CHAPTER 5

Climates and microclimates

For the last 10,000 years or so Earth's climate has been relatively stable and predictable. And that predictability is important for most facets of our lives. Now, there is widespread agreement that human activities over the last two centuries have destabilised world climates.

One of the latest conferences declared, rather depressingly, that 'there is now no stopping global warming' (ABC Radio, March 2005). In Russia, an area of permafrost the size of France and Germany that has been frozen for 10,000 years has started to melt and will have a huge impact on further destabilising climates. The effect of global warming will be that every continent will find its climates unreliable and often unpredictable with extremes of heat, drought, storms, cyclones and ocean rise.

The *Sydney Morning Herald* of 9 September 2005 reported an English study which said that 'present forecasts of climate change could be seriously under-estimated because of huge amounts of carbon pouring out of the earth ... there was little that could be done to tackle the problem without addressing the fundamental question of human carbon dioxide emissions. If we were prepared to turn the whole of arable England back to trees that would work but it's not practical.' Basically, we have over-cleared land everywhere.

In permaculture we apply the precautionary principle, which you read about in Chapter 3 (see page 19), to design settlements and enterprises that are robust and have a chance of withstanding stress and disasters. To do this we work with the elements of climate in siting buildings and growing areas, and identifying sites that need to be enhanced or protected. You started this process when you carried out your inventory and began your observations.

The concept of climate is too big and ill-defined to use effectively in a site analysis and design. Instead, we consider climate by identifying each of its three major components and then studying them separately to see how they are destructive or beneficial on a specific site, and how they interact and follow cyclic patterns. The three components are precipitation, wind and radiation (sun). Together they act on the huge continental landmasses and ocean currents.

Our ethical task is to:

- ensure climatic stability
- reduce atmospheric pollution.

Our design aims when working with elements of climate are to:

- modify extremes of climate
- reduce the risk of animal and crop failures
- choose appropriate animals, plants, buildings
- select correct elements of climate to work with—for example, for solar or wind energy
- achieve more energy- , materials- and water-efficient buildings

- endure, withstand or avoid droughts, floods and other disasters.

If we don't have design aims:

- we contribute to climate destabilisation and disturb microclimates
- we hasten the breakdown of ecosystems
- we lose opportunities for diversity of niches, edges and species.

Precipitation

Precipitation is rain, snow, fog, sleet, hail, mist and frost. All precipitation is seasonal and follows fairly predictable patterns. Cold winter rain comes from the South Pole in the southern hemisphere and the North Pole in the northern hemisphere and always travels from west to east in both hemispheres.

Hail, snowstorms, fog and frost also have patterns of time and place. For example, frost forms on the ground on very cold, cloudless, still nights but it doesn't form under trees, eaves of houses or when there is a breeze. Fogs drift in from oceans and over mountains predictably in autumn and in some places in winter. Cyclones follow patterns in tropical climates, usually on east coasts of continents. Long-term residents often have sayings based on climate patterns. Our local one here is, 'It can frost up until November 15.'

By understanding patterns of precipitation you can plan your growing year to take advantage of favourable conditions or minimise the impact of unfavourable conditions. For example, it is useful to predict likely rainfall or drought for crop planting and water harvesting and storing. However, with the increasingly erratic nature of climates worldwide, it is safer to act as if there will be droughts, floods and other natural disasters and design sturdy environments and enterprises.

Different forms of precipitation occur because water changes form. When it changes from ice to liquid to gas the process is called evaporation and is accompanied by cooling; when it changes from gas to liquid to ice the process is called condensation and there is warming.

As permaculture designers we use knowledge of these two processes to:

- design structures with good temperature control
- select appropriate renewable technologies for heating and cooling
- retain water in the soil
- position plantings and structures appropriately.

Wind

Winds are caused by the earth's rotation and the differential heating of land and sea surfaces. For example, deserts radiate intense heat upwards and this sucks in cooler, moist air from the oceans, bringing rain as it moves in. When this happens for an extended period on a vast scale, monsoon climates are created. When it occurs daily, the effect is diurnal and local. Winds are divided into orders. The large orders such as monsoons, cyclones and typhoons are all part of climate, whereas small breezes that move up and down hills daily or the canyon effects in cities are part of the local microclimates. Whether winds are of large or small orders they all have patterns.

Like precipitation, world climates have fairly predictable wind patterns, although these too are changing with global warming. Knowing these patterns helps you to:

- harvest wind energy for electricity
- design your home and animal shelters to benefit from, or minimise, the impact of winds
- design and plant protective windbreaks
- select wind-tolerant species
- change activities for different seasons
- build buffers against climate change.

