bark			
	Branches	7.8	11.0	11.8
	Fruits etc.			
	Foliage	4.3	5.7	6.0
	Root estimate	18.0	20.2	21.8
CAI (m^3/ha/yr)				
Net production (t/ha/yr)	Stem wood		9.54	
	Stem bark			
	Branches		0.79[b] + 0.37[c]	
	Fruits etc.			
	Foliage		0.30 + 5.07[c]	
	Root estimate		ca.9.0[d]	

Twenty-six trees were sampled over the three years, and 7 root systems were excavated. Stand biomass values were derived from regressions on D, H and stem diameter at the base of the crowns. There was at least 6.0 t/ha of dead branches at age 15.
a. Mean height of the dominant trees.
b. Branch increment, excluding the increase in biomass of standing dead branches, which Kinerson *et al.* 1977 estimated to be 5 to 6 t/ha/yr.
c. Litterfall.
d. Root increment and turnover, estimated by Harris *et al.* (1977).

Wells, C.G., Jorgensen, J.R. and Burnette, C.E. (1975). "Biomass and Mineral Elements in a Thinned Loblolly Pine Plantation at Age 16." U.S.D.A. Forest Service Res. Paper SE-126. Southeast For. Exp. Stn, Ashville, N.C., U.S.A.

ca.36°N 79°W 149 m U.S.A., North Carolina, Duke Forest.

Plantation.
Coarse sandy loam,
of average fertility,
pH 4.5.

Pinus taeda

Age (years)		16
Trees/ha		2243
Tree height (m)		15.0
Basal area (m^2/ha)		49
Leaf area index		
Stem volume (m^3/ha)		
Dry biomass (t/ha)	Stem wood	109.6
	Stem bark	15.2
	Branches	14.6
	Fruits etc.	
	Foliage	8.0
	Root estimate	36.3
CAI (m^3/ha/yr)		
Net production (t/ha/yr)	Stem wood	5.6[a]
	Stem bark	
	Branches	1.9[a]
	Fruits etc.	
	Foliage	3.8[b] (or 4.8)[c]
	Root estimate	

Sixteen trees were sampled in September, and two root systems were excavated. Stand biomass values for a 0.3 ha plot were derived from regressions on basal area per tree. Increments were estimated between ages 14 and 16. There was 8.6 t/ha of dead branches. Nutrient contents were determined.

a. Excluding woody litterfall and any mortality.
b. Determined by regression analysis.
c. The new foliage biomass.

Madgwick, H.A.I. (1968). Seasonal changes in biomass and annual production of an old field *Pinus virginiana* stand. *Ecology* 49, 149-152.

37°15'N 80°25'W 700 m U.S.A., Virginia, Blacksburg, Fishburn Tract.

Shallow Calvin silt-loam.

Pinus virginiana

Natural regeneration on an abandoned field.

Age (years)		17
Trees/ha		5750
Tree height (m)		8.6[a]
Basal area (m^2/ha)		25.3
Leaf area index		
Stem volume (m^3/ha)		
Dry biomass (t/ha)	Stem wood	47.2
	Stem bark	
	Branches	19.3
	Fruits etc.	0.4
	Foliage	8.8
	Root estimate	
CAI (m^3/ha/yr)		
Net production (t/ha/yr)	Stem wood	5.8
	Stem bark	
	Branches	3.6[b]
	Fruits etc.	0.6
	Foliage	5.3[c]
	Root estimate	

Five trees were sampled on each of 9 occasions during one year and stand biomass values were derived from regressions on D^2H. The stem and branch biomass values given above are the means of the 9 samples; the leaf biomass value is the mean during June to September.

a. Height of the dominant trees.

b. Branch biomass divided by its mean age of 5.5 years; excluding woody litterfall.

c. New foliage biomass of 4.3 t/ha plus estimated growth of old foliage and loss in weight of the new foliage before sampling.

Dice, S.F. (1970). "The Biomass and Nutrient Flux in a Second Growth Douglas-fir Ecosystem." Ph.D. thesis. University of Washington, Seattle, Washington, U.S.A.
Cole, D.W., Gessel, S.P. and Dice, S.F. (1968). In: "Primary Productivity and Mineral Cycling in Natural Ecosystems" (H.E. Young, ed.), pp.197-233. Univ. Maine, Orono.
Cole, D.W. and Rapp, M. (1981). In: "Dynamic Properties of Forest Ecosystems" (D.E. Reichle, ed.), pp.341-409. Cambridge University Press, Cambridge, London.
Grier, C.C., Cole, D.W., Dyrness, C.T. and Fredriksen, R.L. (1974). In: "Integrated Research in the Coniferous Forest Biome". (see p.340)

ca.47°23'N 122°15'W 212 m U.S.A., Washington, Cedar River, Thompson Research Center.

Plantation.
Infertile, well-drained, gravelly sandy loam.

		Pseudotsuga menziesii	
		a	*b*
Age (years)		36	36
Trees/ha		2223	2223
Tree height (m)		20	18
Basal area (m^2/ha)		37.7	37.7
Leaf area index			
Stem volume (m^3/ha)			
Dry biomass (t/ha)	Stem wood	134.4	121.7
	Stem bark	18.5	18.7
	Branches	11.2	13.9
	Fruits etc.		
	Foliage	7.8	9.1
	Root estimate	31.4	33.1
CAI (m^3/ha/yr)			
Net production (t/ha/yr)	Stem wood	9.55[c]	6.05 } + 0.70[d]
	Stem bark	1.32[c]	0.69 }
	Branches	0.80	0.42 }
	Fruits etc.		
	Foliage	2.20[e]	1.99[e]
	Root estimate	3.63	1.19

Many trees were sampled in the autumn, and roots were excavated. Stand biomass values were derived from regressions on D. Nutrient contents were determined.
a. Values from Dice (1970). He estimated there to be 5.8 t/ha of dead branches, and measured foliage litterfall of 1.9 t/ha/yr.
b. Values from Cole *et al.* (1968) and Cole and Rapp (1981). They estimated there to be 8.1 t/ha of dead branches, and measured foliage litterfall of 2.2 t/ha/yr.
c. Including estimated woody litterfall and mortality.
d. Woody litterfall, excluding any mortality.
e. New foliage biomass.

Heilman, P.E. (1961). "Effects of Nitrogen Fertilization on the Growth and Nitrogen Nutrition of Low-site Douglas-fir Stands." Ph.D. thesis, University of Washington, Seattle, Washington, U.S.A.

Heilman, P.E. and Gessel, S.P. (1963). The effect of nitrogen fertilization on the concentration and weight of nitrogen, phosphorus, and potassium in Douglas fir trees. *Proc. Soil Sci. Soc. Am.* 27, 102-105.

ca.46°40'N 122°20'W (alt. given below) U.S.A., Washington, La Grande, Charles Lathrop Pack Forest.

Gravelly infertile acid loams, fertilized during previous 2-9 years.

Pseudotsuga menziesii

		488 m		235 m	
		Untreated	560 kg/ha N	Untreated	740 kg/ha N
Age (years)		28-32	28-32	38	38
Trees/ha		2840	3520	2480	2000
Tree height (m)		6-7	7-9	11-17	11-17
Basal area (m^2/ha)		13.2	22.5	39.9	43.4
Leaf area index					
Stem volume (m^3/ha)		46	70	226	248
Dry biomass (t/ha)	Stem wood	18.9	29.6	51.7	63.9
	Stem bark	4.0	5.4	18.1	21.4
	Branches	6.3	10.0	8.5	17.1
	Fruits etc.				
	Foliage	8.0	13.2	8.0	14.2
	Root estimate	25.1	20.1	10.0	9.8
CAI (m^3/ha/yr)		4.3	8.1	9.7	17.1
Net production (t/ha/yr)	Stem wood	1.8[a]	3.1[a]	4.2[a]	6.7[a]
	Stem bark				
	Branches	0.0[b]	0.0[b]	0.3[b]	0.3[b]
	Fruits etc.				
	Foliage	1.3[b]	1.7[b]	2.1[b]	2.5[b]
	Root estimate				

Eight trees were sampled per plot in winter, and stand biomass values were derived from regressions on D. Root biomass was estimated from soil core samples. There was 1.3, 0.9, 10.2 and 13.4 t/ha of dead branches in columns left to right. Nutrient contents were determined.

a. Excluding the bark, and assuming wood density to be 0.41, 0.38, 0.43 and 0.39 g/cm^3 in columns left to right.

b. Litterfall only.

Continued from p.330.

U.S.A., Washington	48°15'N 121°37'W 152 m Near Darrington.		47°13'N 123°05'W 137 m Matlock, Shelton.	
Infertile, acid, sandy loam.	*Pseudotsuga menziesii*			
	Untreated	560 kg N applied per hectare at ages 25-29.	Untreated	336 kg N applied per hectare at age 37.
Age (years)	32	32	38	38
Trees/ha	4040	3520	1600	1440
Tree height (m)	9-11	9-12	9-12	9-12
Basal area (m^2/ha)	14.5	23.4	35.8	32.1
Leaf area index				
Stem volume (m^3/ha)	46	80	280	237
Dry biomass (t/ha) Stem wood	19.2	34.4	115.5	91.9
Stem bark	4.1	6.6	14.4	13.1
Branches	4.6	9.4	13.9	19.0
Fruits etc.				
Foliage	5.3	9.6	9.0	16.2
Root estimate	20.7	19.7	16.8	15.6
CAI (m^3/ha/yr)	3.4	8.1	17.8	28.5
Net production (t/ha/yr) Stem wood	1.4[a]	3.5[a]	8.4[a]	13.1[a]
Stem bark				
Branches	0.1[b]	0.0[b]	0.4[b]	0.3[b]
Fruits etc.				
Foliage	1.0[b]	1.4[b]	1.8[b]	2.4[b]
Root estimate				

At Darrington, 10 trees were sampled per plot in winter; at Shelton 4 trees were sampled per plot in March. Stand biomass values were derived from regressions on D. Root biomass values were estimated from soil core samples. There was 2.6, 3.2, 6.7 and 6.1 t/ha of dead branches in columns left to right. Nutrient contents were determined.

a. Excluding the bark.

b. Litterfall only.

Continued from p.331.

48°17'N 122°40'W 91 m U.S.A., Washington, near Oak Harbour, Whidbey Island.

Sandy, acid, infertile loam.

Pseudotsuga menziesii with some *Tsuga heterophylla* and *Thuja plicata*.

		Untreated	224 kg N applied per hectare at age 50.
Age (years)		52	52
Trees/ha		2480	2160
Tree height (m)		16	17
Basal area (m^2/ha)		46.6	52.1
Leaf area index			
Stem volume (m^3/ha)		339	337
Dry biomass (t/ha)	Stem wood	147.5	142.5
	Stem bark	27.3	30.9
	Branches	17.9	21.3
	Fruits etc.		
	Foliage	12.0	13.9
	Root estimate	12.3	11.4
CAI (m^3/ha/yr)		11.2	12.6
Net production (t/ha/yr)	Stem wood	5.3[a]	7.1[a]
	Stem bark		
	Branches	0.9[b]	0.8[b]
	Fruits etc.		
	Foliage	1.5[b]	2.1[b]
	Root estimate		

Four trees were sampled per plot in winter, and stand biomass values were derived from regressions on D. Root biomass was estimated from soil core samples. There was 11.2 and 9.0 t/ha of dead branches in the left and right columns, respectively. Nutrient contents were determined.

a. Excluding the bark.

b. Litterfall only.

