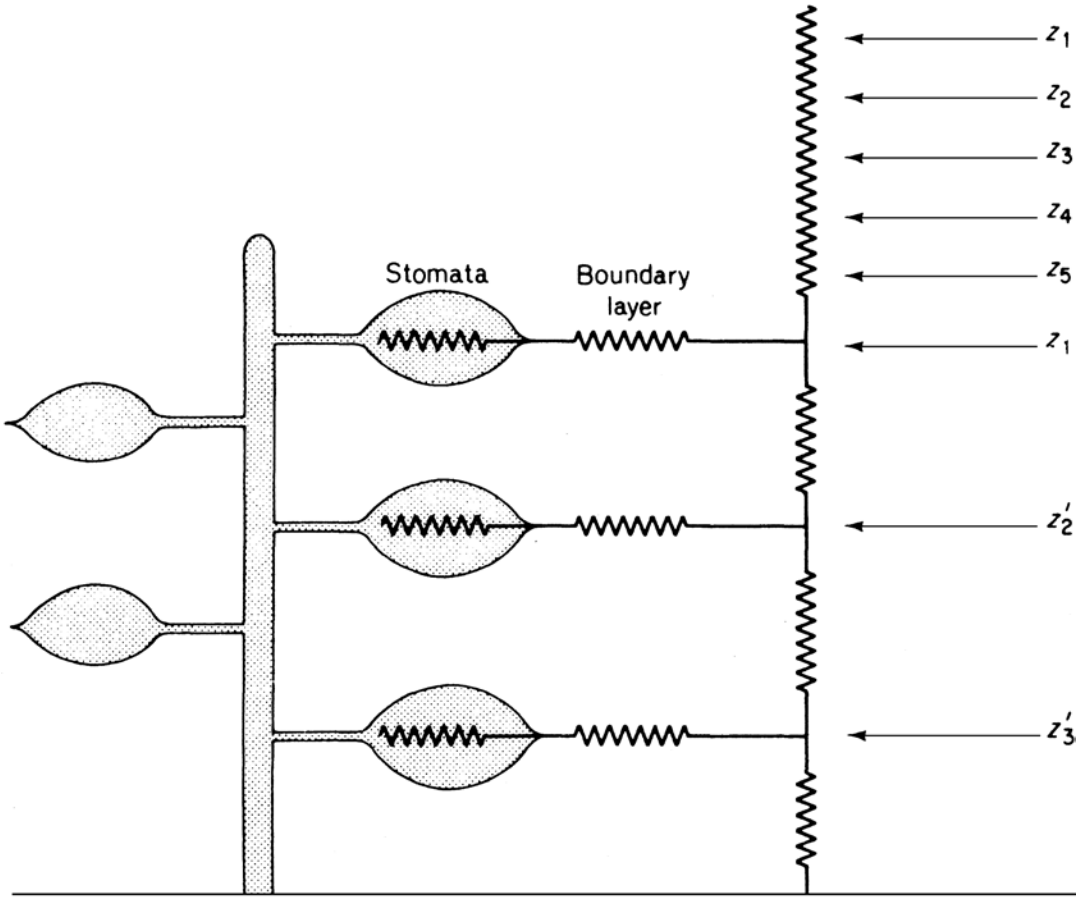

Figure 17.1 Resistance model for a plant in a stand of vegetation.

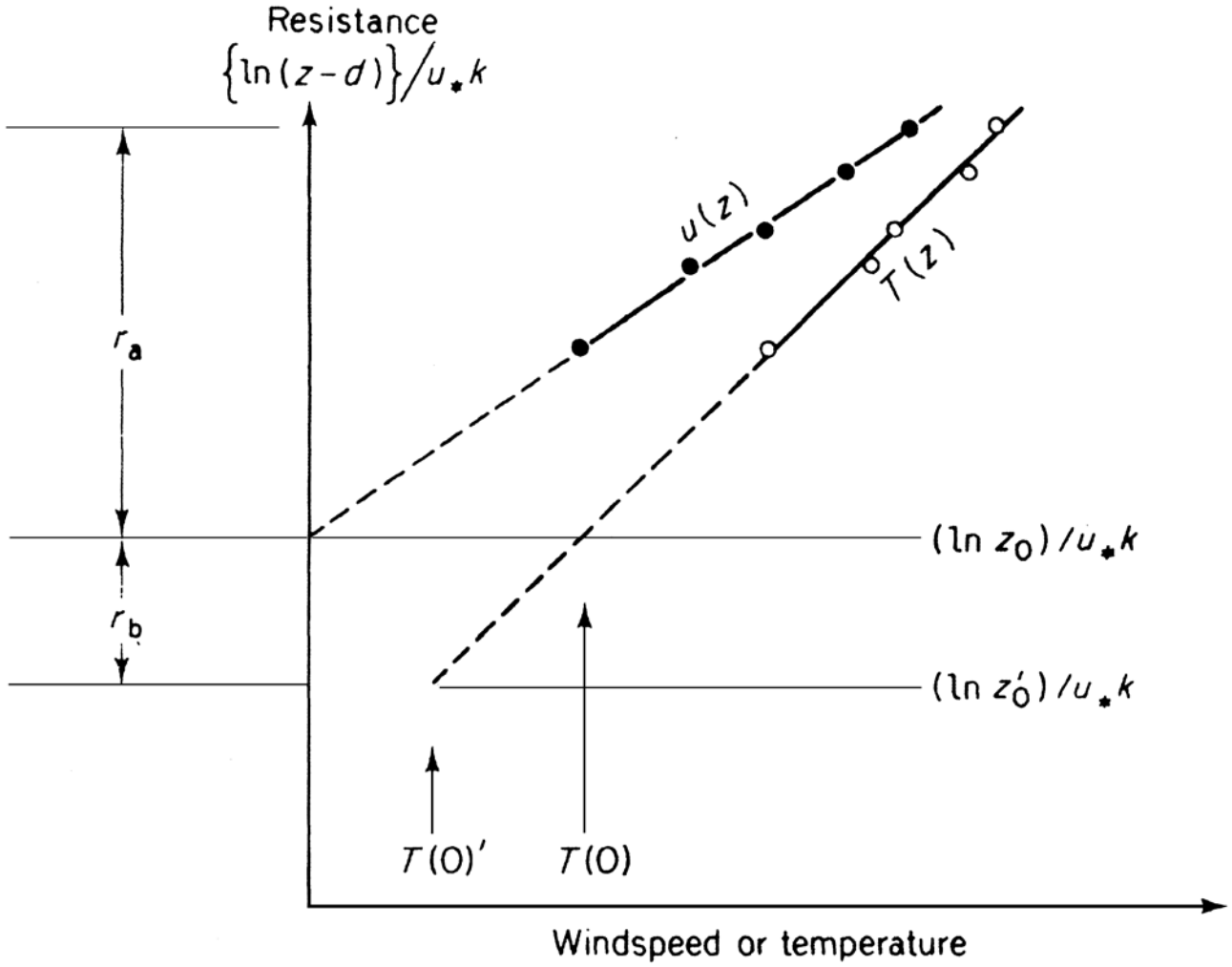

Figure 17.2 Diagram showing how T (0) and T (0)' are determined by plotting temperature against [ln $(z - d)/u_* k$. T (0) is the value of temperature extrapolated to $z - d = z_0$ and T (0)' is the value extrapolated to $z - d = z_0'$. The significance of r_a and r_b is shown on the left-hand axis and is discussed on pp. 324–325.