Radiation

Most radiation is white light. It comes from the sun and is absorbed by water, plants, soils, materials and animals, and is changed into other energy forms such as heat and chemical energy. It can be:

- radiated back as heat energy from the soil, water and some materials

- turned into chemical energy by green plants when they photosynthesise
- turned from light energy into heat energy after passing through glass.

Photosynthesis is the process by which plants turn light into food (chemical energy). Plants absorb different wavelengths in different parts of their structures—for example, the back and front of their leaves. Young leaves absorb different amounts of light to older leaves. In addition, in the tropics, dark green and red leaves absorb large amounts of radiation and assist in cooling the environment, while in temperate climates, where plants have light-coloured leaves and bark, light is reflected back to increase light and its absorption in the environment. Light is vitally important to life.

- Light absorbed by plants in photosynthesis has a cooling effect. One impact of removing forests and other vegetation is to increase heat and light in the Earth's biosphere, causing thermal pollution—global warming.

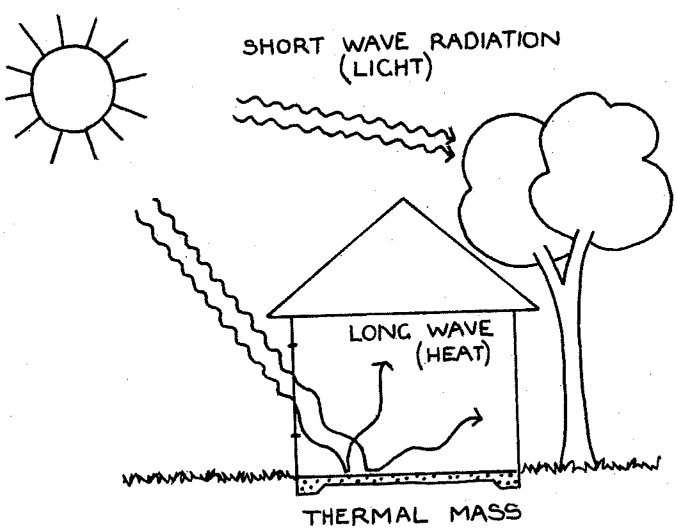

Figure 5.1 Use of thermal mass for heating. Light from the sun is absorbed by surfaces and is converted into heat energy which is re-radiated into the surroundings. This process can be used to capture and store energy for heating your home. If you expose a concrete slab floor to sunlight during the day, light energy is absorbed and converted to heat which is conducted throughout the slab and re-radiated later when the surrounding air has cooled. This helps to warm the room at night and generally maintain a more even temperature in the house.

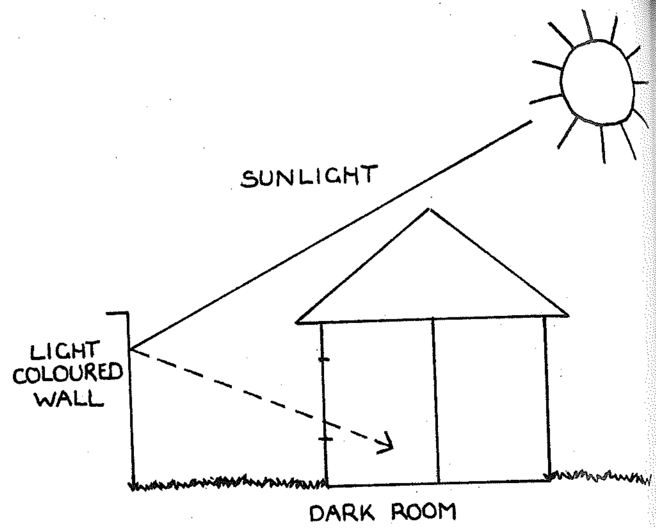

Figure 5.2 Reflection of light. A light-coloured wall can be placed so that is faces the sun and reflects light into dark rooms on the shady side of the house.

So a city parking lot or a piece of bare ground is hotter and glarier than a similar vegetated area. Soil moisture, which helps to stabilise climate, is also lost.