Keyes, M.R. and Grier, C.C. (1981). Above- and below-ground net production in 40-year-old Douglas-fir stands on low and high productivity sites. *Can. J. For. Res.* 11, 599-605.

46°40'N 122°20'W 320 m U.S.A., Washington, 90 km SE of Seattle, Charles Lathrop Pack Experimental Forest.

Pseudotsuga menziesii

		Poor site: gravelly loam sand, low in N and low base saturation.	Good site: colluvial soil with 33% base saturation.
Age (years)		40	40
Trees/ha			
Tree height (m)		23	33
Basal area (m^2/ha)			
Leaf area index			
Stem volume (m^3/ha)			
Dry biomass (t/ha)	Stem wood	188.5	368.8
	Stem bark	33.0	55.2
	Branches	17.1	27.7
	Fruits etc.		
	Foliage	10.0	16.0
	Root estimate	49.3 + 8.3[a]	85.4 + 2.7[a]
CAI (m^3/ha/yr)			
Net production (t/ha/yr)	Stem wood	4.2[b]	8.2[b]
	Stem bark	0.9[b]	1.7[b]
	Branches	0.2[b]	0.6[b]
	Fruits etc.		
	Foliage	2.0[c]	3.2[c]
	Root estimate	2.5 + >5.6[a]	2.7 + >1.4[a]

Stand biomass values for one 400 m^2 plot per stand were derived using published regressions of woody biomass on D and foliage biomass on sapwood basal area. Production was estimated over the previous one year. Fine root biomass and increment values were estimated by soil core sampling and root observations at underground windows.

a. Fine roots, not more than 2 mm in diameter.
b. Including estimated mortality, but excluding woody litterfall.
c. Assumed to be 20% of the foliage biomass.

Whittaker, R.H. and Niering, W.A. (1975). Vegetation of the Santa Catalina Mountains, Arizona. V Biomass, production and diversity along the elevation gradient. *Ecology* 56, 771-790.

Whittaker, R.H. and Niering, W.A. (1968). Vegetation of the Santa Catalina Mountains, Arizona. IV Limestone and acid soils. *J. Ecol.* 56, 523-544.

ca.32°20'N 110°50'W 2645 m U.S.A., Arizona, Santa Catalina Mountains, near Tucson.

Soils described by Whittaker and Niering (1968).		*Pseudotsuga menziesii* (88%)[a] *Abies concolor* (7%)[a] *et al.*	*P. menziesii* (79%)[a] *A. concolor* (17%)[a] *et al.*
Age (years)		252[b]	321[b]
Trees/ha		340 380[c]	400 870[c]
Tree height (m)		27.6[b]	27.9[b]
Basal area (m^2/ha)		70.5 + 0.3[c]	118.1 + 1.4[c]
Leaf area index		6.7[d]	7.3[d]
Stem volume (m^3/ha)		980[e]	1666[e]
Dry biomass (t/ha)	Stem wood Stem bark	363 + 0.3[c]	681 + 4.0[c]
	Branches	57 + 0.2[c]	82 + 2.3[c]
	Fruits etc.		
	Foliage	17 + 0.0[c]	20 + 2.3[c]
	Root estimate		
CAI (m^3/ha/yr)		3.1[e]	5.9[e]
Net production (t/ha/yr)	Stem wood Stem bark	2.27[f] 0.67[f] + 0.02[cf]	3.40[f] 1.13[f] + 0.21[cf]
	Branches	1.39[f] + 0.02[cf]	1.77[f] + 0.23[cf]
	Fruits etc.	0.40	0.50
	Foliage	3.60 + 0.03[c]	3.95 + 0.46[c]
	Root estimate		

Ten to fifteen trees were sampled of each of the major species, and stand biomass values for the above two 0.1 ha plots were derived from regressions on D, wood volumes and surface areas, and from other relationships. All trees and shrubs over 1 cm D were included.

a. Percentage of the total stem volume.
b. Weighted mean ages and heights.
c. Understorey shrubs.
d. All-sided LAI values were 15.5 and 16.7 in columns left and right, respectively.
e. Parabolic volumes.
f. Excluding woody litterfall and any mortality.

Gholz, H.L. (1981). Environmental limits on aboveground net primary production, leaf area, and biomass in vegetation zones of the Pacific Northwest. *Ecology* (in press).
Gholz, H.L., Grier, C.C., Campbell, A.G. and Brown, A.T. (1979). "Equations for Estimating Biomass and Leaf Area of Plants in the Pacific Northwest." Forest Research Laboratory, Oregon State University, Corvallis, U.S.A. Research Paper no.41.
Gholz, H.L., Fitz, F. and Waring, R.H. (1976). Leaf area differences associated with old-growth forest communities in the western Oregon Cascades. *Can. J. For. Res.* 6, 49-57.

44-45°N 122-124°W (alt. given below) U.S.A., Oregon.

		Interior Coast Range	Western Cascade Mountains
		Pseudotsuga menziesii and *Abies grandis*	*P. menziesii*
		365 m	410 m
Age (years)		150	125
Trees/ha		312[a]	488[a]
Tree height (m)		35-55	35-55
Basal area (m^2/ha)		84.2	54.5
Leaf area index		7.8[b]	6.5[b]
Stem volume (m^3/ha)			
Dry biomass (t/ha)	Stem wood	789	407
	Stem bark		
	Branches	60	30
	Fruits etc.		
	Foliage	16	12
	Root estimate		
CAI (m^3/ha/yr)			
Net production (t/ha/yr)	Stem wood	5.0[c]	3.0[c]
	Stem bark		
	Branches	0.5[c]	0.2[c]
	Fruits etc.		
	Foliage	5.0[d]	3.0[d]
	Root estimate		

Stand values for plots of at least 0.25 ha were derived from regressions on D.
a. Trees over 10 cm D; there were 110 and 12 trees/ha less than 10 cm D in columns left and right, respectively.
b. All-sided LAI values were 18 and 15 in columns left and right, respectively.
c. Excluding woody litterfall and any mortality.
d. Assumed to be 20-30% of the foliage biomass, depending on the species.

Fujimori, T., Kawanabe, S., Saito, H., Grier, C.C. and Shidei, T. (1976). Biomass and primary production in forests of three major vegetation zones of the northwestern United States. *J. Jap. For. Soc.* 58, 360-373.

Gholz, H.L. (1981). Environmental limits on aboveground net primary production, leaf area, and biomass in vegetation zones of the Pacific Northwest. *Ecology* (in press).

U.S.A., Oregon	44°10'N 122°31'W 450 m Blue River	44-45°N 121-122°W 1500 m West Cascades
At Blue River: red-brown gravelly silt clay loams.	*Pseudotsuga menziesii* (91%)[a] *Acer macrophyllum* (6%)[a] *et al.*	*P. menziesii*, with *Tsuga heterophylla* and *Abies amabilis*
	(Fujimori *et al.* 1976)	(Gholz 1981)
Age (years)	90-110	150
Trees/ha	478	1005[b]
Tree height (m)	62.6[c]	35-55
Basal area (m^2/ha)	63.3	72.4
Leaf area index		9.6[d]
Stem volume (m^3/ha)	1406	
Dry biomass (t/ha): Stem wood	529.9	467
Dry biomass (t/ha): Stem bark	71.2	
Dry biomass (t/ha): Branches	49.0	43
Dry biomass (t/ha): Fruits etc.		
Dry biomass (t/ha): Foliage	11.1	18
Dry biomass (t/ha): Root estimate		
CAI (m^3/ha/yr)	19.1	
Net production (t/ha/yr): Stem wood	7.2[e]	5.0[e]
Net production (t/ha/yr): Stem bark	1.0[e]	
Net production (t/ha/yr): Branches	1.7[e]	0.5[e]
Net production (t/ha/yr): Fruits etc.		
Net production (t/ha/yr): Foliage	2.8	4.0[f]
Net production (t/ha/yr): Root estimate		

Fujimori *et al.* (1976) derived stand biomass values for a 0.38 ha plot, using regressions on D^2H for the main species and proportional basal area allocation for the minor species; branches and bark were assumed to grow at the same relative rates as stem wood.
Gholz (1981) derived stand biomass values for a plot of at least 0.25 ha from regressions on D.

a. Percentage of the total basal area.
b. Trees over 10 cm D; there were 1250 trees/ha less than 10 cm D.
c. Mean height of the dominant trees. *d*. All-sided LAI was 22.
e. Excluding woody litterfall and mortality. *f*. Foliage production was assumed to be between 20 and 30% of the foliage biomass, depending on the species.

Fogel, R. and Hunt, G. (1979). Fungal and arboreal biomass in a western Oregon Douglas-fir ecosystem: distribution patterns and turnover. *Can. J. For. Res.* 9, 245-256.

44°28'N 123°29'W 305 m U.S.A., Oregon, 11.3 km SW of Philomath.

Well-drained gravelly loam. pH 5.2-5.7.

Pseudotsuga menziesii (94%)[a] with *Castanopsis chrysophylla* and *Alnus rubra*.

Overstocked second generation forest.

Age (years)		40 (35-50)
Trees/ha		1626[b]
Tree height (m)		24.1
Basal area (m^2/ha)		49.1
Leaf area index		
Stem volume (m^3/ha)		423[b]
Dry biomass (t/ha)	Stem wood	212.9
	Stem bark	
	Branches	22.8
	Fruits etc.	
	Foliage	14.7
	Root estimate	(49.3 + 15.0)[c]
CAI (m^3/ha/yr)		
Net production (t/ha/yr)	Stem wood	1.37[d]
	Stem bark	
	Branches	0.27[e]
	Fruits etc.	
	Foliage	2.41[e]
	Root estimate	9.16[f]

Stand biomass values were derived from regressions on D taken from Dice (1970) (see p.329). There was 7.7 t/ha of dead branches.

a. Percentage of the total basal area.
b. Live *P. menziesii* trees over 10.2 cm D.
c. Non-mycorrhizal (49.3 t/ha) plus mycorrhizal (15.0 t/ha) roots.
d. Mortality only, taken as dead log biomass divided by stand age; stem and branch increments were not determined.
e. Litterfall, measured over one year, adjusted for pre-fall losses.
f. Estimated turnover of mycorrhizal roots.

Franklin, J.F. and Waring, R.H. (1980). Distinctive features of the northwestern coniferous forest: development, structure and function. In: "Forests: Fresh Perspectives from Ecosystem Analysis" (R.H. Waring, ed.), pp.59-86. Oregon State University Press, Corvallis, Oregon, U.S.A.

ca.46°45'N 122°W below 1200 m U.S.A., Washington, Mount Rainier National Park.

Pseudotsuga menziesii with *Tsuga heterophylla*.