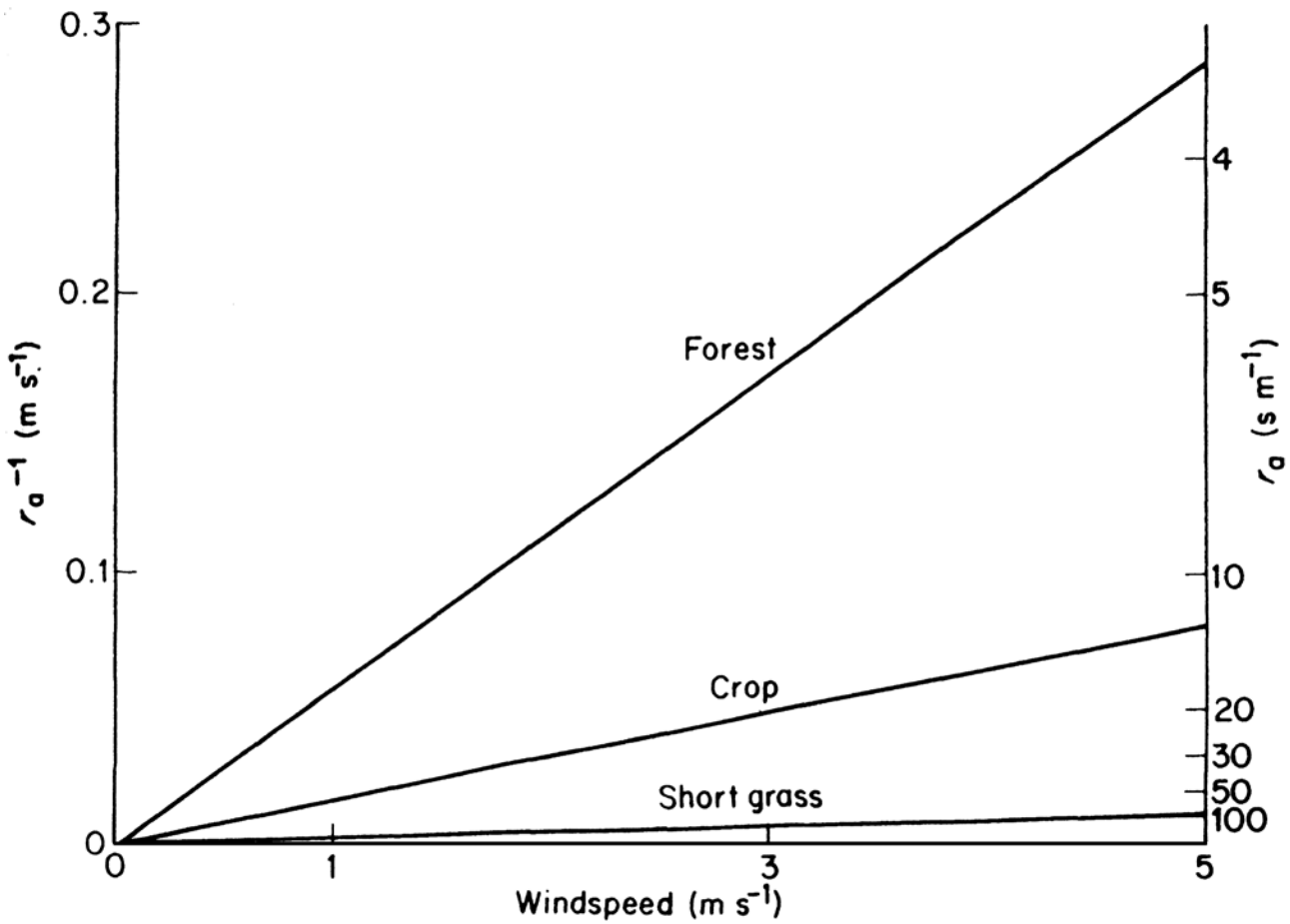

Figure 17.3 Calculated values (from Eq. (17.5)) of resistance r_a in relation to windspeed over surfaces with roughnesses characteristic of: short grass *(z_0* = 1 mm*, d* = 7 mm*)*; cereal crop *(z_0* = 0.2 m*, d* = 0.95 m*)*; and forest *(z_0* = 0.9 m*, d* = 11.8 m*)*. Windspeeds are referred to a standard height $z - d$ = 5 m for each surface.

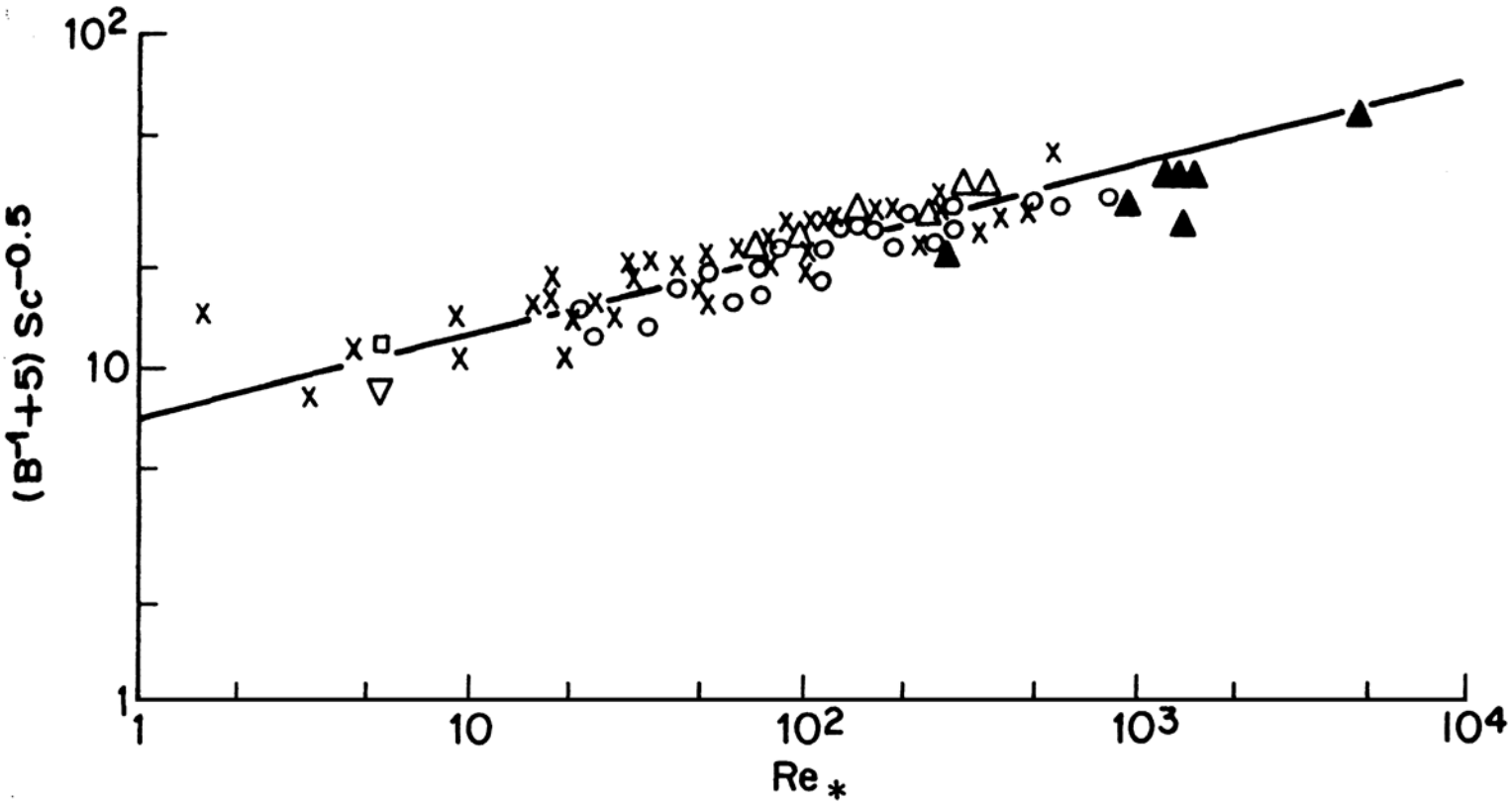

Figure 17.4 Diffusive transport to rough surfaces (from Chamberlain et al., 1984). Symbols refer to different surface structures, vapors, and particles: 212Pb vapor ▽,△, x; ^{123}I vapor ▲ ; water vapor ○; Aitken nuclei *(r* = 0.08 μm*)* □. The straight line has slope 0.25 and intercept 7.3. Re_* is the roughness Reynolds number $u_* z_0/\nu$ and Sc is the Schmidt number ν/D.

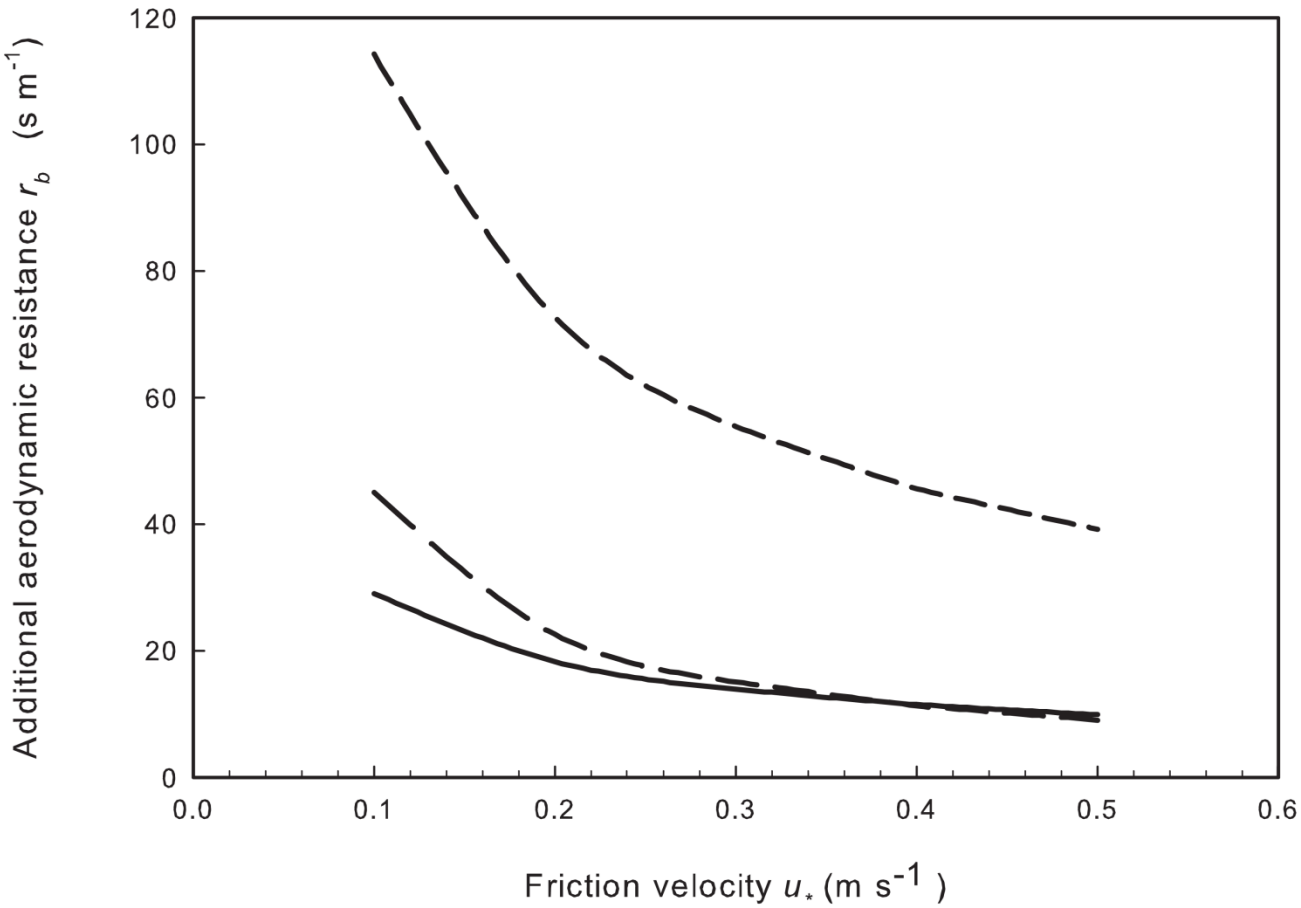

Figure 17.5 The dependence of the additional resistance r_b on friction velocity u_* (i) for vegetation canopies according to Thom (Eq. (17.8), ———), and Wesley and Hicks (Eq. (17.9), —— —) and (ii) for rigid rough surfaces according to Chamberlain (Eq. (17.10), – – –).