- Certain seeds have evolved mechanisms so that light triggers germination. They are often dry-climate or desert plants. Others need short days to germinate—that is, long periods of darkness. This is called photoperiodism and tends to occur in high latitudes. With plants in equatorial regions, where day and night are about equal, light has less effect and instead it is usually rainfall that triggers germination. The same mechanisms occur with blossom set and seed set. Light also initiates oestrus in some animals.
- Light is absorbed and stored by dark bodies, also called thermal mass, which later radiate it back as heat. Figure 5.1 shows how this process can be used to warm a room.
- In contrast, light is reflected from light-coloured bodies such as plants, water and materials, and the reflected light can be used by plants and animals. Figure 5.2 uses reflection of white light to increase light in a room.
- Light is also turned into heat energy after passing through glass.
- Finally, light changes the habit (shape) of plants. Where there is little light, plants grow

tall and straggly in an effort to capture more light. Where there is full light plants tend to become round. It is important to know this when planning plant spacing in gardens and forests.

Interaction of precipitation, wind and radiation

Each of these components of climate interacts with the others all the time and changes in impact and force. On any site, however, one may be more useful or destructive than another. For example, in some latitudes and seasons, winds are destructive and limiting. If you know their patterns you can modify the site you are designing. For building structures, knowledge of radiation as light energy and its forms can help you to retrofit a building to modify the extremes of heat and cold.

However, the focus of most of your work will be the microclimate, because it is here you can achieve the greatest gain and impact for the least work. In Part Three you will analyse the components, or elements, of microclimate and then put them together in a microclimate study of a home site you have selected to study.

Microclimates

The place where you live is a microclimate of the larger general climate. In my area and climate, the cold weather always comes from the south. But at my place, the cold winds and rain always come from the west. I live on a ridge and two large valleys channel the southerly winds around to the west Also, data shows the sun rises at 6.30 in autumn for my latitude and longitude but at my place it rises at 8.30 because of a hill to the east of my house. These special effects comprise part of my microclimate.

In our look at climate, we examined three elements: precipitation, wind and radiation. The major climates always have local variations in temperature, wind speed, direction, relative humidity and light levels. This is because the set of five local microclimate factors acts on the larger climate to give rise to a series of microclimates nested within the larger climate. These local factors are:

- topography
- soils
- water masses or bodies
- artificial structures
- vegetation.

Overall, in designing diverse and stable landscapes, knowledge of microclimate is more important than knowledge of general climate. Microclimates can be a rich source of diversity, and so your design should take advantage of those occurring naturally rather than eliminate them. You can increase the diversity of plants and animals in your site by applying your knowledge of the elements of climate and microclimate through design. For example, in a cool temperate climate you may be able to grow an almond tree if you place it against a warm dry westerly wall, and you can create special niches for more plants by using stone paths to give a warm root run.

Characteristics of microclimates

The general climate sets the broad limiting factors of your site and knowing and analysing microclimates will help you to modify these. The factors of microclimate, like those of climate, are dynamic and interactive. Take any site and start your observations. For example, steep slopes usually have shallow soils at the top and deeper soils at the base, are dry at the top and damp at the base.

Observation is only the beginning, however; you need to connect your observations and make deductions for design strategies and techniques. This is called microclimate analysis. It enables you to:

- read the landscape and predict microclimate effects—you may notice that paint is peeling off one side of the house and this shows the direction of the prevailing winds or drying winds across your site
- modify climate extremes—you can terrace slopes to capture more sunlight and warmth or to hold water on a dry steep hillside
- design effective strategies to achieve the microclimates you require—the careful placement of windbreaks as suntraps can increase temperature