Age (years)	500[a]	500[a]	500[a]	500[a]	500[a]	500[a]	500[a]	500[a]
Trees/ha								
Tree height (m)								
Basal area (m^2/ha)	50	81	76	65	89	69	98	74
Leaf area index	7.1[b]	11.7[b]	13.2[b]	9.7[b]	12.2[b]	10.7[b]	14.7[b]	12.2[b]
Stem volume (m^3/ha)								
Dry biomass (t/ha): Stem wood, Stem bark, Branches	303	567	559	586	933	520	760	539
Dry biomass (t/ha): Fruits etc.								
Dry biomass (t/ha): Foliage	14	23	26	19	24	21	29	24
Dry biomass (t/ha): Root estimate								
CAI (m^3/ha/yr)								
Net production (t/ha/yr): Stem wood								
Net production (t/ha/yr): Stem bark								
Net production (t/ha/yr): Branches								
Net production (t/ha/yr): Fruits etc.								
Net production (t/ha/yr): Foliage								
Net production (t/ha/yr): Root estimate								

The biomass of one hectare reference stands or permanent sample plots were derived using published regressions on D and H (Dice, 1970; Heilman, 1961; Grier and Logan, 1977) (see pp. 329, 330 and 340, respectively).

a. Age of the oldest trees.

b. Approximate all-sided LAI values can be obtained by multiplying by 2.3.

Continued from p.338.

44°15'N 122°20'W 360–1200 m U.S.A., Oregon, 70 km E of Eugene, Andrews Experimental Forest.

Gravelly silty clay.

Pseudotsuga menziesii with *Tsuga heterophylla*.

Age (years)	450[a]	450[a]	450[a]	450[a]	450[a]	450[a]	450[a]	450[a]
Trees/ha								
Tree height (m)								
Basal area (m^2/ha)	68	84	92	99	118	116	92	129
Leaf area index	7.1[b]	9.2[b]	12.7[b]	10.2[b]	14.7[b]	15.2[b]	10.7[b]	15.2[b]
Stem volume (m^3/ha)								
Dry biomass (t/ha) Stem wood, Stem bark, Branches	701	893	801	1203	1208	1107	1018	1392
Dry biomass (t/ha) Fruits etc.								
Dry biomass (t/ha) Foliage	14	18	25	20	29	30	21	30
Dry biomass (t/ha) Root estimate								
CAI (m^3/ha/yr)								
Net production (t/ha/yr) Stem wood								
Net production (t/ha/yr) Stem bark								
Net production (t/ha/yr) Branches								
Net production (t/ha/yr) Fruits etc.								
Net production (t/ha/yr) Foliage								
Net production (t/ha/yr) Root estimate								

See p.338.

Grier, C.C. and Logan, R.S. (1977). Old-growth *Pseudotsuga menziesii* communities of a western Oregon watershed: biomass distribution and production budgets. *Ecol. Monogr.* 47, 373-400.

Grier, C.C., Cole, D.W., Dyrness, C.T. and Fredriksen, R.L. (1974). Nutrient cycling in 37- and 450-year-old Douglas fir ecosystems. In: "Integrated Research in the Coniferous Forest Biome" (R.H. Waring and R.L. Edmonds, eds), pp.21-36. US/IBP Bull. No.5, University of Washington, Seattle, Washington, U.S.A.

44°15'N 122°20'W 430-470 m U.S.A., Oregon, 70 km E of Eugene, Andrews Experimental Forest.

Gravelly silty clay. pH 6.2.

Pseudotsuga menziesii, with *Tsuga heterophylla*, *Thuja plicata et al.*

	Xeric	Xeric	Warm mesic	Mesic	Cool moist
	90%[a]	91%[a]	90%[a]	90%[a]	81%[a]
Age (years)	450[b]	450[b]	450[b]	450[b]	450[b]
Trees/ha	ca.290	ca.290	ca.290	ca.290	ca.290
Tree height (m)	70[b]	70[b]	70[b]	70[b]	70[b]
Basal area (m^2/ha)	ca.62	ca.62	ca.62	ca.62	ca.62
Leaf area index	ca.12	ca.12	ca.12	ca.12	ca.12
Stem volume (m^3/ha)					
Dry biomass (t/ha) Stem wood	538.8	794.7	399.1	655.2	438.3
Stem bark	68.3 +4.6[c]	96.9 +4.9[c]	48.3 +6.8[c]	78.7 +1.1[c]	52.6 +8.8[c]
Branches	41.7	64.4	32.7	54.2	47.9
Fruits etc.					
Foliage	11.6 + 1.7[c]	14.5 + 1.8[c]	8.6 + 1.8[c]	14.1 + 4.5[c]	11.4 + 1.3[c]
Root estimate	143.8	204.0	104.9	172.8	122.6
CAI (m^3/ha/yr)					
Net production (t/ha/yr) Stem wood, Stem bark	-4.1 + 1.1[c] + 6.6[e]	-6.2 + 1.2[c]	-3.1 + 0.3[c]	-5.0 + 0.2[c]	-2.9 + 0.4[c]
Branches, Fruits etc., Foliage	4.3[d] + 0.4[f]	5.0[d] + 0.4[f]	3.8[d] + 0.4[f]	4.4[d] + 0.4[f]	4.2[d] + 0.4[f]
Root estimate	2.8[g]	3.0[g]	2.0[g]	3.3[g]	2.7[g]

Sixty-one trees were sampled and stand biomass values were derived using calculated regressions on D and regressions published by Dice (1970) and Heilman (1961) (see pp. 329 and 330). Fine roots were core sampled. There was 4.7, 5.3, 3.2, 5.3 and 4.3 t/ha of dead branches in columns left to right. Values given here are from Grier and Logan (1977) which updated those published earlier.

a. Percentage of the total biomass accounted for by *P. menziesii*. *b*. Age and height of the oldest trees. *c*. Understorey shrubs. *d*. Total litterfall, measured over 2 years. *e*. Mortality, estimated in this stand only. *f*. Throughfall and consumption losses. *g*. Coarse roots were assumed to grow at the same relative rate as above-ground woody parts and fine root production was assumed to be 20% of the fine root biomass; but see updated values on p.341.

Grier, C.C. and Logan, R.S. (1977). Old-growth *Pseudotsuga menziesii* communities of a western Oregon watershed: biomass distribution and production budgets. *Ecol. Monogr.* 47, 373-400.

Santantonio, D., Hermann, R.K. and Overton, W.S. (1977). Root biomass studies in forest ecosystems. *Pedobiologia* 17, 1-31.

Santantonio, D. (1979). Seasonal dynamics of fine roots in mature stands of Douglas fir of different water regimes - a preliminary report. In: "Root Physiology and Symbiosis" (A. Riedacker & J. Gagnaire-Michard, eds), pp.190-193. Nancy, France.

44°15'N 122°20'W 430-670 m U.S.A., Oregon, 70 km E of Eugene, Andrews Experimental Forest.

Gravelly silty clay, pH 6.2.

Pseudotsuga menziesii (80%)[a], *Tsuga heterophylla*, *Thuja plicata* with understorey shrubs.

Age (years)		up to 450
Trees/ha		290
Tree height (m)		5 to 70
Basal area (m^2/ha)		62.7
Leaf area index		12.5
Stem volume (m^3/ha)		
Dry biomass (t/ha)	Stem wood	575.8
	Stem bark	70.4 + 5.3[b]
	Branches	47.8
	Fruits etc.	
	Foliage	12.4 + 1.5[b]
	Root estimate	209[cg]
CAI (m^3/ha/yr)		
Net production (t/ha/yr)	Stem wood	-4.3 + 0.6[b] + 7.0[d]
	Stem bark	
	Branches	
	Fruits etc.	4.3[e] + 0.4[f]
	Foliage	
	Root estimate	8.5 to 10.2[g]

These are average values for the whole watershed, and update values published earlier. Sixty-one trees were sampled and stand values were derived from regressions on D. There was an average of 4.8 t/ha of dead branches. Roots of three large trees were excavated and fine roots were core sampled.

a. Percentage of the total basal area.
b. Understorey shrubs.
c. Comprised of 198 t/ha of roots over 1 mm diameter and 11 t/ha of fine roots.
d. Mortality.
e. Total litterfall.
f. Throughfall and consumption losses.
g. From Santantonio *et al.* (1977) and Santantonio (1979).

Turner, J. and Long, J.N. (1975). Accumulation of organic matter in a series of Douglas fir stands. *Can. J. For. Res.* 5, 681-690.

Turner, J. (1981). Nutrient cycling in an age sequence of western Washington Douglas fir stands. *Ann. Bot.* 48, 159-169.

ca.47°50'N 123°00'W 210 m U.S.A., Washington, Cedar River, Thompson Research Center.

Gravelly loams derived from glacial till.

Pseudotsuga menziesii with understorey shrubs.

	Natural regeneration		Plantation	Natural regeneration
Age (years)	22	30	30	42
Trees/ha	2756	2346	1800	822
Tree height (m)				
Basal area (m^2/ha)	42.4	32.4	34.4	35.7
Leaf area index				
Stem volume (m^3/ha)				
Dry biomass (t/ha) Stem wood	99.4	121.3	128.5	157.5
Stem bark	13.9	16.1	17.4	19.5
Branches	13.2[a]	15.6[a]	16.7[a]	19.5[a]
Fruits etc.				
Foliage	5.0	6.2	6.5	8.3
Root estimate	+7.6[b]	+5.1[b]	+10.9[b]	+4.2[b]
CAI (m^3/ha/yr)				
Net production (t/ha/yr) Stem wood	6.13[c]	4.76[c]	4.98[c]	6.39[c]
Stem bark				
Branches	0.54[c]	0.53[c]	0.54[c]	0.67[c]
Fruits etc.				
Foliage	2.10[d]	3.14[d]	2.10[d]	2.23[d]
Root estimate	+1.99[b]	+0.95[b]		+0.63[b]

Stand values for the above 450 m^2 plots were derived from regressions on D calculated by Dice (1970) (see p.329). Nutrient contents were determined.

a. Including stem biomass above the base of the crowns.

b. Understorey shrubs.

c. Including woody litterfall and mortality, measured over one year.

d. New foliage biomass; total litterfall was 2.67, 3.53, 2.50 and 2.57 t/ha/yr in columns left to right.

Continued from p.342.

ca. 47°50'N 123°00'W 210 m U.S.A., Washington, Cedar River, Thompson Research Center.

Gravelly loams derived from glacial till.

Pseudotsuga menziesii with *Tsuga heterophylla*, *Thuja plicata*, and understorey shrubs.

	Plantation 100%[a]	Plantation 73%[a]	Natural regeneration 95%[a]
Age (years)	42	49	73
Trees/ha	1289	1067	1889
Tree height (m)			
Basal area (m^2/ha)	44.5	41.6	57.2
Leaf area index			
Stem volume (m^3/ha)			
Dry biomass (t/ha) Stem wood	182.6	178.4	237.0
Stem bark	23.6	22.8	30.4
Branches	23.2[b] +3.4[c]	23.4[b] +3.4[c]	26.2[b] +2.8[c]
Fruits etc.			
Foliage	9.4	9.4	10.8
Root estimate			
CAI (m^3/ha/yr)			
Net production (t/ha/yr) Stem wood	3.65[d]	3.30[d]	2.50[d]
Stem bark			
Branches	0.48[d] +0.54[e]	0.42[d] +0.53[e]	0.33[d] +0.57[e]
Fruits etc.			
Foliage	2.44[e]	2.20[e]	2.28[e]
Root estimate			

Stand values for the above 450 m^2 plots were derived from regressions on D calculated by Dice (1970) (see p.329). Nutrient contents were determined.

a. Percentage of the total tree number that were *P. menziesii*.

b. Including stem biomass above the base of the crowns.

c. Understorey shrubs.

d. Including woody litterfall and mortality, measured over one year.

e. New foliage biomass; total litterfall was 3.12, 2.28 and 3.73 t/ha/yr in columns left to right.