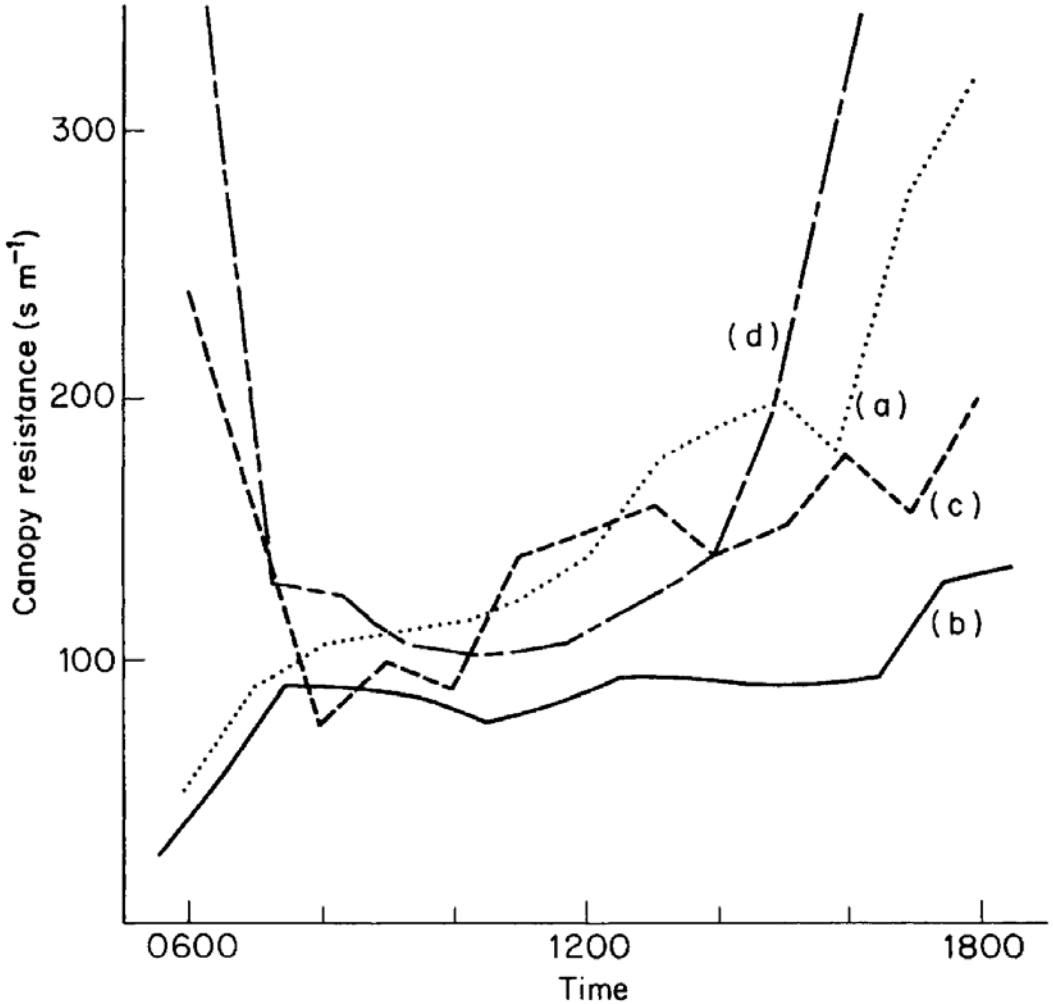

Figure 17.6 Diurnal variation of the canopy resistance of forests (after Jarvis et al., 1976): (a) Scots pine (*Pinus sylvestris*), Thetford,UK(Stewart and Thom, 1973), (b) Sitka spruce (*Picea sitchensis*), Fetteresso, UK (Jarvis et al., 1976), (c) Douglas fir (*Pseudotsuga menziesii*), British Columbia (McNaughton and Black, 1973), and (d) Amazonian forest, Brazil (Shuttleworth et al., 1984).

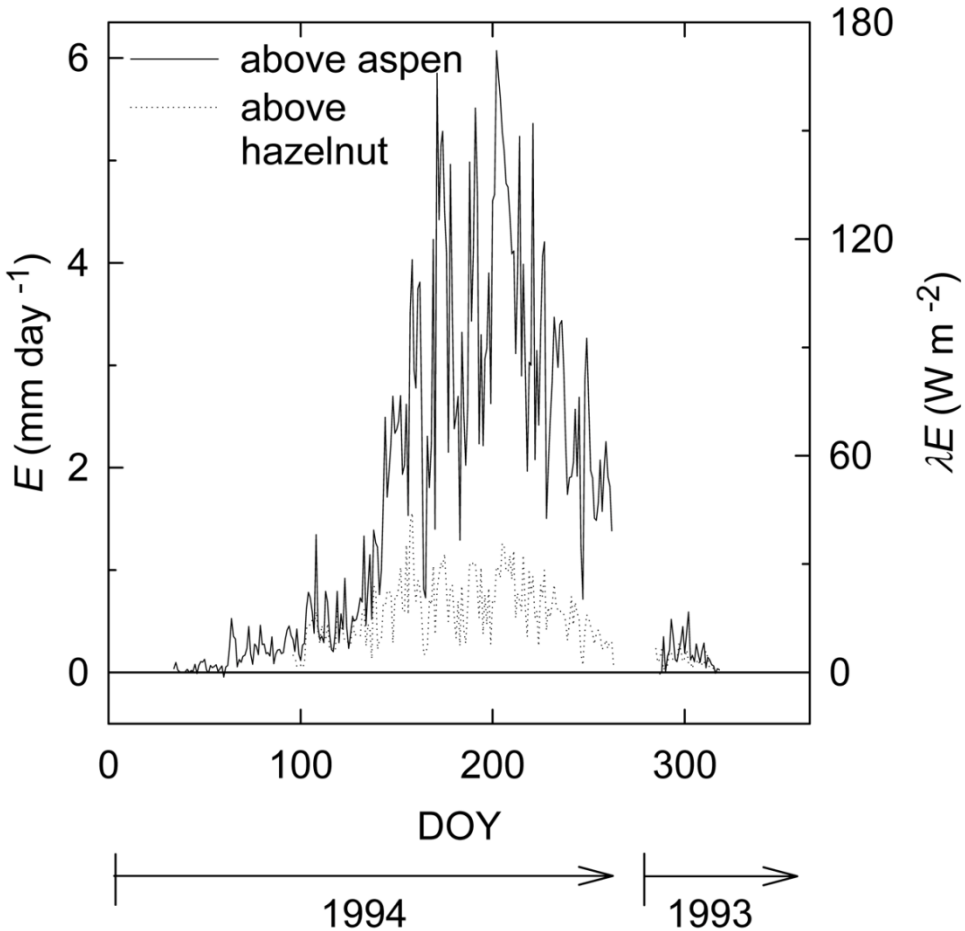

Figure 17.7 (a) Comparison of daily average evaporation rates and latent heat fluxes measured using eddy covariance techniques above an aspen over-storey and above a hazelnut under-storey. (from Black et al., 1996).

