Hardy Fern Foundation
NEWSLETTER
Editor Sue Olsen ■ VOLUME 3 NUMBER 1 ■ WINTER 1993

Special Issue - *The Cultural Requirements of Ferns* from Encyclopaedia of Ferns, by David Jones, Timber Press 1987. Reprinted with permission.

Fern likes and dislikes

People associate ferns with coolness, visits to ferny nooks and days in the country. These happy associations are a major factor in inducing people to grow ferns on their own plot of land, which may range from the postage stamp size backyards of terraces and tenements in the cities, to the rambling estates of the country. Ferns are also treasured for the beauty and delicate symmetry of their fronds; collectors find them irresistible, not only because of the large numbers available from various parts of the world, but also because of the mutations and sports which occur so freely in some species. There is, after all, always the chance of discovering a new fern.

Whatever the reasons for people wanting to grow ferns, the facts are that fern cultivation and study is again gaining impetus in many countries around the world. This may not reach the mania of the Victorian era, but nevertheless, it is a healthy trend.

Nowadays, ferns have to compete for gardener's favour with a wide range of colourful garden plants, from bedding annuals whose displays are brilliant, through a wide selection of herbaceous perennials to popular shrubs such as azaleas, rhododendrons and camellias. In the tropics we have the flamboyance of a vast range of plants to demand attention. Little wonder that the interest in ferns has waned somewhat from that enjoyed during the Victorian era. The relative popularity of ferns now is probably a position of strength since it recognizes and caters for their needs. After all, few plants can better liven a drab dark wall or line a shaded walk or survive in the root-filled soil under established trees. In the nursery trade, ferns are well entrenched and are grown by the thousands in various parts of the world, simply because they are unexcelled for their main purpose, that of decorating people's houses, verandahs and work places.

The successful fern grower is one who studies the ferns in their various natural environments and from this study learns to understand their needs and then translate this knowledge to all aspects of the garden including soil, exposure to sun and wind, pollution, competition from trees and shrubs and even to the niches which occur in any garden and which have their own microclimate.

FERN LIKES

Shade

Ferns as a group like shade. Some species will happily tolerate deep shade; others need much more light for their growth. Complete shade is the ideal situation for delicate ferns, however, the range that can be grown is greater if the site ranges from shade to brightly lit with parts perhaps even exposed to some sun.

Dappled shade, such as occurs when the sun is filtered through the canopy of established trees, is generally ideal for ferns. Situations exposed by large breaks in the canopy should not be planted with tender species which may burn, however, there are plenty of ferns which will tolerate this degree of exposure. Competition from roots is a problem under existing trees and the ferns will need extra watering, mulching and fertilizing if they are to cope, especially in the establishment phase.

Situations of partial sun and semi-shade can also be suitable for ferns providing that the sun is not too hot at the time of exposure. Morning sun is most suitable, however, the last hour in the afternoon may also be satisfactory for many species.

Humidity

Those who have been in a fern gully will immediately appreciate the atmosphere created by humidity rising from damp soil and not being dispersed by winds. It is this humidity which enables a wide range of ferns to proliferate and to grow in situations that would otherwise be unsuitable, e.g. on the trunks and branches of trees. The same is true of rainforests whether they be tropical or temperate. Even in woodlands the protection afforded by the trees and the moisture from the springy, humus-rich soil is enough to increase the humidity noticeably. Ferns growing in soaks, swamps and marshes, even though the situation may be quite exposed, are also growing in a very humid atmosphere.

Humidity then is greatly appreciated by ferns and fortunately this is readily catered for in a garden. Humidity can be rapidly increased by watering or misting and a site protected from wind will reduce its dispersal. Planting ferns in groups helps create a congenial humid atmosphere since the transpiration from the fronds of one contributes to the atmosphere around another. Mulches on the soil surface also tend to increase humidity by presenting a larger surface area for evaporation.

Shelter and Warmth

These two factors generally go together. Ferns, like any other plants, appreciate warmth for growth. This even includes those very hardy species which have adapted to survive the rigours of an icy winter in cold

climates. For tropical ferns the need is obvious. Warmth does not imply that a hot situation is needed, but rather a warm, sheltered situation that is insulated from the worst effects of a cold snap or a hot spell. Such a situation in cold climates may be against a brick wall which will catch the early rays of the sun or in the lee of a large boulder which will protect the ferns against the worst effects of winds, whether they be chilling or drying. Large ferns can provide shelter for small growing types and this is another reason why ferns like company and prefer to be planted in groups.