Long, J.N. and Turner, J. (1975). Above-ground biomass of understorey and overstorey in an age sequence of four Douglas fir stands. *J. appl. Ecol.* 12, 178-188.

ca.47°50'N 123°00'W 210 m U.S.A., Washington, near Seattle, Thompson Research Center.

Coarse gravelly glacial outwash soils.

Pseudotsuga menziesii with *Tsuga heterophylla* with an understorey of broadleaved species. Natural regeneration with incomplete canopy cover.

	99%[a]	97%[a]	96%[a]	68%[a]
Age (years)	22	30	42	73
Trees/ha	1664	1941	540	1137
Tree height (m)				
Basal area (m^2/ha)	18.0	22.1	25.6	44.8
Leaf area index				
Stem volume (m^3/ha)				
Dry biomass (t/ha) Stem wood	56.6	69.6	123.8	206.8
Stem bark				
Branches	4.0[b]	5.9[b]	7.3[b]	12.6[b]
Fruits etc.	+7.6[c]	+5.3[c]	+4.2[c]	+2.8[c]
Foliage	2.5	3.1	5.6	9.3
Root estimate				
CAI (m^3/ha/yr)				
Net production (t/ha/yr) Stem wood				
Stem bark				
Branches				
Fruits etc.				
Foliage				
Root estimate				

Stand biomass values for five 375 m^2 plots per stand were derived from regressions on D taken from Dice (1970) and Zavitkovski and Stevens (1972) (see pp. 329 and 252).

a. Percentage of the total basal area accounted for by *P. menziesii*.

b. Including the stems within the crowns.

c. Understorey shrubs.

Westman, W.E. and Whittaker, R.H. (1975). The pygmy forest region of northern California: studies on biomass and primary productivity. *J. Ecol.* 63, 493-520.

Whittaker, R.H. (1966). Forest dimensions and production in the Great Smoky Mountains. *Ecology* 47, 103-121.

ca.39°20'N 123°45'W (alt. given below) U.S.A., California, Mendocino, near Fort Bragg.

Sequoia sempervirens with *Pseudotsuga menziesii et al.*

	83%[a] Hugo soils on 25-50° slopes.			99%[a] Flat alluvial terraces.		
	270 m	270 m	50 m	30 m	60 m	240 m
Age (years)	Mature	Mature	Mature	Mature	Mature	Mature
Trees/ha	240[b]+230[c]	170[b]+810[c]	570[b]+720[c]	234[b]+78[c]	400[b]+30[c]	270[b]+0[c]
Tree height (m)	43[d]	64[d]	30[d]	79[d]	81[d]	79[d]
Basal area (m^2/ha)	96	164	144	250	243	247
Leaf area index						
Stem volume (m^3/ha)	2055[e]	5188[e]	2184[e]	8980[e]	9732[e]	
Dry biomass (t/ha): Stem wood, Stem bark, Branches, Fruits etc., Foliage	732	1799	934	2980	3280	3300
Dry biomass (t/ha): Root estimate						
CAI (m^3/ha/yr)	4.6[e]	12.9[e]	15.0[e]	13.3[e]	16.0[e]	
Net production (t/ha/yr): Stem wood, Stem bark, Branches, Fruits etc., Foliage	5.3[f]	13.0[f]	18.9[f]	11.1[f]	13.1[f]	18.8[f]
Net production (t/ha/yr): Root estimate						

Stand values for the above plots of 0.1 to 0.5 ha were derived from regressions on various dimensions following Whittaker *et al.* (1974) (see p.259).

a. Percentage of the total basal area accounted for by *S. sempervirens*.
b. Number of *S. sempervirens*.
c. Number of *P. menziesii*.
d. Weighted mean height.
e. Parabolic volume.
f. Excluding all litterfall, estimated to be about 2.1 t/ha/yr, and excluding mortality.

Fujimori, T. (1977). Stem biomass and structure of a mature *Sequoia sempervirens* stand on the Pacific coast of northern California. *J. Jap. For. Soc.* 59, 435-441.

40°20'N 124°00'W 80 m U.S.A., California, Humboldt State Park, Bull Creek.

Alluvial soils.

Sequoia sempervirens

Age (years)		to over 1000
Trees/ha		167
Tree height (m)		88
Basal area (m^2/ha)		338[a]
Leaf area index		
Stem volume (m^3/ha)		10817
Dry biomass (t/ha)	Stem wood	3461
	Stem bark	
	Branches	
	Fruits etc.	
	Foliage	
	Root estimate	
CAI (m^3/ha/yr)		
Net production (t/ha/yr)	Stem wood	
	Stem bark	
	Branches	
	Fruits etc.	
	Foliage	
	Root estimate	

Eight fallen old trees and eleven felled young trees were used to calculate stand values for a 1.44 ha plot from regressions on D^2H.

a. Ninety-six per cent of the basal area was accounted for by 66 trees.

Reiners, W.A. (1972). Structure and energetics of three Minnesota forests. *Ecol. Monogr.* 42, 71-94.

Reiners, W.A. (1974). Foliage production by *Thuja occidentalis* L. from biomass and litter fall estimates. *Am. Midl. Nat.* 92, 340-345.

Reiners, W.A. and Reiners, N.M. (1970). Energy and nutrient dynamics of forest floors in three Minnesota forests. *J. Ecol.* 58, 497-519.

45°30'N 193°20'W 400 m U.S.A., Minnesota, north of Minneapolis.

		Thuja occidentalis (29%)[a] *Fraxinus nigra* (32%)[a] *et al.* Marginal fen.	*T. occidentalis* (65%)[a] *Betula papyrifera* (16%)[a] *et al.* Cedar swamp.
Age (years)		45-50	70-100
Trees/ha		3348	2755
Tree height (m)		ca.15	ca.15
Basal area (m^2/ha)		25.1	42.2
Leaf area index			
Stem volume (m^3/ha)			
Dry biomass (t/ha)	Stem wood	64.9	104.5
	Stem bark	7.9	12.1
	Branches	21.4	34.6
	Fruits etc.	0.0	0.5
	Foliage	3.9	7.8
	Root estimate		
CAI (m^3/ha/yr)			
Net production (t/ha/yr)	Stem wood	2.17	3.19
	Stem bark	0.28	0.37
	Branches	1.19[b] + 1.24[c]	1.37[b] + 1.28[c]
	Fruits etc.	0.01[d]	1.10[d]
	Foliage	2.87[e]	4.10[e]
	Root estimate		

Stand biomass values for sixteen 100 m^2 plots in each stand were derived from regressions on D and wood volume. Production values were estimated for the previous one year.

a. Percentage of the total biomass.

b. Increment of old branches plus new twigs.

c. Approximate values for woody litterfall; total litterfall was 4.12 and 4.88 t/ha/yr in columns left and right, respectively, according to Reiners and Reiners (1970).

d. Fruits etc. litterfall.

e. Broadleaved foliage biomass plus 35% of the foliage biomass of *T. occidentalis*.

Whittaker, R.H. (1963). Net production of heath balds and forest heaths in the Great Smoky Mountains. *Ecology* 46, 176-182.

Whittaker, R.H. (1966). Forest dimensions and production in the Great Smoky Mountains. *Ecology* 47, 103-121.

ca.35°40'N 83°30'W (alt. given below) U.S.A., Tennessee, Great Smoky Mountains, Mount LeConte.

	Tsuga canadensis (40%)[a] *Fagus grandifolia* (28%)[a] *et al.* 430 m	*T. canadensis* (87%)[a] *Betula alleghaniensis* (4%)[a] with understorey of *Rhododendron maximum* (8%)[a] 1280 m
Age (years)		
Trees/ha	1300 + 3810[b]	230 + 2730[b]
Tree height (m)	29 7.6[b] (21.1)[c]	34 5.2[b] (30.3)[c]
Basal area (m^2/ha)	24.6 + 4.5[b]	56.3 + 4.4[b]
Leaf area index	3.6[b]	2.1[b]
Stem volume (m^3/ha)	252[d] + 14.3[bd]	805[d] + 19.1[bd]
Dry biomass (t/ha): Stem wood, Stem bark, Branches, Fruits etc., Foliage	170 + 23.0[b]	490.0 + 20.5[b]
Dry biomass (t/ha): Root estimate		
CAI (m^3/ha/yr)	5.4[d] + 0.1[bd]	5.3[d] + 0.5[bd]
Net production (t/ha/yr): Stem wood, Stem bark, Branches, Fruits etc., Foliage	11.0[e] + 2.3[be]	8.5[e] + 1.7[be]
Net production (t/ha/yr): Root estimate		

Stand values were estimated for plots of at least 0.1 ha from the weight of clippings of current year's twigs, from published regressions, from stem volumes, branch/stem biomass ratios, and other relationships.

a. Percentage of the total volume increment; *B. alleghaniensis* syn. *lutea*.

b. Understorey shrubs.

c. Weighted mean height (in brackets).

d. Parabolic volume.

e. Excluding woody litterfall and mortality; total foliage production of trees plus shrubs was 3.7 and 3.2 t/ha/yr in columns left and right, respectively.

Fujimori, T. (1971). "Primary Production of a Young *Tsuga heterophylla* Stand and some Speculation about Biomass of Forest Communities on the Oregon Coast." U.S.D.A. Forest Service Research Paper PNW-123, 1-11.
Grier, C.C. (1976). Biomass, productivity and nitrogen-phosphorus cycles in hemlock-spruce stands of the central Oregon coast. In: "Western Hemlock Management", pp. 71-81. Univ. of Washington, Coll. of Forest Resources. Contribution no.34.
Fujimori, T., Kawanabe, S., Saito, H., Grier, C.C. and Shidei, T. (1976).(see p.336) *J. Jap. For. Soc.* 58, 360-373.

45°02'N 123°56'W 50-100 m U.S.A., Oregon, Cascade Head, near Otis.