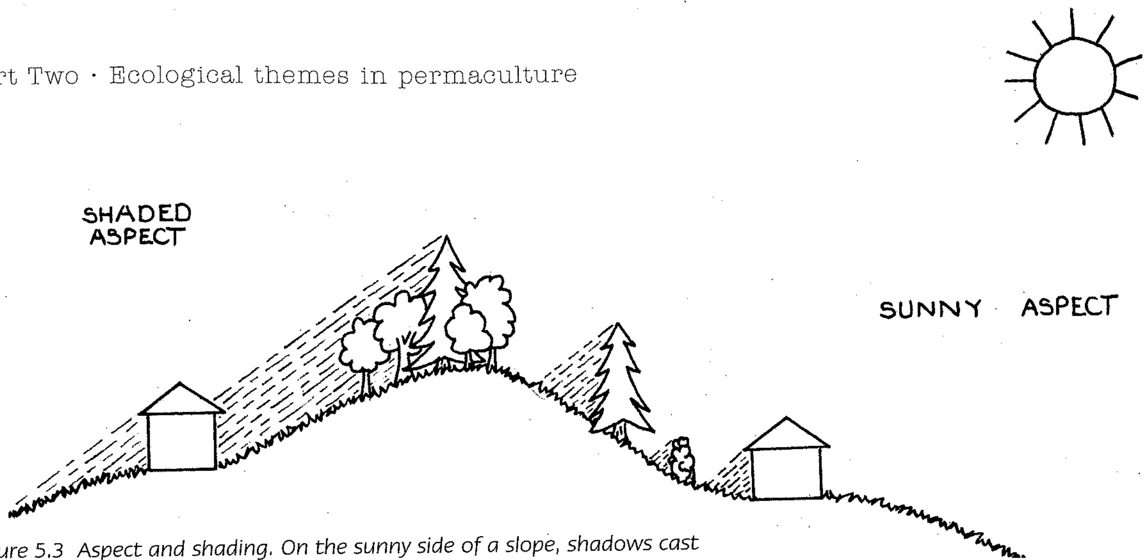

Figure 5.3 Aspect and shading. On the sunny side of a slope, shadows cast by objects are significantly shorter than the shadows cast on the shaded side.

- extend the growing season and biodiversity —frosts can be avoided by the use of vegetation and structures or directed breezes
- live more comfortably and use less of non-renewable resources—design an efficient solar home.

Topography

For our purposes the main elements of topography are aspect and slope.

Aspect

Aspect is the direction that a slope faces and is characterised by the amount of radiation it receives. Figure 5.3 shows how the aspect of a slope affects warming, cooling, and shadows cast by structures and vegetation. On the shaded side of the slope shadows can be up to three times longer than on the sunny side.

Aspect gives rise to thermal zones and/or cold sinks. These occur because:

- air moves faster uphill than downhill
- cool air is heavy air and moves downhill
- warm air is lighter and moves uphill
- cool air replaces warm air by pushing it up or sliding underneath it.

When cool air flowing downhill is impeded by any barrier, it pools and is called a 'cold sink'. On slopes warm air is pushed upwards by cool air. When this warm air is trapped by a building or plants, it is called a 'thermal zone'. If there is no barrier, the warm air will continue to drift up the

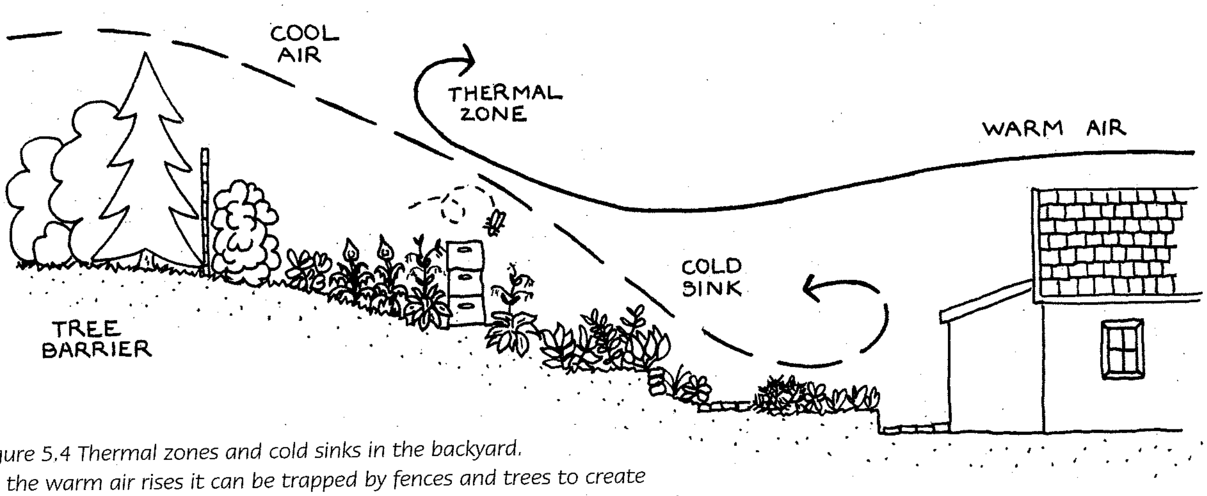

Figure 5.4 Thermal zones and cold sinks in the backyard. As the warm air rises it can be trapped by fences and trees to create a warm thermal zone on the upper slope. The downhill area will be cooler and more prone to frosts as the cool air sinks at the end of the day. The same process occurs on a much larger scale in valleys.

slope until it cools. You can design thermal zones and cold sinks to suit your needs for more warmth or coolness, or to site a home or suit a crop.