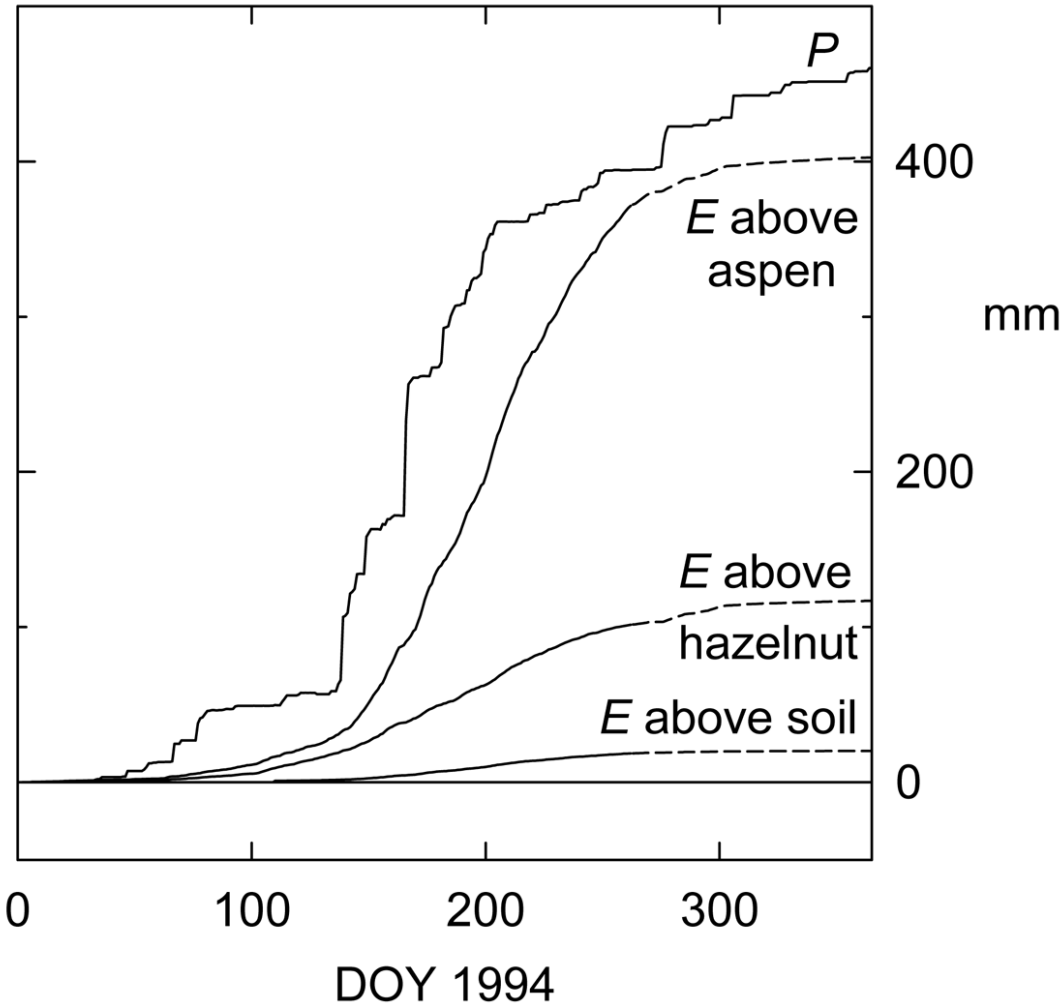

Figure 17.7 (b) Cumulative evaporation (E) over a year above an aspen over-storey, above a hazelnut under-storey, and above the soil surface. The dashed sections are estimated. Also shown is the cumulative precipitation *P* (from Black et al., 1996).

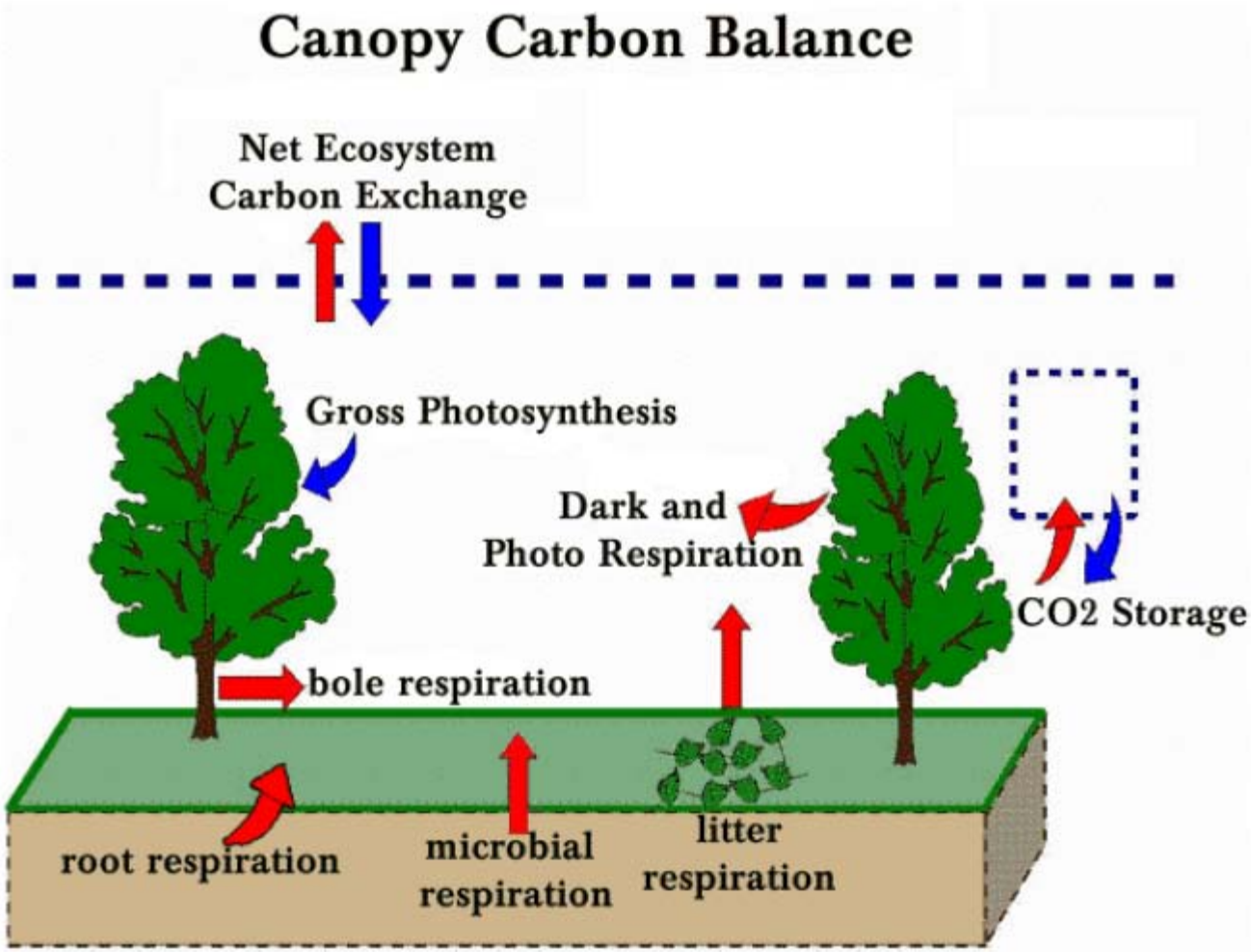

Figure 17.8 Schematic diagram of the main components of the carbon exchange between vegetation and the atmosphere (courtesy of Dr. D. Baldocchi).

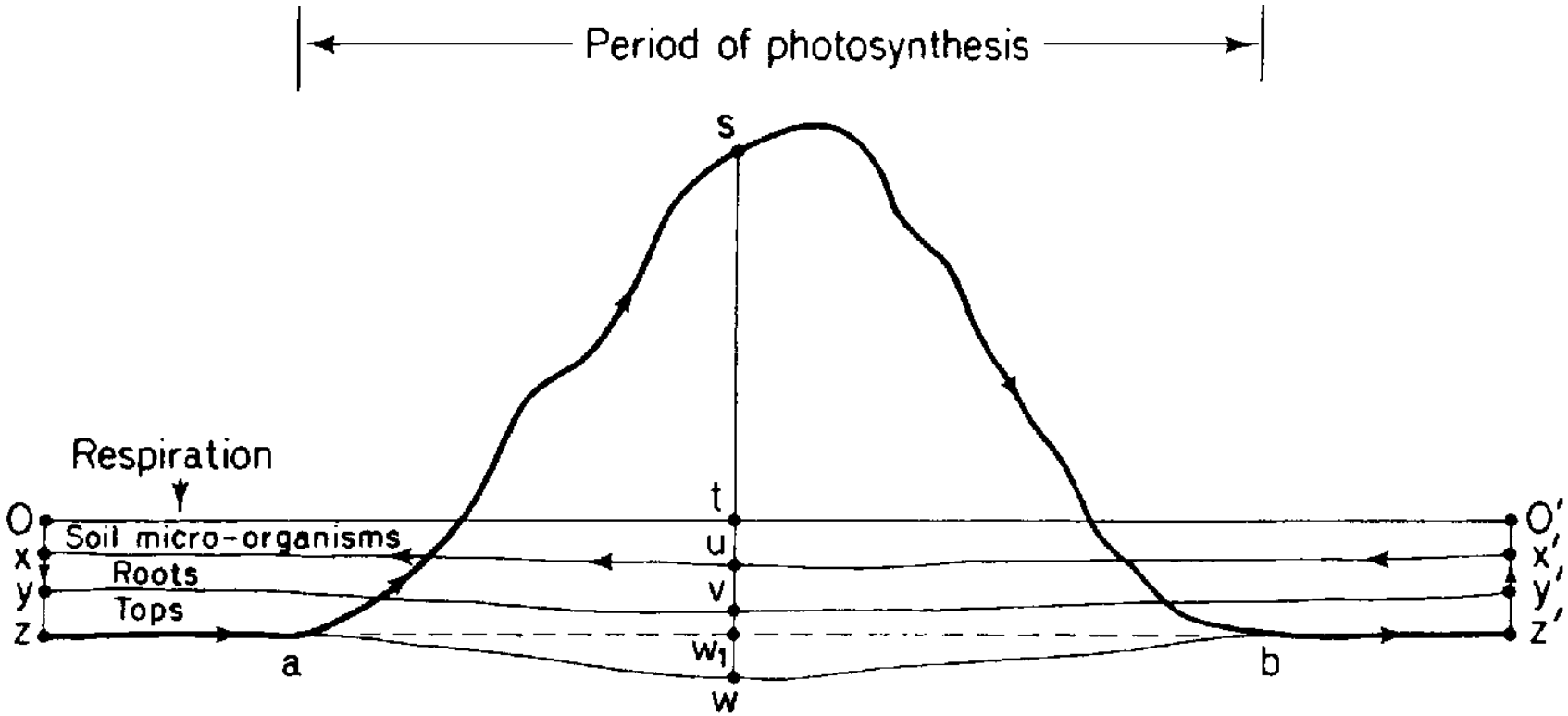

Figure 17.9 The diurnal change of CO_2 flux above a stand of vegetation, shown by the bold line Zasbz'. The axis of zero flux is OO'. For explanation of other components, see text.