Deep fertile red-brown porous loams. pH 3.7-4.4.	*Tsuga heterophylla* Thinned between ages 7 and 8.	*T. heterophylla* (76%)[a] and *Picea sitchensis*, with understorey shrubs.
Age (years)	26 (19 to 32)	121
Trees/ha	6627	373
Tree height (m)	10.0	47.7
Basal area (m^2/ha)	49.4	98.2
Leaf area index	16.1[b]	20.2[b]
Stem volume (m^3/ha)		1979
Dry biomass (t/ha) Stem wood	150.9	751.5
Dry biomass (t/ha) Stem bark	150.9	63.2 + 2.1[c]
Dry biomass (t/ha) Branches	20.7	48.7
Dry biomass (t/ha) Fruits etc.		
Dry biomass (t/ha) Foliage	21.1	8.1 + 2.1[c]
Dry biomass (t/ha) Root estimate	38.4[d]	186.7[d]
CAI (m^3/ha/yr)		16.0
Net production (t/ha/yr) Stem wood	20.4 + 0.3[e]	6.1 + 5.8[e]
Net production (t/ha/yr) Stem bark	20.4 + 1.0[f]	0.5 + 3.4[f] + 0.4[c]
Net production (t/ha/yr) Branches	4.3	0.9
Net production (t/ha/yr) Fruits etc.		
Net production (t/ha/yr) Foliage	6.0[g] + 0.2[h]	2.9[g] + 0.1[h]
Net production (t/ha/yr) Root estimate	5.5[d]	2.7[d]

Ten trees were sampled from the 26-year-old stand, and stand values were derived by proportional basal area allocation. Stand values for a 0.41 ha plot of the 121-year-old trees were derived from regressions on D. Roots were assumed to grow at the same relative rates as above-ground woody parts. Nutrient contents were determined.

a. Percentage of the total basal area.
b. All-sided LAI values were 37.0 and 46.5 in columns left and right, respectively.
c. Understorey shrubs.
d. 'Coarse' roots only.
e. Mortality.
f. Woody litterfall.
g. New foliage biomass; foliage litterfall was 6.0 and 2.8 t/ha/yr in columns left and right, respectively.
h. Consumption.

Greene, S. (1981). Forest Science Laboratories, 3200 Jefferson Way, Corvallis, Oregon 97331, U.S.A. Personal communication.

45°05'N 124°00'W 46 m U.S.A., Oregon, Cascade Head, Otis.

Tsuga heterophylla (61%)[a]
and *Picea sitchensis*.

Age (years)		up to 250
Trees/ha		367 + 49
Tree height (m)		
Basal area (m^2/ha)		35.3 + 22.4
Leaf area index		
Stem volume (m^3/ha)		570 + 475
Dry biomass (t/ha)	Stem wood	197.7 + 253.2
	Stem bark	
	Branches	70.7 + 21.4
	Fruits etc.	
	Foliage	13.2 + 1.9
	Root estimate	
CAI (m^3/ha/yr)		
Net production (t/ha/yr)	Stem wood	
	Stem bark	
	Branches	
	Fruits etc.	
	Foliage	
	Root estimate	

Stand values for circular plots of up to 0.1 ha along 4 transects were derived from regressions on D, based on data from various tree samplings in the Pacific Northwest and British Columbia.
Values are given for *T. heterophylla* plus *P. sitchensis*, left and right, respectively.
a. Percentage of the total basal area.

Gholz, H.L. (1981). Environmental limits on aboveground net primary production, leaf area and biomass in vegetation zones of the Pacific Northwest. *Ecology* (in press).
Gholz, H.L., Grier, C.C., Campbell, A.G. and Brown, A.T. (1979). "Equations for Estimating Biomass and Leaf Area of Plants in the Pacific Northwest." Forest Research Laboratory, Oregon State University, Corvallis, U.S.A. Research Paper no.41.
Gholz, H.L., Fitz, F. and Waring, R.H. (1976). Leaf area differences associated with old-growth forest communities in the western Oregon Cascades. *Can. J. For. Res.* 6, 49-57.

44-45°N 122-124°W (alt. given below) U.S.A., Oregon.

	Western Coast Range		Cascade Mountains
	Tsuga heterophylla		*Tsuga mertensiana*
	200 m	200 m	1590 m
Age (years)	130	130	Mature
Trees/ha	294[a]	499[a]	804[a]
Tree height (m)	35-55	35-55	35-55
Basal area (m^2/ha)	118.2	111.2	57.2
Leaf area index	13.5[b]	19.1[b]	4.3[b]
Stem volume (m^3/ha)			
Dry biomass (t/ha): Stem wood, Stem bark	960	1316	228
Dry biomass (t/ha): Branches	97	144	35
Dry biomass (t/ha): Fruits etc.			
Dry biomass (t/ha): Foliage	23	32	15
Dry biomass (t/ha): Root estimate			
CAI (m^3/ha/yr)			
Net production (t/ha/yr): Stem wood, Stem bark	7.0[c]	4.0[c]	1.0[c]
Net production (t/ha/yr): Branches	2.0[c]	1.0[c]	0.2[c]
Net production (t/ha/yr): Fruits etc.			
Net production (t/ha/yr): Foliage	6.0[d]	8.0[d]	3.0[d]
Net production (t/ha/yr): Root estimate			

Stand values for plots of 0.25 to 0.41 ha were derived from regressions on D.
a. Trees over 10 cm D; there were 2500, 1500 and 1700 trees/ha less than 10 cm D in columns left to right.
b. All-sided LAI values were 31, 44 and 10 in columns left to right.
c. Excluding woody litterfall and any mortality.
d. Assumed to be 20-30% of the foliage biomass, depending on the species.

Merzoev, O.G. (1981). In: "Dynamic Properties of Forest Ecosystems" (D.E. Reichle, ed.), pp.622-623. Cambridge University Press, Cambridge, London, New York, and Melbourne.

ca.41°N 48°E 2000 m U.S.S.R., Azerbaijan, Caucasus.

Betula pendula syn. *verrucosa*

Age (years)		20	20
Trees/ha		9480	3560
Tree height (m)		4.5	6.5
Basal area (m^2/ha)			
Leaf area index			
Stem volume (m^3/ha)			
Dry biomass (t/ha)	Stem wood	18.0	16.9
	Stem bark		
	Branches	5.3	4.1
	Fruits etc.		
	Foliage	2.3	1.3
	Root estimate		
CAI (m^3/ha/yr)			
Net production (t/ha/yr)	Stem wood		
	Stem bark		
	Branches		0.07[a]
	Fruits etc.		
	Foliage	2.34[a]	1.27[a]
	Root estimate		

a. Litterfall only.

Rodin, L.E. and Bazilevich, N.I. (1967). "Production and Mineral Cycling in Terrestrial Vegetation." Oliver and Boyd, Edinburgh and London. (Quoting Russian authors in their Table 32).

U.S.S.R.	ca.56°N 36°E -- Moscow Province	ca.55°N 83°E -- Novosibirsk	
Podzols	*Betula verrucosa*[a]	*B. verrucosa*[a] *Populus* sp. *et al.*	*Betula pubescens* *Populus* sp. *et al.*
Age (years)	42	35	20
Trees/ha			
Tree height (m)	19.4	15.0	8.0
Basal area (m^2/ha)			
Leaf area index			
Stem volume (m^3/ha)			
Dry biomass (t/ha) Stem wood, Stem bark, Branches	203.4	164.2	57.0
Dry biomass (t/ha) Fruits etc.			
Dry biomass (t/ha) Foliage	3.6[b]	5.2[b]	2.7[b]
Dry biomass (t/ha) Root estimate	42.8	43.9	30.1
CAI (m^3/ha/yr)			
Net production (t/ha/yr) Stem wood, Stem bark, Branches	5.6 + 1.6[c]	5.5 + 1.2[c]	4.2 + 0.5[c]
Net production (t/ha/yr) Fruits etc.			
Net production (t/ha/yr) Foliage	3.6[b]	5.2[b]	2.7[b]
Net production (t/ha/yr) Root estimate	1.9	1.9	2.9

Values given above include understorey shrubs. Nutrient contents were determined.

a. *B. verrucosa* syn. *pendula*.

b. Foliage litterfall.

c. Woody litterfall.

Rodin, L.E. and Bazilevich, N.I. (1967). "Production and Mineral Cycling in Terrestrial Vegetation." Oliver and Boyd, Edinburgh and London. (Quoting Russian authors in their Table 32.)

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ca.45°N 36°E -- U.S.S.R., Crimea.

Brown leached forest soils.

Carpinus betulus, with a few *Fagus sylvatica*. *Quercus* spp. *et al.* with understorey shrubs.

Age (years)		46
Trees/ha		
Tree height (m)		17.0
Basal area (m^2/ha)		
Leaf area index		
Stem volume (m^3/ha)		
Dry biomass (t/ha)	Stem wood	216.3
	Stem bark	
	Branches	
	Fruits etc.	
	Foliage	6.4
	Root estimate	57.6
CAI (m^3/ha/yr)		
Net production (t/ha/yr)	Stem wood	
	Stem bark	
	Branches	
	Fruits etc.	
	Foliage	
	Root estimate	

Values given above include understorey shrubs. Nutrient contents were determined.

Rodin, L.E. and Bazilevich, N.I. (1967). "Production and Mineral Cycling in Terrestrial Vegetation." Oliver and Boyd, Edinburgh and London. (Quoting Russian authors in their Tables 9 and 32.)

U.S.S.R.	ca.52°N 39°E -- Voronezh Province		ca.56°N 30°E -- Velikiye Luki Province
	Populus tremula, *Quercus* spp., *Aegopodium* sp. *et al.*		*P. tremula* (70%)[a], *Betula* spp., *Picea abies* *et al.*
	Grey sandy loams		Peaty podzol
Age (years)	25	50	45-55
Trees/ha			
Tree height (m)	17.0	28.0	(6.6 26.3)[b]
Basal area (m^2/ha)			
Leaf area index			
Stem volume (m^3/ha)			
Dry biomass (t/ha): Stem wood, Stem bark, Branches	147.0	253.0	191.9
Dry biomass (t/ha): Fruits etc.			
Dry biomass (t/ha): Foliage	3.4	4.8	6.1
Dry biomass (t/ha): Root estimate	35.9	47.1	32.9
CAI (m^3/ha/yr)			
Net production (t/ha/yr): Stem wood, Stem bark, Branches	13.5 + 2.0[c]	10.6 + 7.1[c]	5.6 + 2.9[c]
Net production (t/ha/yr): Fruits etc.			
Net production (t/ha/yr): Foliage	3.5[c]	4.7[c]	3.9[c]
Net production (t/ha/yr): Root estimate	3.7	2.1	1.2

Values given above include understorey shrubs. Nutrient contents were determined.
a. Percentage of the total tree number.
b. Heights of the lower and upper storeys.
c. Litterfall.

Safarov, I.S. and Djhalilov, K.G. (1973). Biological productivity of the *Quercus castaneifolia* forests of the Talysh region (Soviet Azerbaijan). *Lesovedenie* 3, 40-46.

Djhalilov, K.G. and Safarov, I.S. (1981). In: "Dynamics of Forest Ecosystems" (D.E. Reichle, ed.), p.625. Cambridge University Press, Cambridge, London, New York, Melbourne.

38°40-50'N 48°30'E (alt. given below) U.S.S.R., Azerbaijan Region.

Subtropical yellow soils.	*Quercus castaneifolia*, *Zelkova carpinifolia*, *Parrotia persica*	*Q. castaneifolia* (50%)[a], *Alnus glutinosa* var. *barbata* (30%)[a], *Ulmus carpinifolia* syn. *nitens* (10%)[a] *et al.*
	450 m	minus 22 m
Age (years)	75-80	50-60
Trees/ha	490	420
Tree height (m)	27.5	22.6
Basal area (m^2/ha)	30.9	
Leaf area index		
Stem volume (m^3/ha)		
Dry biomass (t/ha): Stem wood	292.8	250.0
Dry biomass (t/ha): Stem bark		
Dry biomass (t/ha): Branches	49.7	79.0
Dry biomass (t/ha): Fruits etc.		
Dry biomass (t/ha): Foliage	7.2	8.2
Dry biomass (t/ha): Root estimate		
CAI (m^3/ha/yr)		
Net production (t/ha/yr): Stem wood	0.08[b]	0.07[b]
Net production (t/ha/yr): Stem bark		
Net production (t/ha/yr): Branches	0.91[b]	0.78[b]
Net production (t/ha/yr): Fruits etc.	0.32[b]	0.15[b]
Net production (t/ha/yr): Foliage	3.65[b]	5.67[b]
Net production (t/ha/yr): Root estimate		

a. Percentage of the total tree number.
b. Litterfall only.