Aspects give rise to winds with differing qualities. Winds tend to be warmer and drier on western slopes and flow upwards because the west receives more intense radiation after midday. On the aspect away from the sun, cool heavy air drifts down and if it is blocked will then form a very cold little microclimate. Cooler and wetter winds arise from poleward slopes, while winds from the east tend to be reasonably moderate and pleasant on eastern coastlands, and evening winds on west coasts come off the sea and are refreshing. This knowledge, verified by observation, helps you in siting and orienting homes and animal housing for the maximum realisation of renewable energy and site potential.

Aspect also affects your choice of plant and animal species. Some species prefer the eastern aspect with the morning sun, and others prefer the warmer, drier western slopes.

Slope

Slope affects wind speed because the steeper the slope, the faster wind moves uphill. This has implications for managing wildfires, capturing wind energy, and siting windbreaks (see Figure 5.5).

Slope also has a major effect on water speed because water increases its velocity as it moves downhill. Sloping land erodes faster and more severely than flat land. Fast-moving water is usually very destructive; however, it can be harnessed for hydropower, or controlled and redistributed, or erosion-prevention works can be effectively designed. People living in hot, wet, mountainous areas of the world terrace their slopes to prevent water erosion.

Slope affects cultivation techniques. Because of the destructive nature of cultivation machinery, and the tendency of slopes to collapse in landslides, it is a good general rule that slopes of greater than 15 degrees from the horizontal are better placed under permanent productive trees.

Soils

Soil used to be considered the least important factor in determining microclimate but we now know that the moisture in soils has a major impact on climate stability. Soil texture and structure affect the absorption, shedding or evaporation of water. Soil types give rise to specific local effects and affect what can be grown.

Clay soils hold more water, shrink and swell when drying and wetting, and respond differently to different cultivation techniques. Clay soils crack open when dry and are ready for the rain to penetrate deeply in the first storms. Sandy soils drain fast, don't shrink or swell, and are easy for cultivation machinery.

Soils like to be covered. Bare soils reflect more heat and light compared to covered soils. They are also more vulnerable to wind and water erosion and desiccation.

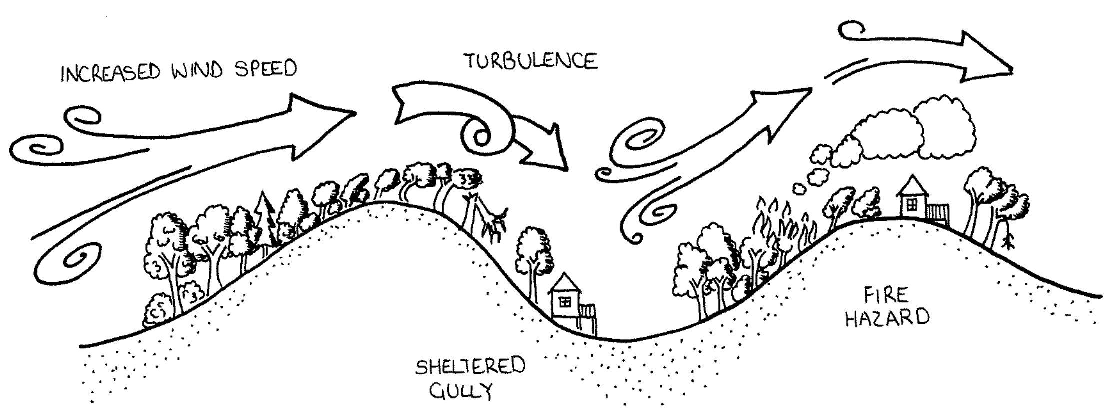

Figure 5.5 Slope and wind speed.

Water bodies

Rivers, lakes, dams and ponds modify climate and generally contribute to more pleasant microclimates. This is because water gains and loses heat more slowly than land. Water bodies provide the following benefits in the microclimate:

- Because they reflect light and warmth they can be situated so as to warm buildings. A wider range of plants can be grown around lakes and dams. Sites around lakes and rivers can be 5°C warmer than land with no water bodies.
- Sites close to oceans and seas have a 'maritime' effect, where cooling evening breezes relieve heatwaves. Inland climates have 'continental' effects, with extremes of heat and cold occurring in a single day because land both gains and loses heat fast.
- They increase humidity in the air and extend your choice of species—many palms require high levels of moisture or humidity in the air.
- They provide habitats for water-loving plants and animals, and they add immeasurably to pest control because so many predatory animals need regular access to water.
- They modify temperature extremes because water bodies cool warm air and also warm cool air. After heavy summer rains, when soils hold a lot of water, the wet soil can act like a local lake to modify climate. Weather forecasters often predict warmer winters after wet summers.