Soil Moisture and Aeration

Ferns love moisture and need it for their healthy growth and development. This moisture must be fresh and sweet and not the sour, wetness of a water-logged soil. Drainage then is of prime significance to most ferns and must be unimpeded, allowing excess water to drain rapidly through the root zone. This means that plenty of oxygen is available to the roots. Water is also still available to the fern because the soil retains it as a film around the smaller particles and within tiny pores. A certain proportion of this water is available to the fern roots and this level needs to be regularly topped up by watering or rainfall.

Mulches are very important for retaining soil moisture and the organic types add extra depth into which the fern roots can grow.

Few, if any, ferns will grow happily in a situation where the soil moisture stagnates. Such waterlogged soils lack oxygen and are generally cold and lifeless. People have difficulty in not equating this situation with that in a swamp or bog and wonder why ferns thrive under these conditions naturally. Appearances are deceptive however, for in a swamp or bog, the water is kept viable by the whole complex interchange that takes place between the various swamp plants and the animals large and small that inhabit such areas.

Although ferns do not like stagnant conditions they will thrive in wet situations where the water moves through the soil, even if this movement is slow and free water is visible. Such soakage areas in nature are commonly colonized by ferns and if they happen to occur in a garden well and good, for they can be converted into a fern oasis. Similar conditions can be created artificially by the controlled release of water from a hose or dripping tap. Where ferns are grown in such situations with the roots regularly bathed with moving water, the plants prove surprisingly hardy, and tolerant of adverse conditions such as strong sunshine and drying winds. The plants are also sturdy, often paler green with colourful new fronds, and may bear little resemblance in general appearance to those plants of the same species growing in shadier aspects (for more details on watering see page 165).

Mulches

Ferns are by nature shallow-rooting plants with a large percentage of the roots being found near the soil surface. Here they collect nutrients and moisture from that important layer where the active breakdown of organic material is taking place. They are therefore particularly susceptible to drying of the soil surface and greatly appreciate the application of mulches. These must be applied thickly and topped up at regular intervals to keep the plants healthy (for more details on mulching see page 85).

Fertilizers and Manures

Ferns, like any other plants, need nutrients from the soil and if for any reason the nutrient supply is poor then the soil should be treated with fertilizers or manures. For more details see Chapter 9.

FERN DISLIKES

Sun

The sun is a major enemy of ferns and the vast majority of species need shade for their successful culture. Hot sun can be particularly damaging even during brief periods of exposure. It kills delicate species and renders others unsightly by bleaching or scorching fronds and shrivelling new growth. There are of course hardy ferns which will tolerate considerable exposure to sun. Many of these, however, are not widely cultivated, and some indeed may be difficult to grow or have specific cultural requirements.

The scorching effects of the sun are influenced by a variety of factors including obvious ones such as the time of the year, the latitude and the altitude. Less obvious factors are fog, pollution and the garden surrounds. Reflective light-coloured surfaces or absorbent dark-coloured surfaces (such as brick walls) can aggravate the heating effects of summer sun and reduce the number of species that can be grown in their proximity. Similar surfaces exposed to winter sun, however, can create a warm environment which can allow some cold-sensitive species to survive winter conditions.

Wind

Ferns like air movement but dislike wind. Wind causes obvious physical damage from its buffeting effects and also causes less obvious but more insidious effects. Winds generally lower humidity by simple dispersal of the water vapour. Drying winds, especially if they are hot, may shrivel immature fronds and may damage young croziers, causing papery patches to appear in the fronds when they unroll. Cold winds stunt growth, and if they are especially chilling, may also cause papery patches to appear in unrolling fronds. Draughts cause insidious effects and are to be avoided if possible. Wind funnelling around buildings and through openings such as gateways and arches can retard the growth of ferns. Salt laden winds in coastal districts may cause salt burn on maturing fronds and damage delicate species. Many ferns though, are surprisingly tolerant of general coastal conditions and damage only follows severe winds when large quantities of salt may be deposited in a short time.

Dryness

Ferns are moisture-loving plants and dislike dry soils and dry atmosphere. Delicate species cannot tolerate dryness at all and shrivel and collapse quickly when such conditions even threaten. Some species are so sensitive to dryness (even when they are well established plants) that they collapse and die quickly if their roots dry out (e.g. *Ctenitis sloanei*, *Gleichenia* spp., *Pteris macilenta*).