Rodin, L.E. and Bazilevich, N.I. (1967). "Production and Mineral Cycling in Terrestrial Vegetation." Oliver and Boyd, Edinburgh and London. (Quoting Russian authors in their Table 32.)

U.S.S.R.	ca.52°N 39°E -- Voronezh Province				ca.45°N 36°E -- Crimea
	Quercus robur (60-90%)[a], *Fraxinus excelsior*, *Acer platanoides*, *et al.*				*Q. robur* with a few *F. excelsior*, *Cornus* sp. *et al.*
	Grey sandy loams.				Brown leached soils.
Age (years)	12	43	48	220	40
Trees/ha					
Tree height (m)	5.0	17.5	23.0	30.0	11.0
Basal area (m^2/ha)					
Leaf area index					
Stem volume (m^3/ha)					
Dry biomass (t/ha) Stem wood, Stem bark, Branches	43.0	104.9	187.0	402.8	118.9
Dry biomass (t/ha) Fruits etc.					
Dry biomass (t/ha) Foliage	3.3	3.8	3.6	3.7	4.1
Dry biomass (t/ha) Root estimate	22.7	45.9	70.2	97.3	31.8
CAI (m^3/ha/yr)					
Net production (t/ha/yr) Stem wood, Stem bark, Branches	1.9+1.1[b]	3.7+2.0[b]	3.6+1.1[b]	2.5+1.8[b]	
Net production (t/ha/yr) Fruits etc.					
Net production (t/ha/yr) Foliage	3.3[b]	3.7[b]	3.6[b]	3.7[b]	
Net production (t/ha/yr) Root estimate	2.2	0.6	1.6	0.3	

Values given above include understorey shrubs. Nutrient contents were determined.
a. Percentage of the total tree number.
b. Litterfall.

Goryshina, T.K. (1981). In: "Dynamic Properties of Forest Ecosystems" (D.E. Reichle, ed.), pp.626-627. Cambridge University Press, Cambridge, London, New York.

Goryshina, T.K. (1974a). Investigations of biological productivity and factors affecting it in the Les na Vorske forest-steppe oak wood. *Ekologija* 3, 5-10.

Goryshina, T.K. (ed.) (1974b). "Biological Productivity and its Factors in the Oaks of the Forest Steppe." Scientific Notes, Series of Biological Science No.367, 2. Leningrad University Press, Leningrad.

50°38'N 35°58'E 200 m U.S.S.R., Belgorod Region, Les na Vorske.

Grey soils.
pH 4.9-6.4

Quercus robur, *Tilia cordata* syn. *parvifolia*, *Acer platanoides* and *Ulmus scabra*, with understorey shrubs.

Age (years)		80	250
Trees/ha		446	557
Tree height (m)		25	31
Basal area (m^2/ha)		25	37
Leaf area index			
Stem volume (m^3/ha)			
Dry biomass (t/ha)	Stem wood	161.2 + 3.4[a]	191.1 + 2.5[a]
	Stem bark	21.7 + 1.5[a]	36.9 + 0.3[a]
	Branches	55.3 + 3.0[a]	67.9 + 3.2[a]
	Fruits etc.		
	Foliage	2.7 + 0.1[a]	3.6 + 0.1[a]
	Root estimate	45.9	91.7
CAI (m^3/ha/yr)			
Net production (t/ha/yr)	Stem wood	2.52 + 0.43[b]	2.37 + 2.20[b]
	Stem bark		
	Branches	1.64 + 0.99[a] + 1.40[c]	1.27 + 0.58[a] + 2.30[c]
	Fruits etc.		
	Foliage	3.56[c]	3.76[c]
	Root estimate		

a. Understorey shrubs.
b. Mortality.
c. Litterfall.

Rodin, L.E. and Bazilevich, N.I. (1967). "Production and Mineral Cycling in Terrestrial Vegetation." Oliver and Boyd, Edinburgh and London. (Quoting Russian authors in their Table 32.)

ca.54°N 45°E -- U.S.S.R., Mordovskaya.

Grey forest sandy loams.

Tilia cordata syn. *parvifolia* with a few *Picea abies*, *Betula* spp. *et al.*

Age (years)		40	74
Trees/ha			
Tree height (m)		18.0	22.6
Basal area (m^2/ha)			
Leaf area index			
Stem volume (m^3/ha)			
Dry biomass (t/ha)	Stem wood, Stem bark, Branches	116.8	165.1
	Fruits etc.		
	Foliage	2.8	4.5
	Root estimate	38.9	55.4
CAI (m^3/ha/yr)			
Net production (t/ha/yr)	Stem wood, Stem bark, Branches	4.9 + 1.6[a]	1.8 + 0.7[a]
	Fruits etc.		
	Foliage	2.9[a]	4.5[a]
	Root estimate	1.8	0.9

Values given above include understorey shrubs. Nutrient contents were determined.
a. Litterfall.

Karpov, V.G. (ed.) (1973). "Structure and Productivity of Spruce Forests of the Southern Taiga." Nauka, Leningrad Branch, Academy of Sciences, Leningrad, USSR.

56°30'N 32°40'E 200 m U.S.S.R., Central Forest Reserve.

Clayed weak podzol, pH 4.0-4.5.

Picea abies

Age (years)		110
Trees/ha		678
Tree height (m)		26.5
Basal area (m^2/ha)		
Leaf area index		9.7
Stem volume (m^3/ha)		
Dry biomass (t/ha)	Stem wood	155.9
	Stem bark	12.6
	Branches	23.5
	Fruits etc.	
	Foliage	12.5
	Root estimate	68.1
CAI (m^3/ha/yr)		
Net production (t/ha/yr)	Stem wood	
	Stem bark	
	Branches	
	Fruits etc.	
	Foliage	
	Root estimate	

Kazimirov, N.I. and Morozova, R.M. (1981). In: "Dynamic Properties of Forest Ecosystems" (D.E. Reichle, ed.), pp.629-645. Cambridge University Press, Cambridge, London, New York and Melbourne.

Kazimirov, N.I. and Morozova, R.M. (1973). "Biological Cycling of Matter in Spruce Forests of Karelia." Nauka, Leningrad Branch, Academy of Sciences, Leningrad, U.S.S.R.

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ca.62°N 34°E 80-200 m U.S.S.R., Karelia.

Humus iron podzols.
pH 4.1-4.4

Picea abies

Age (years)		22	37	45	54
Trees/ha		34800	13750	9240	4820
Tree height (m)		2.6	6.8	8.8	11.1
Basal area (m^2/ha)		10.6	21.9	23.5	24.8
Leaf area index		1.8	3.0	3.2	3.6
Stem volume (m^3/ha)					
Dry biomass (t/ha)	Stem wood	12.4	38.1	51.2	67.2
	Stem bark	1.5	4.2	5.1	5.8
	Branches	6.5	10.6	12.1	14.2
	Fruits etc.				
	Foliage	5.5	9.1	9.8	10.9
	Root estimate	6.2	14.1	15.8	21.6
CAI (m^3/ha/yr)					
Net production (t/ha/yr)	Stem wood	1.05	1.67	1.88	1.98
	Stem bark	0.13 + 0.42[a]	0.18 + 0.84[a]	0.18 + 0.93[a]	0.17 + 1.08[a]
	Branches	0.29 + 0.24[b]	0.24 + 0.36[b]	0.19 + 0.40[b]	0.15 + 0.42[b]
	Fruits etc.				
	Foliage	0.30 + 1.43[b]	0.21 + 2.31[b]	0.14 + 2.51[b]	0.07 + 2.73[b]
	Root estimate	0.52	0.48	0.52	0.53

There was 1.0, 3.4, 4.2 and 5.6 t/ha of standing dead wood in columns left to right.
a. Mortality.
b. Litterfall, omitting consumption.

Continued from p.361.

ca.62°N 34°E 80-200 m U.S.S.R., Karelia.

Picea abies

		Peat pH 6.0	Peat pH 3.6	Sandy podzol pH 4.4	Sandy podzol pH 4.6
Age (years)		41	42	43	38
Trees/ha		9930	9410	6310	4480
Tree height (m)		6.7	5.8	9.8	12.2
Basal area (m^2/ha)		17.7	14.8	23.2	25.4
Leaf area index		2.4	2.0	4.3	4.4
Stem volume (m^3/ha)					
Dry biomass (t/ha)	Stem wood	23.4	18.7	53.2	60.1
	Stem bark	2.6	2.3	5.3	5.2
	Branches	8.2	7.0	12.5	12.2
	Fruits etc.				
	Foliage	7.5	6.5	9.5	9.9
	Root estimate	9.5	8.0	16.8	18.3
CAI (m^3/ha/yr)					
Net production (t/ha/yr)	Stem wood	1.22	1.07	2.11	2.27
	Stem bark	0.15 + 0.75[a]	0.13 + 0.59[a]	0.23 + 1.26[a]	0.23 + 1.51[a]
	Branches	0.16 + 0.26[b]	0.14 + 0.21[b]	0.25 + 0.40[b]	0.27 + 0.45[b]
	Fruits etc.				
	Foliage	0.11 + 1.81[b]	0.10 + 1.51[b]	0.15 + 2.85[b]	0.16 + 3.12[b]
	Root estimate	0.53	0.29	0.53	0.61

There was 3.4, 2.7, 6.2 and 6.9 t/ha of standing dead wood in columns left to right.

a. Mortality.

b. Litterfall, omitting consumption.

Continued from p.362.

ca.62°N 34°E 80-200 m U.S.S.R., Karelia.

Picea abies

		Eluvium debris pH 3.3	Humus iron podzols pH 4.2	Humus iron podzols pH 3.8	Humus iron podzols pH 4.3
Age (years)		37	39	45	68
Trees/ha		9010	9980	9620	2336
Tree height (m)		4.2	7.8	6.9	14.2
Basal area (m^2/ha)		13.3	20.6	17.9	29.9
Leaf area index		1.8	3.4	2.6	3.8
Stem volume (m^3/ha)					
Dry biomass (t/ha)	Stem wood	14.5	43.4	25.8	98.6
	Stem bark	2.0	4.8	3.2	7.4
	Branches	6.1	11.2	8.7	15.1
	Fruits etc.				0.1
	Foliage	5.7	10.2	8.2	11.5
	Root estimate	6.6	14.6	10.1	29.1
CAI (m^3/ha/yr)					
Net production (t/ha/yr)	Stem wood	0.83 + 0.42[a]	1.84 + 1.16[a]	1.34 + 0.81[a]	1.89 + 1.12[a]
	Stem bark	0.11 + 0.16[b]	0.21 + 0.38[b]	0.17 + 0.29[b]	0.15 + 0.41[b]
	Branches	0.12	0.22	0.17	0.09
	Fruits etc.				0.01
	Foliage	0.08 + 1.40[b]	0.17 + 2.61[b]	0.13 + 2.20[b]	0.00 + 2.86[b]
	Root estimate	0.27	0.48	0.36	0.50

There was 2.0, 5.3, 3.7 and 6.9 t/ha of standing dead wood in columns left to right.

a. Mortality.

b. Litterfall, omitting consumption.