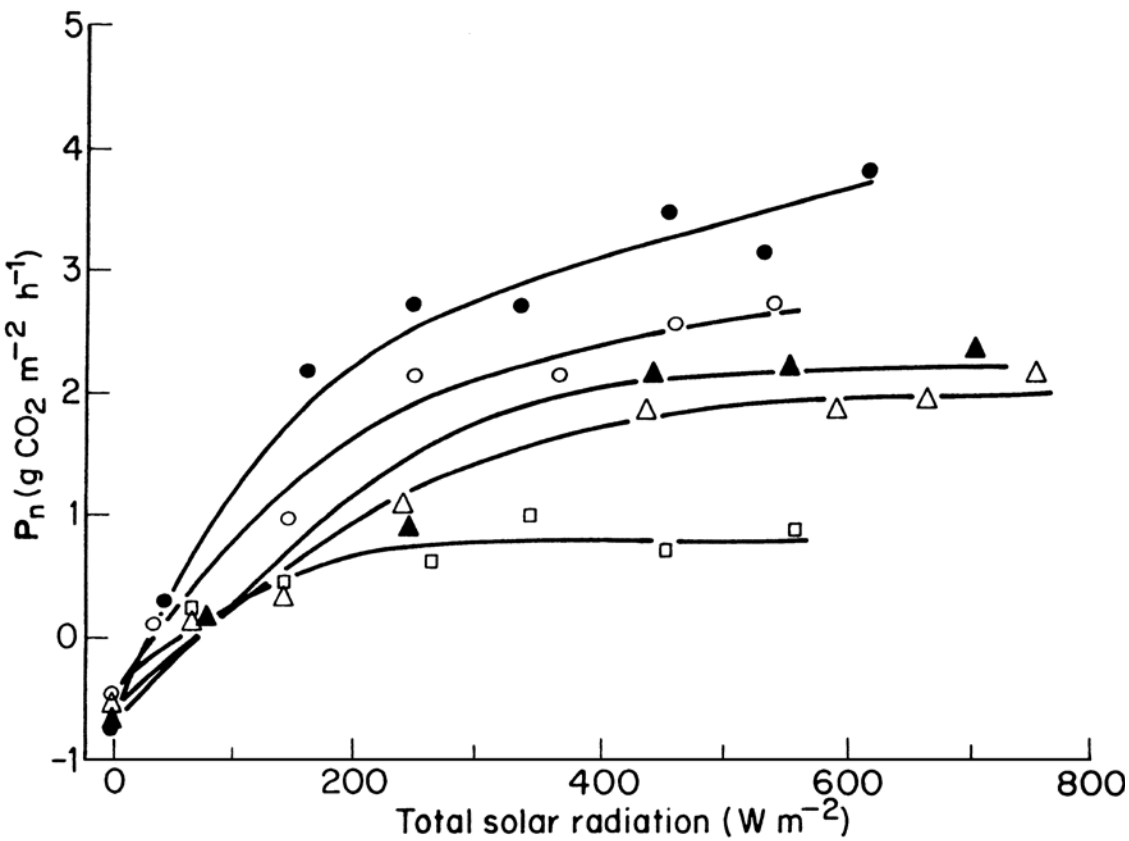

Figure 17.10 The relation between net CO_2 fixation of a barley crop and irradiance for the 5 weeks after anthesis. Dates, total green leaf area indices, and symbols are as follows: 28 June, 5.95 (•), 5 July, 5.69 (o), 12 July, 5.59 (▲), 19 July, 4.02(△), 26 July, 2.68 (□) (from Biscoe et al., 1975b).

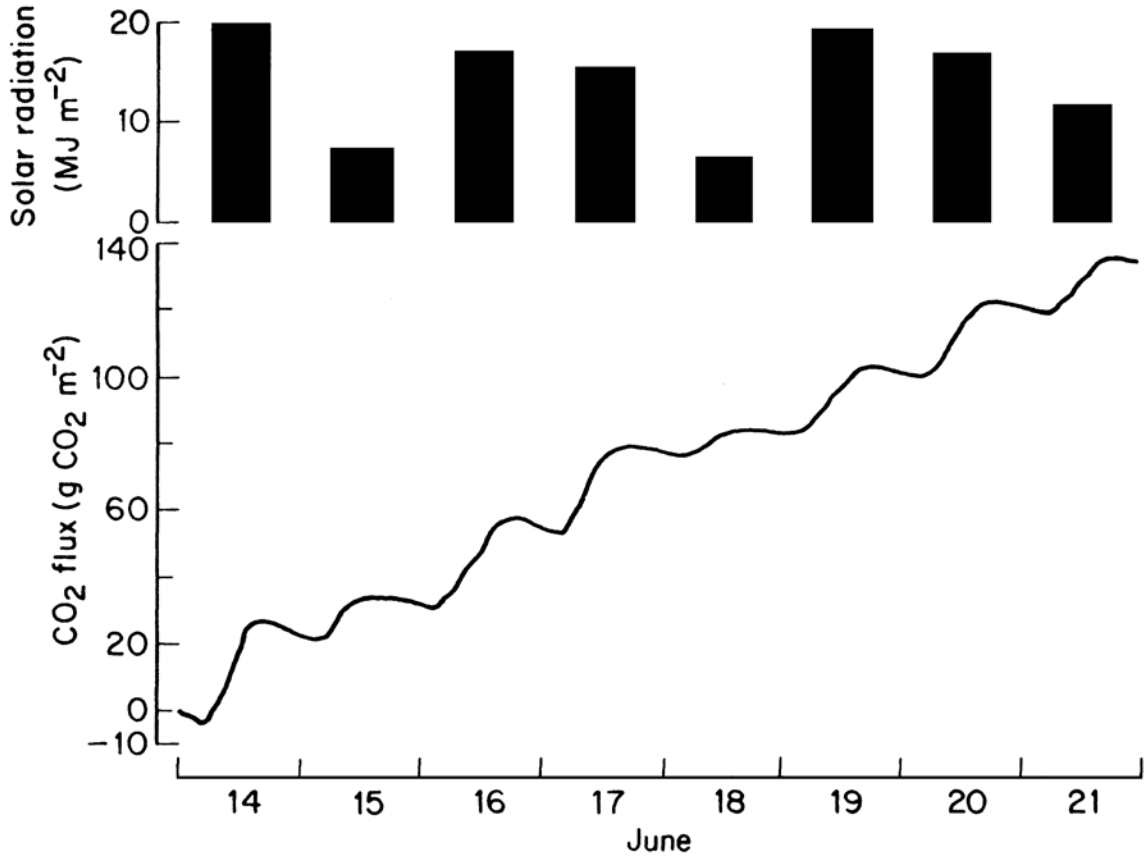

Figure 17.11 The hourly rates of net CO_2 fixation by a barley crop summed over the period 14–21 June 1972. The histogram shows the total solar radiation for each day (from Biscoe et al., 1975b).