Many ferns though, are surprisingly tolerant of dryness especially once they are established. Such plants will not withstand long dry spells and can in no circumstances be labelled as drought resistant. They also have a far better appearance if they are watered.

A few hardy ferns prefer to be kept on the dry side and are able to cope happily with occasional long dry spells. These, however, are the exception and they are generally uncommon in cultivation (see Resurrection Ferns page 6).

Cold Weather

Ferns generally dislike cold weather and make all of their growth during the warm part of the year. Tropical species obviously have little ability to cope with cold weather but ferns from temperate regions have many adaptations which enable them to survive. Most species stop growth as the days shorten and the nights get colder and by the time the worst of the winter weather has arrived they are in a state of dormancy. Some species are deciduous and shed their fronds completely. Others are able to withstand freezing of their fronds without ill effect. It is perhaps not correct to say that these ferns dislike cold weather because they probably rely on the annual winter chilling for the formation or conversion of growth hormones within their cells.

Frosts cause damage to sensitive ferns and may even affect hardy types if they are in a susceptible stage of soft growth. Hardy ferns usually recover from the set-back but sensitive species often collapse and die. Frosts cause a watery collapse and blackening of unfurling fronds and also cause black patches on hardened fronds which eventually become white and papery. Protection from mild frosts can be obtained by planting near buildings or large shrubs, or beneath the canopies of established trees. Sensitive species grown in areas with a cold winter must be protected by structures such as greenhouses.

Bare Soil

Because ferns are shallow rooted they resent a bare soil surface. Bare soils are subject to greater temperature and moisture fluctuations than are mulched soils and this means that the important top layer of soil is unsuitable and unavailable for fern root growth. The old practice of raking away all surface litter to present a neat appearance is fortunately dying out, for it had catastrophic effects on the soil and consequent fern growth.

SUN AND SHADE IN THE TROPICS

The conditions so far discussed in this chapter will vary somewhat depending on whether the ferns are being grown in a tropical or temperate region.

In the tropics, the winter sun can be nearly as damaging to tender plants as can the summer sun. This is because of the latitude combined with the generally clear skies and low humidity of the season, allowing the passage of a high incidence of burning ultraviolet rays. The effects of the summer tropical sun can also be very severe on tender plants, however, at the hottest time of the year, these effects are usually tempered by the higher prevailing humidity and frequent cloud cover. It is this high humidity which allows some sensitive ferns to survive summer conditions in the tropics.

Another problem in the tropics is encountered when shelter trees shed their leaves. Many tropical trees shed their leaves prior to flowering, and this occurs often during the late part of the dry season, when conditions are quite hot. While the leaf fall provides a beneficial mulch of leaves it also means that sensitive ferns are deprived of their protective cover and can suffer sunburn as a consequence. Trees which shed their leaves in the tropics often do so over a short period and with little prior warning.

A further problem encountered in the tropics is that the sun gets much hotter earlier in the day so that even those ferns in an easterly aspect can be damaged by excessive exposure.

SUN AND SHADE IN TEMPERATE REGIONS

In contrast to the tropics, winter sun in temperate regions is weak, and its effects on ferns are beneficial rather than harmful. Thus ferns growing under deciduous trees receive the dual benefit of a mulch of leaves plus winter sun (when it shines) for 3-4 months.

Summer sun, by contrast, can be quite hot and damaging, the particular effects varying with the latitude, altitude and proximity to the sea. In general, however, exposure to morning summer sun can be tolerated by more sensitive ferns in these regions than it can be in the tropics.

Soils for ferns

Ferns as a group are very adaptable plants and they can often be induced to grow in situations where they would not be found naturally and under conditions which would seem to be unsuitable. The latter is particularly true as far as the soils in which they will grow. Providing the soil is well drained, has a suitable pH and some organic content, ferns are not fussy about soil type.

It is impossible to define the ideal soil for ferns, because of the tremendous variation that occurs in soils around the world and the adaptability of ferns. A study of ferns in their natural habitats shows a distinct preference for well-structured soils rich in organic matter. Well-structured here means free drainage, adequate aeration and sufficient moisture retention for growth. The organic matter also plays a role in moisture retention as well as nutrition. Such soils in nature may be spongy or springy to touch. Although a soil of this type is ideal for fern growth many other common garden soils can be adequate for a wide range of species. Ferns also occur in nature in what would seem to be less than ideal conditions, e.g. rocky scree slopes where the organic matter is low.