Continued from p.363.

ca.62°N 34°E 110-140 m U.S.S.R., Karelia.

Humus iron podzols.
pH 3.8-4.1

Picea abies

Age (years)		82	98	109	126	138
Trees/ha		1898	1319	1080	856	1087
Tree height (m)		17.1	19.6	20.0	22.6	22.8
Basal area (m^2/ha)		32.3	33.1	38.9	40.5	38.0
Leaf area index		3.8	3.6	3.2	2.7	2.4
Stem volume (m^3/ha)						
Dry biomass (t/ha)	Stem wood	109.0	149.0	156.4	174.9	167.9
	Stem bark	7.0	8.9	8.6	9.0	8.1
	Branches	16.8	16.5	17.6	16.6	17.1
	Fruits etc.	0.3	0.4	0.4	0.5	0.4
	Foliage	11.4	10.8	9.7	8.1	7.4
	Root estimate	33.2	41.0	45.0	46.0	47.5
CAI (m^3/ha/yr)						
Net production (t/ha/yr)	Stem wood	1.63	1.29	0.92	0.39	0.05
	Stem bark	0.11 +1.17[a] +0.36[b]	0.07 +1.06[a] +0.26[b]	0.05 +0.89[a] +0.25[b]	0.03 +0.87[a] +0.14[b]	0.00 +0.91[a] +0.10[b]
	Branches	0.06	0.04	0.02	0.01	0.01
	Fruits etc.	0.00	0.01	0.00	0.00	0.00
	Foliage	−0.02+2.88[b]	−0.04+2.63[b]	−0.05+2.48[b]	−0.06+2.25[b]	−0.08+2.17[b]
	Root estimate	0.42	0.25	0.15	0.06	0.02

There was 8.1, 8.0, 7.1, 7.1 and 7.4 t/ha of standing dead wood in columns left to right.
a. Mortality.
b. Litterfall, omitting consumption.

Rodin, L.E. and Bazilevich, N.I. (1967). "Production and Mineral Cycling in Terrestrial Vegetation." Oliver and Boyd, Edinburgh and London. (Quoting Russian authors in their Table 9).

ca.56°N 30°E -- U.S.S.R., Velikiye Luki Province.

		Picea abies, with *Populus* spp. and *Betula* spp.	*P. abies* with understorey shrubs.
		Podzolized loams.	Peaty podzol.
Age (years)		110	72	83
Trees/ha				
Tree height (m)		(9.2 19.2)[b]	22.0	26.9
Basal area (m^2/ha)				
Leaf area index				
Stem volume (m^3/ha)				
Dry biomass (t/ha)	Stem wood	182.3	214.7	260.9
	Stem bark			
	Branches			
	Fruits etc.			
	Foliage	14.9	11.5	19.4
	Root estimate	76.6	64.6	77.6
CAI (m^3/ha/yr)				
Net production (t/ha/yr)	Stem wood	2.3 + 1.1[c]	7.2 + 2.0[c]	3.3 + 2.3[c]
	Stem bark			
	Branches			
	Fruits etc.			
	Foliage	3.2[c]	1.3[c]	2.8[c]
	Root estimate	1.2	0.4	1.3

Values given above include understorey shrubs. Nutrient contents were determined.
a. Percentage of the total tree number.
b. Heights of lower and upper storeys.
c. Litterfall.

Rodin, L.E. and Bazilevich, N.I. (1967). "Production and Mineral Cycling in Terrestrial Vegetation." Oliver and Boyd, Edinburgh and London. (Quoting Russian authors in their Table 9).

Marchenko, A.N. and Karlov, Ye.M. (1962). Mineral exchange in spruce forests of the northern taiga and forest tundra in Arkhangelsk oblast. *Soviet Soil Sci.* 7, 722-734.

U.S.S.R.	ca.68°N 34°E — Kola Peninsula	ca.65°N 47°E — Arkhangelsk Region		ca.59°N 40°E — Vologda Province
	Picea abies (70%)[a] *Betula* spp. (20%)[a] *et al.*	*P. abies*	*P. abies* *Betula* spp. *et al.*	*P. abies* (90%)[a] *Betula* spp.
	Humus-iron podzol.	Poor site.	Sandy, silt podzol.	Poor peaty gley.
Age (years)	120	125	200	130
Trees/ha		1050	700	
Tree height (m)	10.9	15.0	30–32	17.6
Basal area (m^2/ha)				
Leaf area index				
Stem volume (m^3/ha)				
Dry biomass (t/ha) Stem wood	35.5	97.8+1.4[b]	188.6	118.9
Dry biomass (t/ha) Stem bark			12.4	
Dry biomass (t/ha) Branches		21.3+0.7[b]	33.6	
Dry biomass (t/ha) Fruits etc.		0.7		
Dry biomass (t/ha) Foliage	4.5	7.3+0.3[b]	16.3+4.8[b]	12.3
Dry biomass (t/ha) Root estimate	11.3	40.7	85.1	65.7
CAI (m^3/ha/yr)				
Net production (t/ha/yr) Stem wood	0.5[c]	1.1+0.9[c]	3.2+1.8[c]	1.8+1.3[c]
Net production (t/ha/yr) Stem bark				
Net production (t/ha/yr) Branches				
Net production (t/ha/yr) Fruits etc.				
Net production (t/ha/yr) Foliage	1.3[d]	4.3	3.3	2.2
Net production (t/ha/yr) Root estimate		0.6	1.4	1.4

Values in the third column from the left are from Marchenko and Karlov (1962). Nutrient contents were determined.

a. Percentage of the total tree number.

b. Understorey shrubs; other biomass and production values in this table include the understorey shrubs.

c. Woody litterfall.

d. Foliage litterfall; foliage litterfall in the other columns was 2.7, 2.8 and 2.0 t/ha/yr left to right.

Kolli, R. and Kahrik, R. (1970). Phytomass and net primary production in the forests of the *Fragaria - Hepatica* type. *Trans. Estonian Agric. Acad. Soil Regimes and Processes (Sbornik nauctnykh trudov Estonskoi Selskokhozyaistvenov)* 65, 69-91.

ca.58°N 25-30°E -- U.S.S.R., Estonia.

		Mihkli. *Picea abies* (88%)[a] *Quercus robur* (7%)[a] *Betula* spp. *et al.*	Kaarma. *P. abies* (66%)[a] *Alnus incana* (23%)[a] *Betula* spp. *et al.*
Age (years)		84	51
Trees/ha		538 + 70	724 + 376
Tree height (m)		23.7	17.5
Basal area (m^2/ha)			
Leaf area index			
Stem volume (m^3/ha)		249 + 38	201 + 39
Dry biomass (t/ha)	Stem wood	104.6 + 15.4	78.4 + 16.5
	Stem bark	8.1 + 2.0	7.1 + 3.5
	Branches	23.2 + 3.4 + 4.6[b]	20.7 + 3.9 + 3.6[b]
	Fruits etc.	0.2	0.3
	Foliage	13.5 + 0.3	11.0 + 0.7
	Root estimate	64.6	45.8
CAI (m^3/ha/yr)			
Net production (t/ha/yr)	Stem wood	2.45 + 0.35	3.01 + 1.10
	Stem bark	0.18 + 0.05	0.29 + 0.23
	Branches	2.11 + 0.18	2.31 + 0.66
	Fruits etc.	0.23	0.26
	Foliage	2.82 + 0.28	2.70 + 0.72
	Root estimate	5.06	4.49

Values are given above for *P. abies* plus broadleaved trees (left and right, respectively, in each column). There was 5.1 and 3.8 t/ha of dead branches in columns left and right, respectively.

a. Percentage of the total tree number.

b. Understorey shrubs.

c. Including estimated woody litterfall.

Dylis, N. (1971). Primary production of mixed forests. In: "Productivity of Forest Ecosystems" (P. Duvigneaud, ed.), pp.227-230. UNESCO, Paris.

ca.55°00'N 37°30'E 150 m U.S.S.R., S. of Moscow, Pakhra River.

Well-drained podzolic soils.

Picea abies (75%)[a], *Betula pubescens*, *Quercus* spp. and *Populus* spp.

Thinned at various ages.

Age (years)		85
Trees/ha		
Tree height (m)		24
Basal area (m^2/ha)		
Leaf area index		
Stem volume (m^3/ha)		
Dry biomass (t/ha)	Stem wood	176.1
	Stem bark	
	Branches	23.9[b]
	Fruits etc.	17.4[c]
	Foliage	
	Root estimate	63.4
CAI (m^3/ha/yr)		
Net production (t/ha/yr)	Stem wood	6.19[d]
	Stem bark	
	Branches	1.47[d]
	Fruits etc.	0.23
	Foliage	3.08[e]
	Root estimate	

Three trees of average dimensions were sampled per species and their roots were excavated. Stand values were obtained by multiplying mean tree values by the numbers of trees per hectare.

a. Percentage of the total stem biomass.
b. Including dead branches.
c. Including scales, fruits and other green parts as well as the foliage.
d. Excluding woody litterfall and any mortality.
e. New foliage biomass.

Rodin, L.E. and Bazilevich, N.I. (1967). "Production and Mineral Cycling in Terrestrial Vegetation." Oliver and Boyd, Edinburgh and London. (Quoting Russian authors in their Table 9).

U.S.S.R.	ca.68°N 34°E -- Kola Peninsula. *Pinus sylvestris* (60%)[a] *Betula* spp. and *Picea abies*	ca.54°N 45°E -- Mordovskaya ASSR. *P. sylvestris*	59°N 77°E -- Vasyuganye swamp, W. Siberia. *P. sylvestris*
	Peaty humus podzol	Good site	Upland moss bog
Age (years)	100	71	100
Trees/ha			
Tree height (m)	7.8	24.1	5.0
Basal area (m^2/ha)			
Leaf area index			
Stem volume (m^3/ha)			
Dry biomass (t/ha) Stem wood, Stem bark, Branches	56.7	202.4	17.9
Dry biomass (t/ha) Fruits etc.			
Dry biomass (t/ha) Foliage	6.2	13.9	15.1
Dry biomass (t/ha) Root estimate	17.8	63.6	4.0
CAI (m^3/ha/yr)			
Net production (t/ha/yr) Stem wood, Stem bark, Branches	0.7[b]	2.8 + 2.2[b]	0.2 + 0.1[b]
Net production (t/ha/yr) Fruits etc.			
Net production (t/ha/yr) Foliage	2.3[c]	2.4	3.2
Net production (t/ha/yr) Root estimate		0.9	0.1

Values given above include understorey shrubs. Nutrient contents were determined.

a. Percentage of the total tree number.

b. Woody litterfall.

c. Foliage litterfall; foliage litterfall in the other two columns was 2.1 and 2.3 t/ha/yr left and right, respectively.