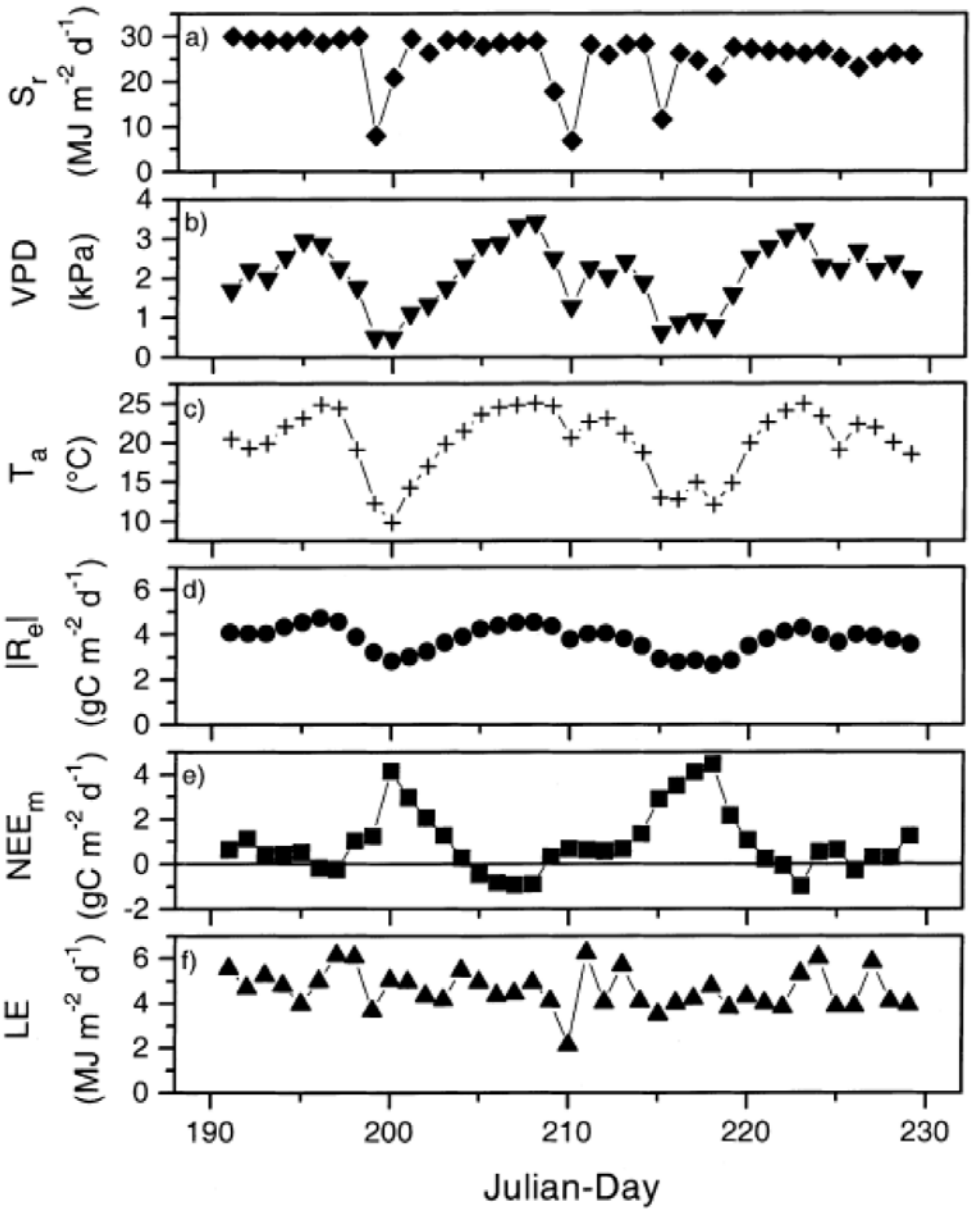

Figure 17.12 Day-to-day variation over an open-canopied ponderosa pine ecosystem in central Oregon of (a) daily total solar insolation $\mathbf{S}_r$, (b) mean daylight vapor pressure deficit VPD, (c) mean daily air temperature T_a, (d) daily total ecosystem respiration R_e (absolute value), (e) daily net ecosystem exchange of CO_2 $\mathbf{NEE}_m$ (measured using eddy covariance methods and plotted as positive (NB: the opposite convention to Figure 17.12 and the text) when CO_2 was being taken up by the ecosystem), and (f) daily latent heat flux **LE** (measured using eddy covariance). (From Anthoni et al., 1999).

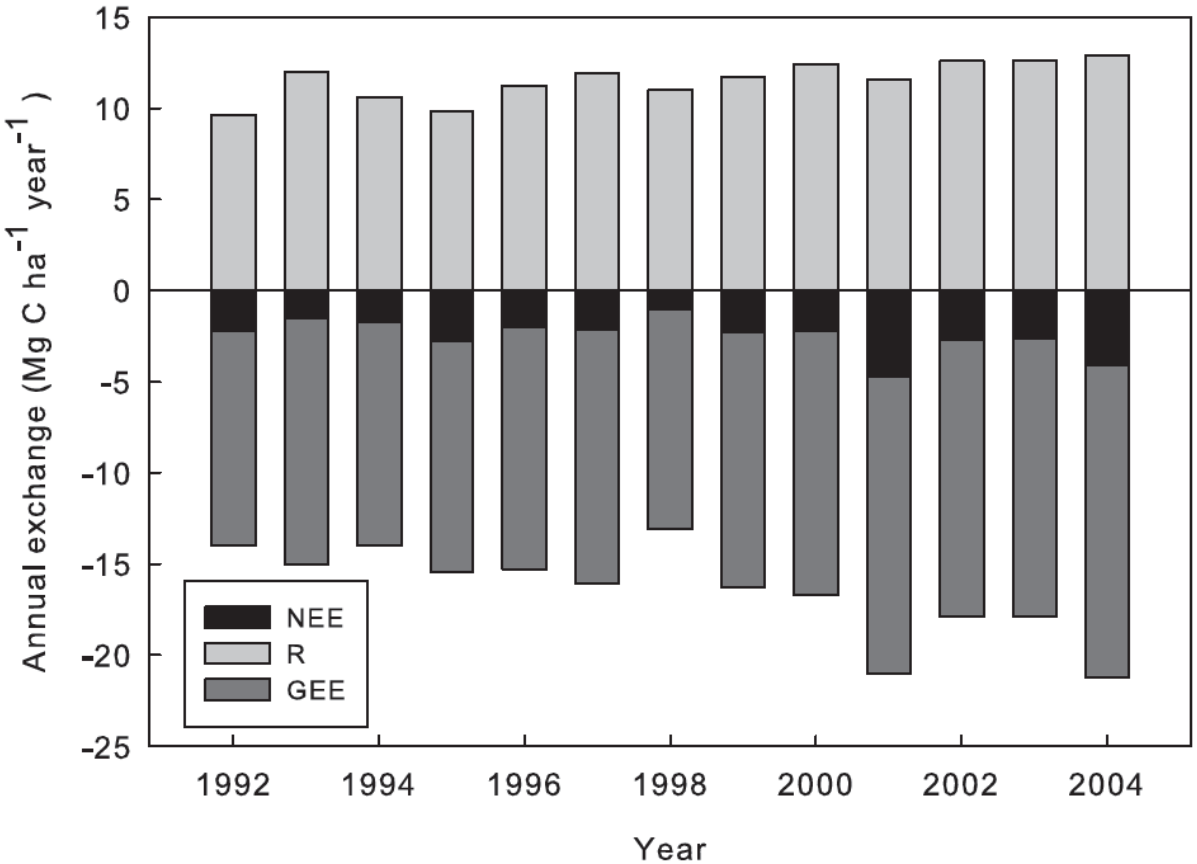

Figure 17.13 Components of the annual exchange of CO_2 between the atmosphere and a northern temperate hardwood forest (Harvard Forest, USA) over the period 1992–2004. Net ecosystem exchange **NEE** (negative sign indicates loss from the atmosphere) was measured using eddy covariance. Respiration **R** was inferred from night-time **NEE** measurements used to estimate daytime respiration. Gross ecosystem exchange **GEE** is calculated as **NEE-R**. Data are summed from 28 October of the previous year to 27 October of the year plotted. Data bars are not cumulative, i.e. in 1992 **NEE** was −2.2 and **GEE** was −11.8 Mg C ha^{-1} $year^{-1}$. (Plotted from data in Urbanski et al., 2007).

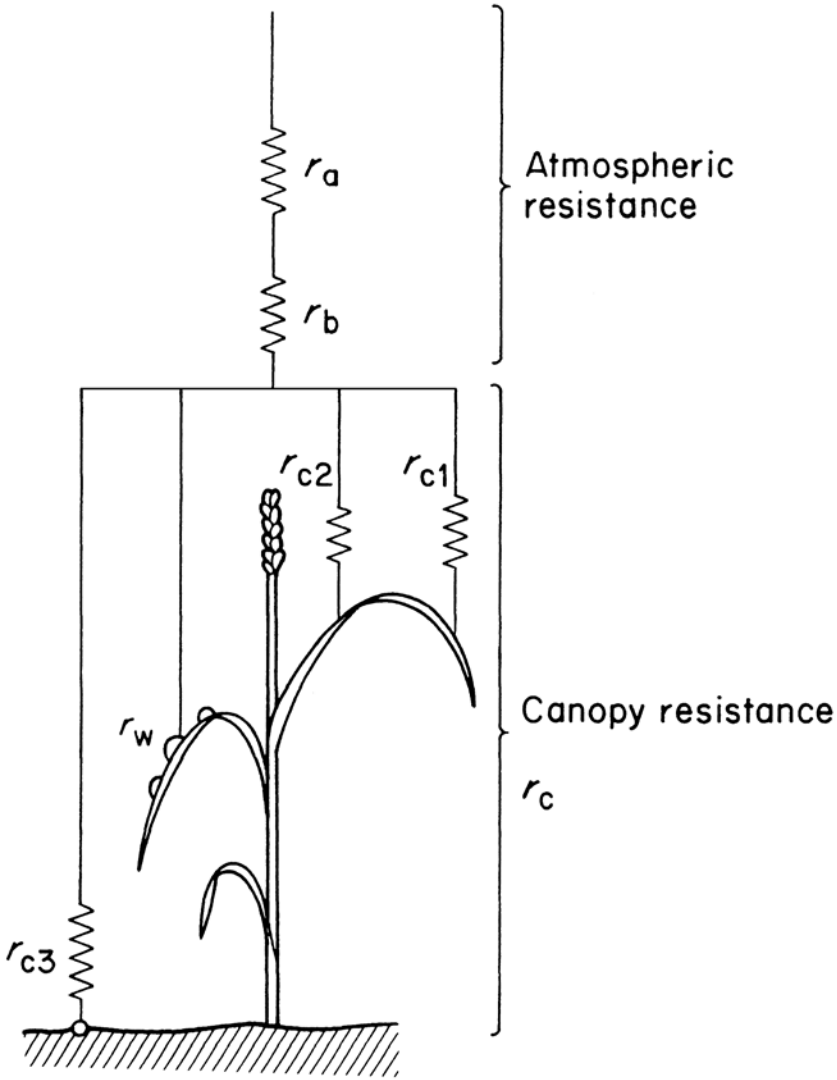

Figure 17.14 Resistance analog of dry deposition of sulfur dioxide, SO_2, to a wheat canopy, showing aerodynamic resistance, r_a, additional boundary layer resistance, r_b, and resistances in canopy, r_{c1}, to stomatal uptake, r_{c2}, to surface deposition, r_{c3}, to uptake by soil, and r_w, to uptake by surface moisture (from Fowler and Unsworth, 1979).