Artificial structures

Structures that affect microclimates range from dog kennels and duck houses to multi-storey buildings, and include items such as fences and roadways. For example, structures with steep 'slopes', such as walls and roofs, can contribute enormously to environmental damage through water run-off or excessive reflection of heat. On the other hand, structures can also be beneficial when used to:

- trap and store water
- collect and store light as heat
- grow plants in, on and around, and so add vertical space to small areas
- funnel or reduce winds
- increase the growing season by providing thermal mass

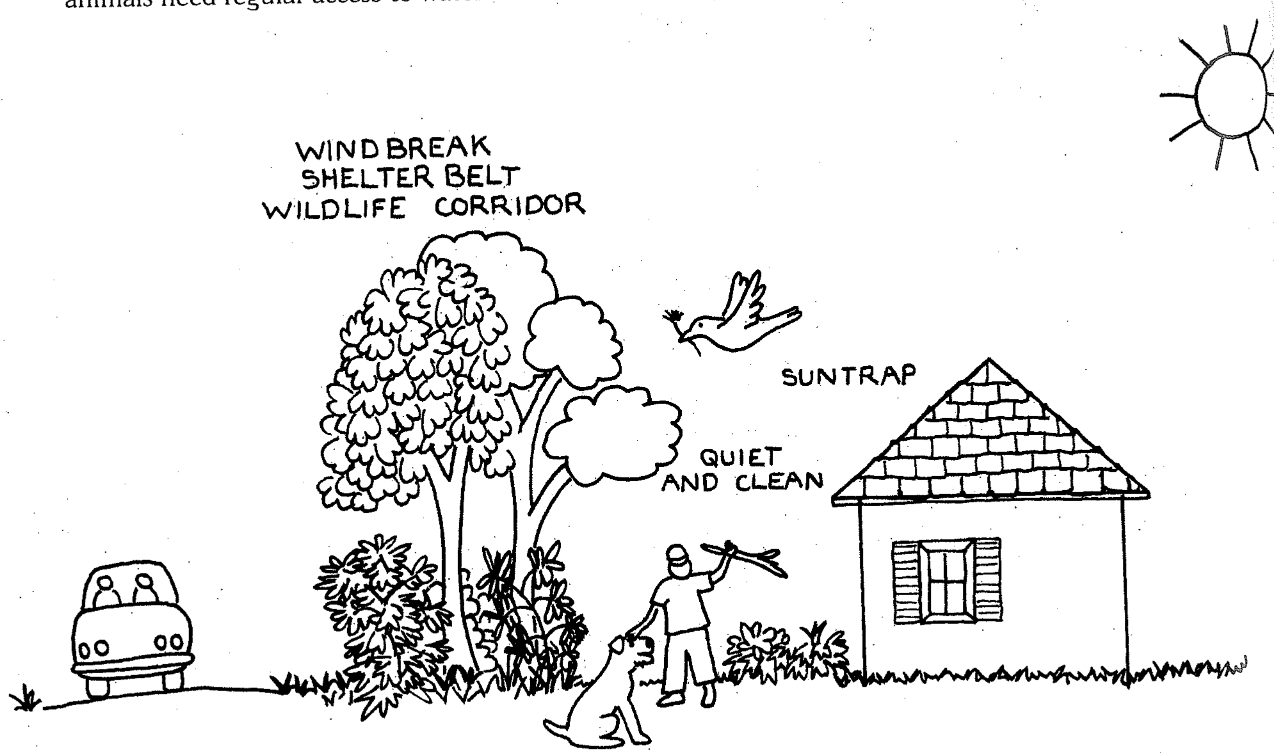

Figure 5.6 Vegetation modifies the environment.