Klinge, H. (1978). Studies on the ecology of Amazon caatinga forest in southern Venezuela. *Acta cient. venez.* 29, 258-262.

Herrera, R. and Klinge, H. (1981). Phytomass of tall Amazon caatinga forest near San Carlos de Rio Negro, south Venezuela. *Vegetatio* (in press).

Klinge, H. and Herrera, R. (1978). Biomass studies in Amazon caatinga forest in southern Venezuela. I Standing crop of composite root mass in selected stands. *Trop. Ecol.* 19, 93-110.

1°54'N 67°06'W 50-100 m Venezuela, near San Carlos de Rio Negro.

Infertile podzols.

Micranda spruceana, *Eperua leucantha* and about 130 other species.

	Blackwater Creek					
	72%[a]	43%[a]	54%[a]	66%[a]	19%[a]	16%[a]
Age (years)						
Trees/ha	5600[b]	6200[b]	9400[b]	9700[b]	14300[b]	13400[b]
Tree height (m)	20.1	18.6	14.1	13.6	14.8	16.1
Basal area (m^2/ha)	36.7[b]	72.9[b]	34.3[b]	34.1[b]	16.1[b]	25.5[b]
Leaf area index	4.4	9.5	5.8	5.4	3.1	5.7
Stem volume (m^3/ha)	403[b]	677[b]	241[b]	263[b]	84[b]	200[b]
Dry biomass (t/ha) Stem wood + Stem bark	178	379	107	154	52	184
Dry biomass (t/ha) Branches	112	215	74	80	52	74
Dry biomass (t/ha) Fruits etc.						
Dry biomass (t/ha) Foliage	4.8 (7)[c]	14.7 (15)[c]	5.3 (9)[c]	8.6 (8)[c]	4.5 (5)[c]	5
Dry biomass (t/ha) Root estimate	71	141	42	101	91	115
CAI (m^3/ha/yr)						
Net production (t/ha/yr) Stem wood						
Net production (t/ha/yr) Stem bark						
Net production (t/ha/yr) Branches						
Net production (t/ha/yr) Fruits etc.						
Net production (t/ha/yr) Foliage						
Net production (t/ha/yr) Root estimate						

The fresh weights of all vegetation, including 'extractable' roots, were determined in each of the above 100 m^2 plots. Six hundred and fifty-one individuals were sampled for dry weight and nutrient determinations. Stand dry biomass values were derived from regressions on D. There was 8.2, 6.5, 1.9, 14.8, 12.6 and 37.0 t/ha of standing dead wood in columns left to right. Nutrient contents were determined.

a. Percentage of the total biomass accounted for by *M. spruceana*.

b. Stems over 1 cm D, which accounted for over 95% of the total biomass.

c. Values in brackets are the total leaf biomass values of woody plus herbaceous vegetation; the unbracketed values refer to the trees only.

Continued from p.370.

Same as p.370.

	57%[a]	13%[a]	20%[a]	46%[a]	10%[a]	33%[a]	Bana woodland 0.1%[a]
Age (years)							
Trees/ha	15800[b]	11700[b]	10300[b]	10700[b]	10600[b]	13300[b]	17500[b]
Tree height (m)	16.0	16.9	16.4	15.9	19.2	15.5	10.1
Basal area (m^2/ha)	22.0[b]	50.7[b]	33.0[b]	40.0[b]	59.5[b]	33.6[b]	21.8[b]
Leaf area index	2.8	9.8	3.9	4.7	4.6	3.2	3.0
Stem volume (m^3/ha)	181[b]	419[b]	221[b]	292[b]	221[b]	200[b]	70[b]
Dry biomass (t/ha) Stem wood + Stem bark	108	263	96	183	276	107	58
Dry biomass (t/ha) Branches	72	256	81	91	166	56	32
Dry biomass (t/ha) Fruits etc.							
Dry biomass (t/ha) Foliage	4.6(5)[c]	14.7(17)[c]	7.3(7)[c]	6.5(10)[c]	7.5(8)[c]	5.5(5)[c]	5.0(5)[c]
Dry biomass (t/ha) Root estimate	173	336	172	83	195	92	142
CAI (m^3/ha/yr)							
Net production (t/ha/yr) Stem wood							
Net production (t/ha/yr) Stem bark							
Net production (t/ha/yr) Branches							
Net production (t/ha/yr) Fruits etc.							
Net production (t/ha/yr) Foliage							
Net production (t/ha/yr) Root estimate							

Same as p.370, except

There was 10.3, 16.1, 4.9, 5.3, 19.9, 22.2 and 10.9 t/ha of standing dead wood in columns left to right.

Jordan, C.F. and Uhl, C. (1978). Biomass of a 'terra firma' forest of the Amazon basin. *Oecologia Plant.* 13, 387-400.

Stark, N. and Spratt, M. (1977). Root biomass and nutrient storage in rainforest oxisols near San Carlos de Rio Negro. *Trop. Ecol.* 18, 1-9.

Jordan, C.F. and Escalante, G. (1980). Root productivity in an Amazonian rainforest. *Ecology* 61, 14-18.

1°54'N 67°06'W 50-100 m Venezuela, Amazonas, near San Carlos de Rio Negro.

Infertile, leached unflooded, sandy lateritic soil.

Tropical rainforest.

Age (years)		Mature
Trees/ha		1760 + 9457[a]
Tree height (m)		ca.14
Basal area (m^2/ha)		34.3
Leaf area index		5.2
Stem volume (m^3/ha)		
Dry biomass (t/ha)	Stem wood, Stem bark, Branches	315.7[b]
	Fruits etc.	
	Foliage	8.0
	Root estimate	56.0
CAI (m^3/ha/yr)		
Net production (t/ha/yr)	Stem wood, Stem bark, Branches	6.00 + 3.40[c]
	Fruits etc.	
	Foliage	6.00[c]
	Root estimate	>2.01[d] (16.80)[e]

Forty-two trees of 28 species were sampled, ignoring a few lianes, and stand biomass values for four plots of 0.5 to 1.0 ha were derived from regressions on D^2H. Values given above are for the authors' plot 1. Roots were excavated in 18 pits in two plots. There was 2 to 8 t/ha of standing dead wood (8.3 t/ha in plot 1).

a. Trees under 5 cm D.
b. Including 30.6 t/ha of bark.
c. Litterfall, measured over 3 years.
d. Increment of surface roots only.
e. Estimated total root increment plus root death.

Bartholomew, W.V., Meyer, J. and Laudelout, H. (1953). "Mineral Nutrient Immobilization under Forest and Grass Fallow in the Yangambi (Belgian Congo) Region, with some Preliminary Results on the Decomposition of Plant Material on the Forest Floor." Publs Inst. natn. Etude agron. Congo belge Sér. Sci. No.57.

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ca.0°50'N 24°25'E 200–500 m Zaire, near Kisangani, Yangambi region.

Musanga cecropioides, et al.

Regeneration after clear-felling and burning.

Age (years)		5	8	17 to 18
Trees/ha				
Tree height (m)				
Basal area (m^2/ha)				
Leaf area index				
Stem volume (m^3/ha)				
Dry biomass (t/ha)	Stem wood, Stem bark, Branches	71.1	116.3	114.6
	Fruits etc.			
	Foliage	5.6	5.4	6.4
	Root estimate	25.8	22.8	31.2
CAI (m^3/ha/yr)				
Net production (t/ha/yr)	Stem wood, Stem bark, Branches	14.5[a]	15.1[a] + 14.2[b]	
	Fruits etc.			
	Foliage			
	Root estimate			

All vegetation was harvested and weighed in an area of 300 m^2 at each of the three sites, and root samples were taken at random. Values given above include understorey shrubs, but exclude dead wood which was not weighed.

a. Wood increment, excluding litterfall.

b. Estimated total litterfall.

Malaisse, F., Alexandre, J., Freson, R., Goffinet, G. and Malaisse-Mousset, M. (1972). The miombo ecosystem; a preliminary survey. In: "Tropical Ecology with an Emphasis on Organic Productivity" (P.M. Golley and F.B. Golley, eds), pp.363-403. Institute of Ecology, University of Georgia, Athens, Georgia, U.S.A.

Malaisse, F. (1981). In: "Dynamic Properties of Forest Ecosystems" (D.E. Reichle, ed.), p.672. Cambridge University Press, Cambridge, London, New York, Melbourne.

11°37'S 27°29'E 1244 m Zaire, Luanza, Kasapa.

Latosol, pH 5.0.

Brachystegia boehmii, Pterocarpus angolensis, Marquesia macroura, et al.

Miombo woodland

Age (years)		120
Trees/ha		446
Tree height (m)		14 to 18
Basal area (m^2/ha)		22.0[a]
Leaf area index		3.5
Stem volume (m^3/ha)		
Dry biomass (t/ha)	Stem wood	52.8
	Stem bark	10.7
	Branches	78.2
	Fruits etc.	0.5
	Foliage	2.6
	Root estimate	25.5
CAI (m^3/ha/yr)		
Net production (t/ha/yr)	Stem wood	0.89[b] (or 0.53)[c]
	Stem bark	
	Branches	(or 0.65)[c]
	Fruits etc.	0.19[b] (or 0.54)[c]
	Foliage	2.98[b] (or 4.26)[c]
	Root estimate	

The biomass of all vegetation was measured in one 625 m^2 clear-felled plot. There was 24.7 t/ha of standing dead wood.

a. The mean basal area of the Kasapa miombo as a whole was 12.7 m^2/ha.

b. Litterfall only, measured over 3 years, from Malaisse *et al.* (1972).

c. Litterfall plus decomposition and other losses given by Malaisse (1981).

Guy, P.R. (1981). Changes in the biomass and productivity of woodlands in the Sengwa wildlife research area, Zimbabwe. *J. appl. Ecol.* 18, 507-519.

18°10'S 28°14'E ca.1200 m Zimbabwe, Sengwa Wildlife Research Area.

Sandy soils.

	Miombo woodland.	Riverine woodlands.		Mopane woodland.
	Julbernardia globiflora, Brachystegia boehmii, et al.	*Acacia, Combretum, Diospyros, et al.*	*Acacia albida*	*Colophospermum mopane, et al.*
Age (years)				
Trees/ha	321	49	30	542
Tree height (m)				
Basal area (m^2/ha)	9.2	4.9	9.8	23.3
Leaf area index				
Stem volume (m^3/ha)				
Dry biomass (t/ha): Stem wood, Stem bark, Branches, Fruits etc., Foliage	21.9 + 1.2[a]	19.8 + 3.7[a]	52.2 + 0.0[a]	64.5 + 1.3[a]
Root estimate				
CAI (m^3/ha/yr)				
Net production (t/ha/yr): Stem wood, Stem bark, Branches, Fruits etc., Foliage	0.45 + 0.07[a]	0.26 + 0.19[a]	0.47 + 0.05[a]	1.21 + 0.07[a]
Root estimate				

Biomass values were derived from regression on D for trees measured along 68 transects in 1972. Tree numbers refer to those over 6 cm D or 3 m height. Basal areas were measured above the basal swelling.
These stands were grazed by elephants, and smaller biomass and production values were recorded for 1974 and 1976; values for undisturbed miombo woodlands are given by Malaisse *et al.* (1972) (see p.374).
a. Understorey shrubs.