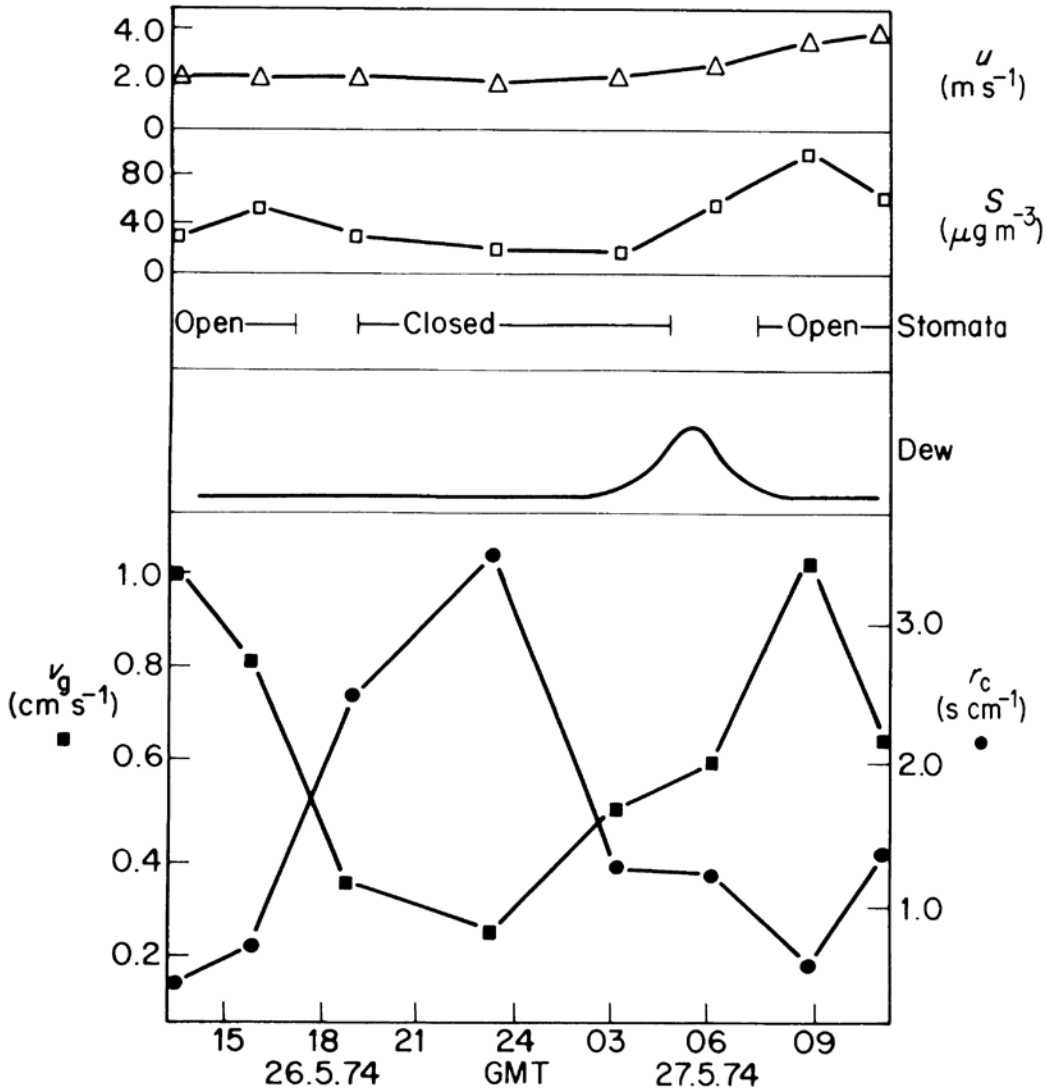

Figure 17.15 Diurnal variations of SO_2 deposition velocity v_g, canopy resistance, r_c, windspeed, u, and SO_2 concentration, S, over a wheat crop. Durations of dew deposition and of estimated stomatal opening are also shown. All height-dependent parameters are referred to 1 m above the zero plane. (From Fowler and Unsworth, 1979).

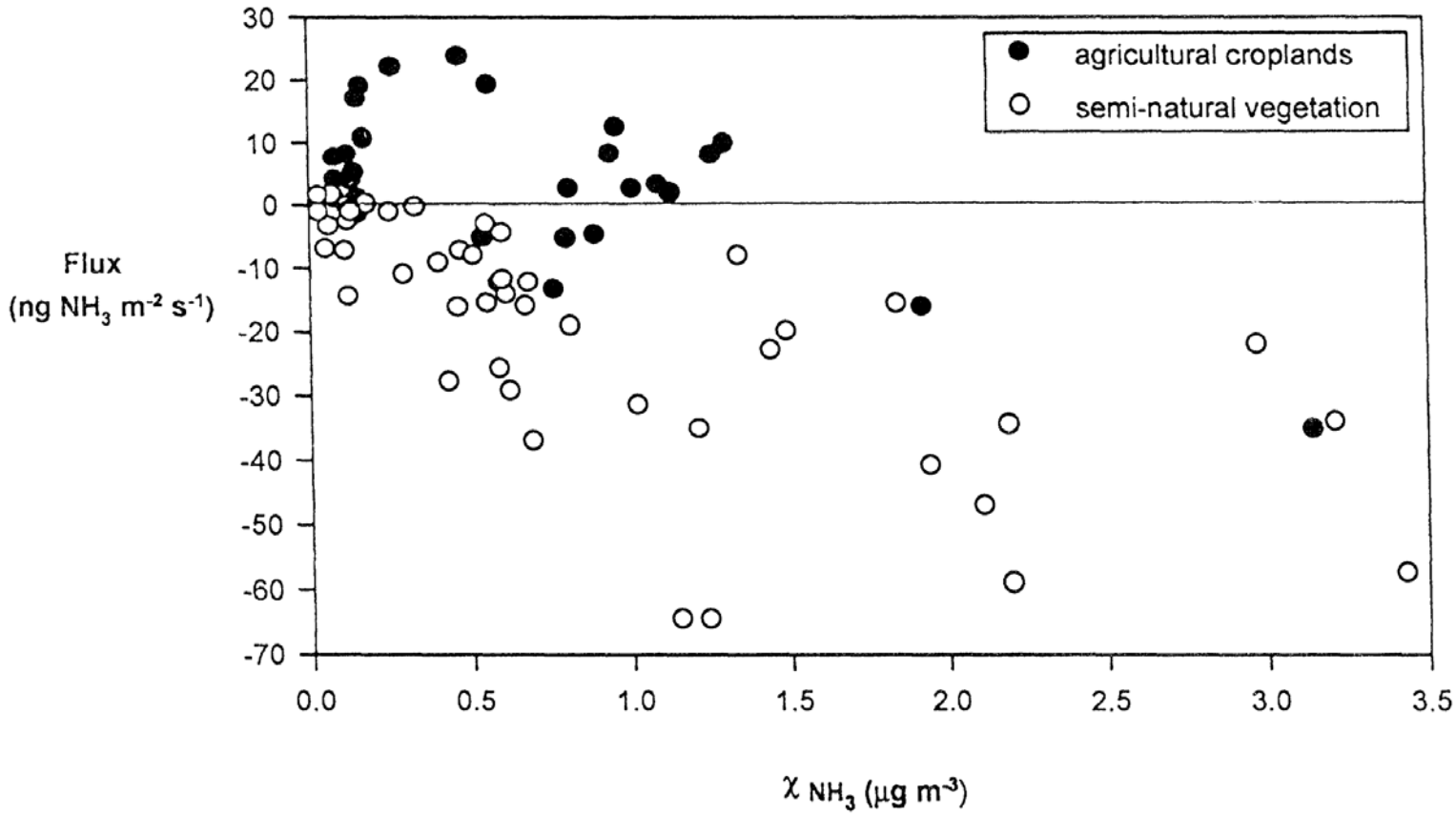

Figure 17.16 Variation with ammonia concentration of fluxes of ammonia *(*NH_3*)* between the atmosphere and two types of vegetation canopies: agricultural cropland; and semi-natural. (Fluxes are plotted as positive when the flux of ammonia was from the vegetation to the atmosphere). (From Sutton et al., 1995).