MICROCLIMATE STUDY					
MICROCLIMATE FACTORS	1. BACK FENCE	2. SIDE FENCE ON WEST	3. EASTERN BOUNDARY	4. COURTYARD	5. FRONT YARD
TOPOGRAPHY					
• ASPECT (SUN)	SOUTHERLY ASPECT, NO WINTER SUN	EASTERLY ASPECT, GOOD MORNING SUN	WESTERLY ASPECT, GOOD AFTERNOON SUN	NORTHERLY ASPECT, SUNTRAP	SOUTHERLY ASPECT, NO WINTER SUN
• SLOPE (WIND)	LEVEL; EXPOSED TO SOUTH	SLOPE INCREASES UPWARDS	SLOPES UPWARDS	LEVEL; COLD SINK	EXPOSED TO SOUTHERLY WINDS
SOIL					
• COVER	COVERED BY WEEDS	COVERED BY GRASS	GRASS AND WEEDS	RAISED GARDEN BEDS	COVERED BY GRASS
• COLOUR	DARK; WITH ORGANIC MATTER	LIGHT; NO ORGANIC MATTER	LIGHT; NO ORGANIC MATTER	DARK; WITH ORGANIC MATTER	DARK; WITH ORGANIC MATTER
• TEXTURE	COARSE	SANDY	CLAY AND SAND FILL	COMPACTED CLAY/SAND	SANDY LOAM
• MOISTURE	ALWAYS DAMP	DRY	DRY	ALWAYS DAMP AND SOUR	DAMP AND SOUR
VEGETATION					
• BARE				MOSTLY PAVED	
• GRASS		GRASSED	GRASS AND WEEDS	WEEDS AND GRASS IN BEDS	GRASS
• SHRUBS	BLACKBERRY AND WEEDS				ORNAMENTAL SHRUBS
• TREES	ONE SMALL EUCALYPT				
WATER					
• RUN-OFF	NO RUN-OFF; POORLY DRAINED	RUN-OFF DOWNSLOPE	RUN-OFF DOWNSLOPE	NO DRAINAGE; WATER SITS IN POOLS	RUN-OFF DOWNSLOPE
STRUCTURES					
• WINDBREAK	SIDE FENCE AS WINDBREAK	SIDE FENCE AS WINDBREAK		HOUSE ACTS AS WINDBREAK	
• WINDFUNNEL			WIND FUNNEL BETWEEN HOUSES		WIND FUNNELLED UP STREET
• COLOUR (THERMAL MASS)	HEAT AND LIGHT REFLECTED	HEAT AND LIGHT REFLECTED	LIGHT, CONCRETE WALL REFLECTS AND HOLDS HEAT	PAVING REFLECTS LIGHT AND HOLDS HEAT	
• INCREASES HEAT					
• INCREASES COLD	BACK FENCE CREATES SHADE	SIDE FENCE CREATES AFTERNOON SHADE		HOUSE TRAPS COLD AIR IN WINTER	HOUSE SHADES GARDEN IN WINTER

Figure 5.7 Microclimate study of Rob's place.

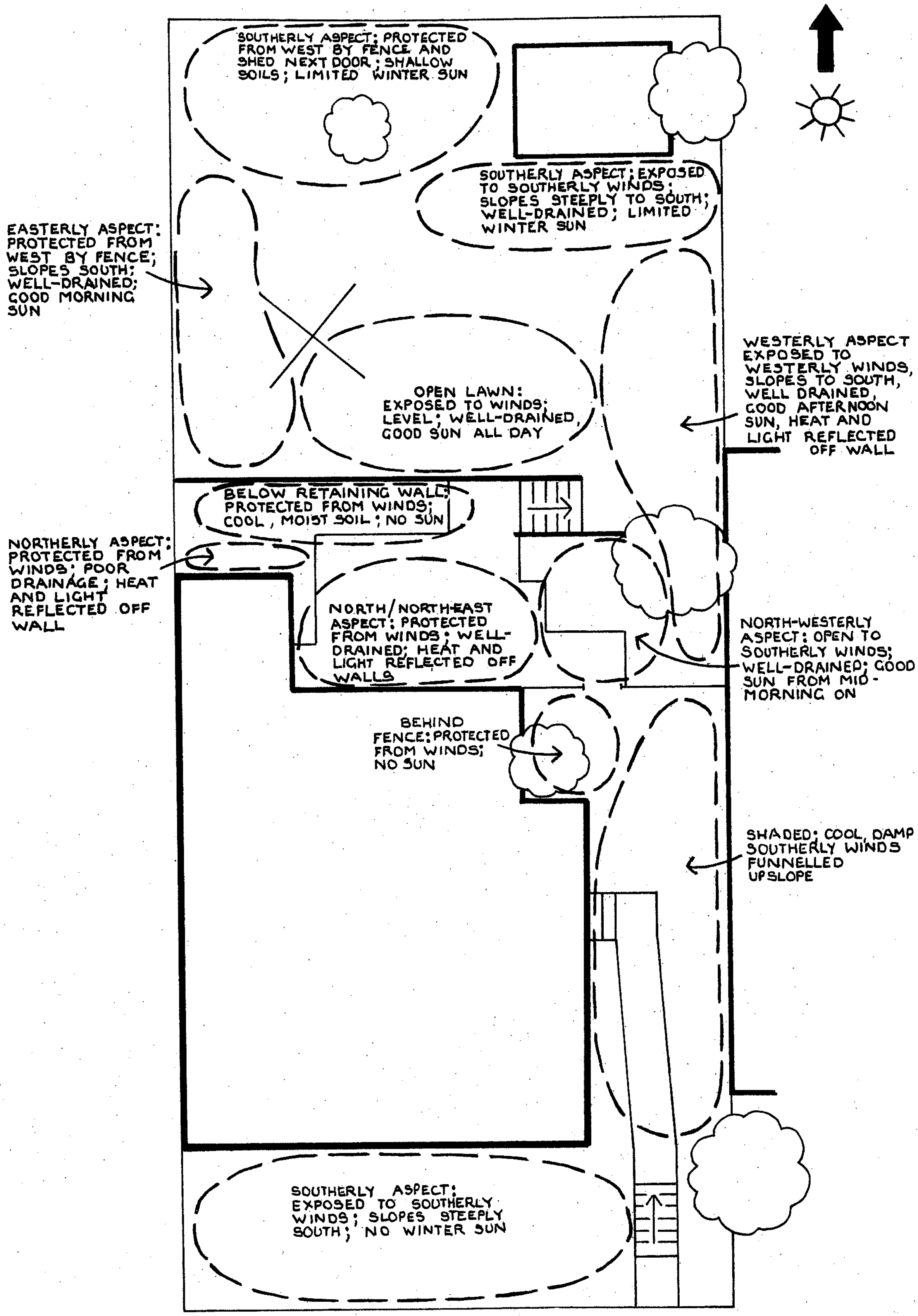

Figure 5.8 Example of a microclimate study at Rob's place.

- ripen plants by reflecting light
- drain land by using contour banks or mounds and ditches
- reduce noise pollution.

Vegetation

Vegetation interacts with and changes other microclimate factors such as soils and water.

- It absorbs heat and light. Without vegetation, solar radiation and reflection is very intense; the soil becomes vulnerable to drying out and losing nutrients, and is exposed to erosive forces.
- Vegetation acts as a carbon sink. It is considered to be the most effective way—and possibly the cheapest—to mop up surplus atmospheric carbon dioxide, which is such a large contributor to global warming.
- It provides habitat, windbreaks, suntraps, shelterbelts, firebelts and firebreaks.
- Vegetation regulates soil temperature, keeping it warmer in winter and cooler in summer than bare ground.
- Dust, diseases and excessive moisture from winds are all filtered by vegetation, as are pollutants from soil and water.

Vegetation has other characteristics that you can incorporate in your design (see Figure 5.6):

- It is adapted to suit its climate of origin, for example rainforest plants often have large, dark leaves that absorb much heat and light and release water vapour, making a microclimate cooler than it would have been otherwise.
- It is used as an architectural tool. In 'biotechture', plants' traits are used to provide desired microclimates.

Try these:

1. Find the climate figures for your area from the Meteorological Bureau. Try to match temperature with rainfall and evaporation. What did you find out?
2. Do a microclimate analysis of a site. Copy your base plan from the last chapter or place a sheet of tracing paper over it. Using the microclimate factors, mark out all the microclimates of the site on the plan. Look at Rob's microclimate analysis in figures 5.7 and 5.8 to see how he did it.
   - Where do the main summer and winter winds cross your land? Verify this from your own experience.
   - Decide whether wind or precipitation is the most damaging, and in what form. For example, determine whether it's heavy frosts in September, or very strong winds in July. Be as precise as you can.
3. Identify two microclimates and analyse them for the factors you have just read about—that is, topography, soil, water bodies, structures and vegetation, and how each functions and interacts with the others.
4. Find these microclimates:
   - a sunny spot where you like to breakfast on a cold and windy morning
   - the most weather-damaged aspect of your house
   - shady places in the garden that get little or no sun
   - cool places to be when the weather is abnormally hot.
5. Observe and record your answers to the following questions:
   - Which insects are active in summer compared to winter?
   - Which plants flower and fruit as the days grow longer?
   - Which plants fruit as the days grow shorter?
   - Which plants turn yellow after many cloudy days, and which ones are not affected?