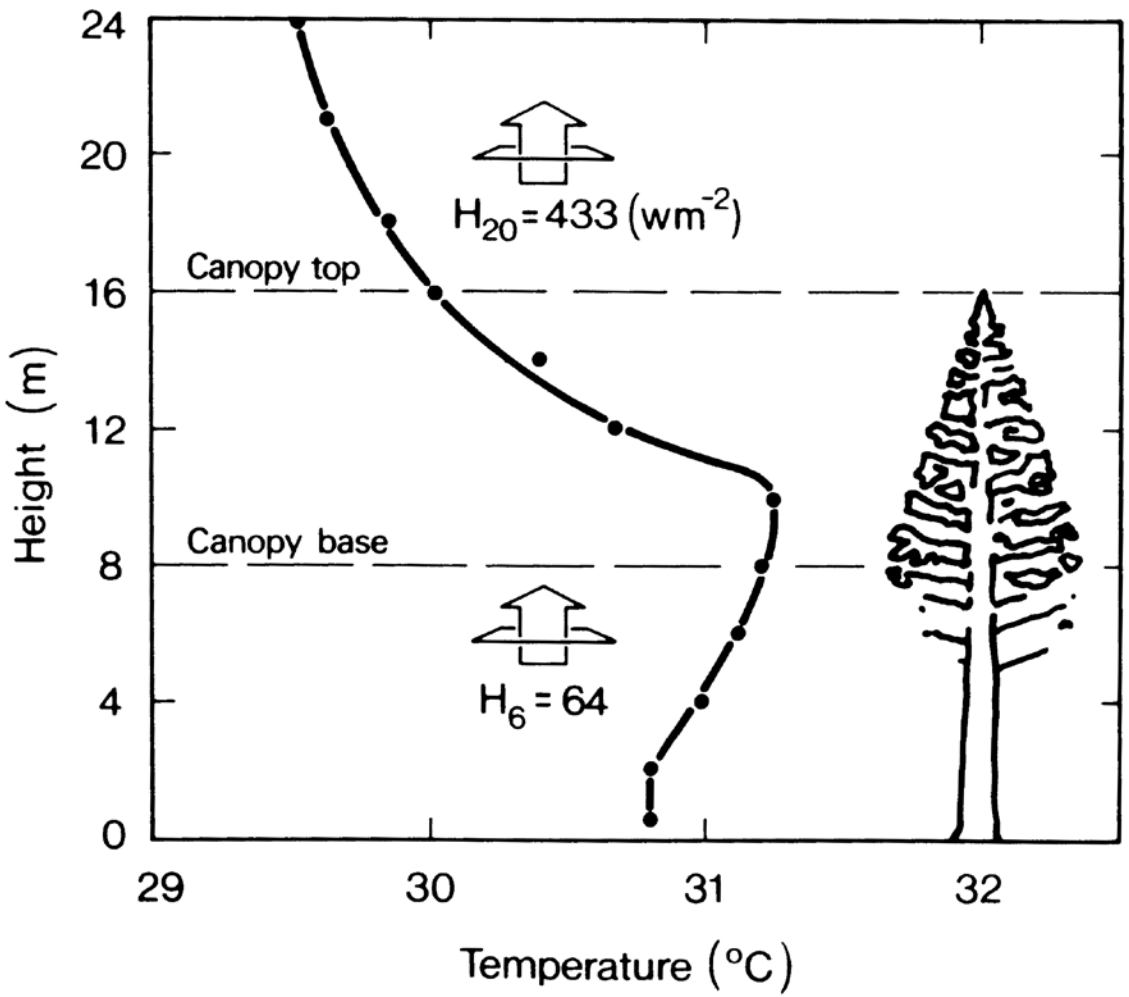

Figure 17.17 The vertical profile of air temperature (averaged over 1 h) and simultaneous measurements of sensible heat flux *(***H***)* by eddy covariance above (**H**$_{20}$) and below (**H**$_6$) the canopy of an extensive Ponderosa pine forest (from Finnigan, 1985).

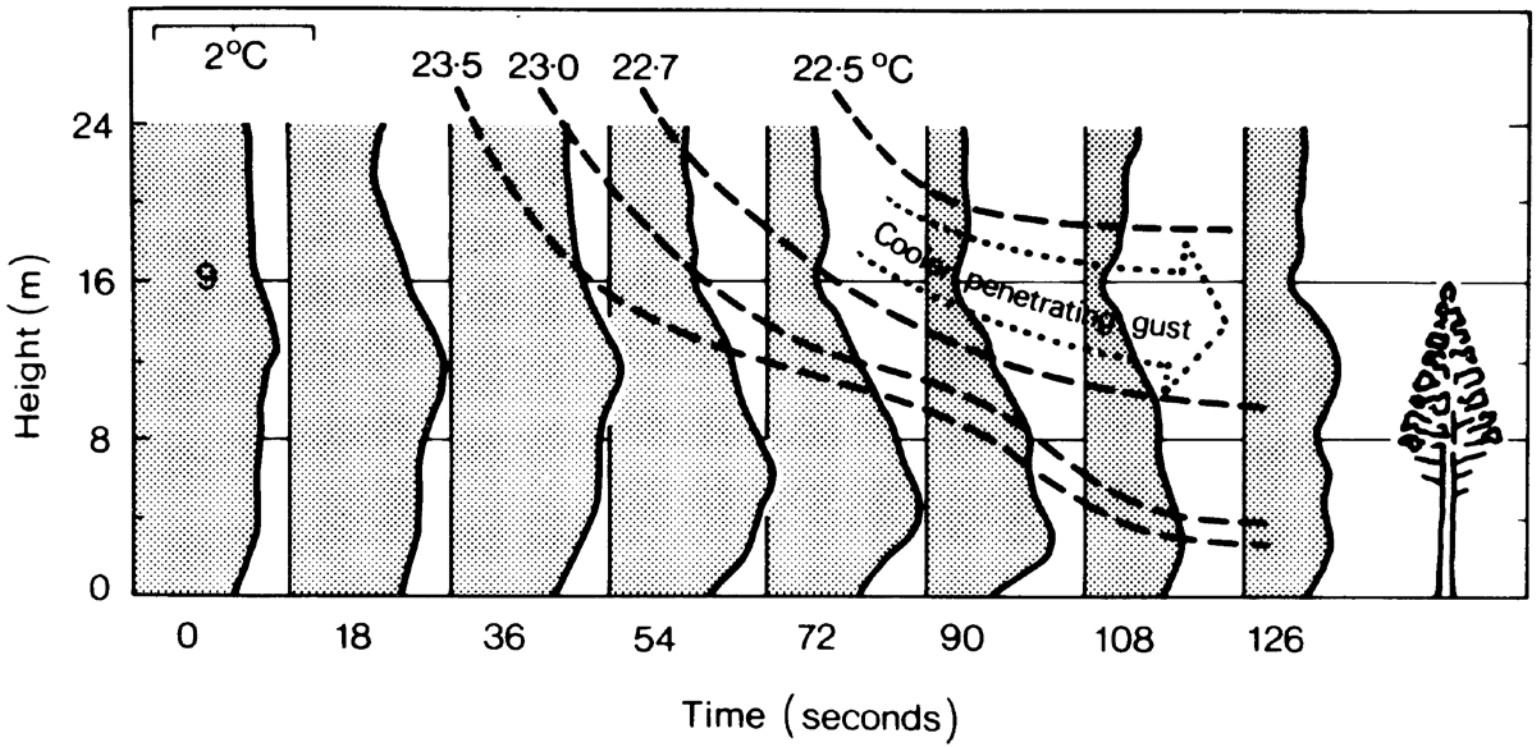

Figure 17.18 Profiles of temperature averaged over 10 s and taken during a short slice of the hour depicted in Figure 17.17. The start time of each period was advanced by 18 s for each profile. Dashed lines are contours of constant temperature, and the baseline for the temperature profiles was 18.5°C (from Finnigan, 1985).

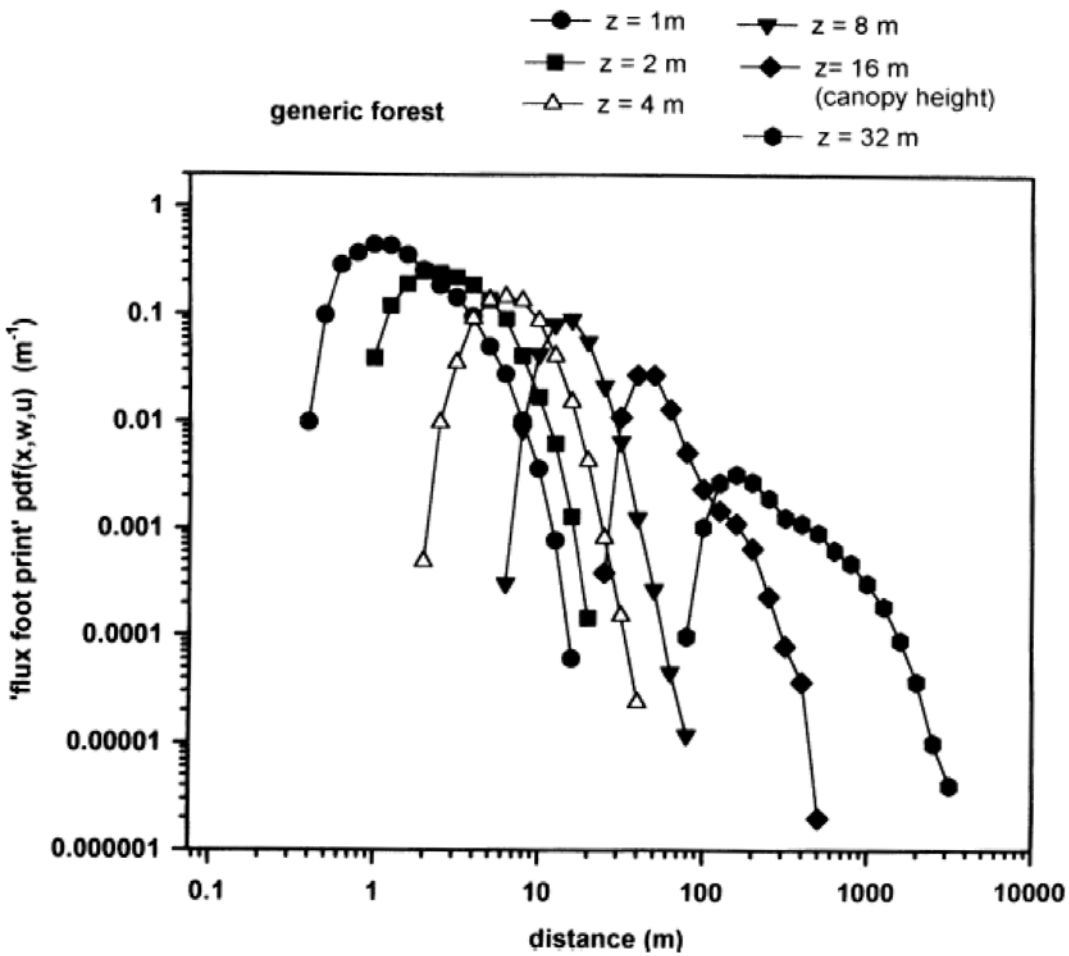

Figure 17.19 The source probability density function (pdf) of flux footprints for observations at several heights within and above a "generic" forest assuming near-neutral stability. The pdf is the probability that fluid elements released at numerous positions upwind will be observed at the defined height. The height *(h)* of the forest was assumed 16 m, zero plane displacement *d* was 0.60 *h*, and roughness length z_0 was 0.10 *h*. An exponential wind profile within the canopy was assumed (from Baldocchi, 1997).