Components of Soils

Soils are a complex system and though it is possible to classify various types it should be realized that changes can occur, even within a small area. Soils are made up of physical components which may be present in variable combinations. A knowledge of these components may aid the understanding of soils, and the processes which occur in them, including fern growth.

The major physical components of these soils are classified according to their particle size. They are as follows:

Name of Component	*Diameter*
Gravel	Greater than 2 mm
Coarse sand	2 mm–0.2 mm
Fine sand	0.2 mm–0.02 mm
Silt	0.02 mm–0.002 mm
Clay	Less than 0.002 mm

SOIL CLASSES

Soils are classified depending on the relative amounts of the components listed above. This classification is based on texture and relies on the feel of a moist sample of soil when worked between the fingers and palm of the hand. Soil classes arranged in increasing order of heaviness are: sand, loamy sand, sandy loam, loam, sandy clay loam, clay loam, sandy clay, clay.

Clay

This is the heaviest of the soil classes and is composed of very small particles that have strong cohesive properties. Clay can be poorly structured when the particles run together or well structured when the particles adhere in little aggregates. The former type drains poorly and lacks aeration while the latter clays can drain freely and be well aerated. Clays retain a greater percentage of water than other soil classes, but in many types only a small amount of this water is available for plant growth. Some clays are plastic and expand when wet and shrink when dry. In severe cases this results in cracking. Clays, despite their reputation have the ability to grow a wide range of ferns and their worst features can be reduced by cultural practices such as adding calcium and organic matter (see page 84).

Clay Loams

These soils are basically well structured clays, fortified with fine sand and silt particles. They are usually friable soils, but some types can lack aeration when wet. They are usually richer in organic matter than are clays and do not expand and shrink to the same extent. Depending on the depth of the topsoil and the pH, a wide range of ferns can be grown in soils of this type.

Loam

Loam is made up of the following components:

Silt	10–25%
Clay	10–25%
Sand	50–65%

Although there is a high proportion of sand this is not readily felt when the moist soil is tested in the hand. The organic content varies with different types of loam, but is usually fairly high. Appearances can be deceptive, as some loams which are dark coloured and appear therefore to be rich in organic matter, may in fact be quite low. Loams make an ideal garden soil with excellent drainage and moisture retentive properties. A very wide range of ferns can be successfully grown in them.

Sandy Loam

As the name suggests, this is a loam with a higher proportion of sand present. Drainage and aeration is excellent but in some sandy loams, especially those low in organic matter, moisture retention may be inadequate and plants may dry out quickly following rain or watering. Sandy loams are often very deep and frequently have ground water present. They also tend to be warmer than heavier soil types and this property may be helpful in cold climates. A good range of ferns can be grown in soils of this type.

Sand

In this soil class, the sand grains are visible. These granules may be fine, or large and coarse, resembling gravels. Although drainage is excellent, the organic matter is often low and mineral deficiencies are common. The range of ferns which can be grown in such soils is limited, although some hardy groups such as species of *Cheilanthes* may succeed very well.

SOIL PREPARATION PRIOR TO PLANTING

Soil preparation is not always necessary prior to planting ferns, however, it can aid in their quick establishment. This is especially true in poor soils or those depleted by the heavy growth of other garden plants or weeds. In poor soils, the better the soil preparation prior to planting, the quicker the establishment and resultant growth of plants.

Digging the soil to a depth of 20–30 cm ((8–12 in) is a simple and obvious preparation technique. Weeds can be removed at the time of digging and the soil will be loosened allowing rapid establishment of new fern roots. If perennial creeping weeds such as couch grass are present these should be removed completely by digging or spraying with an appropriate herbicide. The addition of well rotted manures or other organic material is beneficial to all soils and if it is dug in prior to planting so much the better. Lime will be of benefit in acid soils.

IMPROVEMENT OF PROBLEM SOILS

Heavy Clay

Heavy clay is difficult to cultivate no matter what its moisture content. It can be improved by the liberal incorporation of organic matter, gritty materials such as gravels, crushed rock and coarse sand, and by the addition of gypsum. The gypsum should be applied when the soil is slightly moist at the rate of 1-1.5 kg per square metre (2-3 lb per square yard) and worked into the top soil layer. It acts by causing the clay particles to clump together into small aggregates allowing better moisture penetration and aeration. Gypsum works best in the presence of organic matter, and for maximum improvement of clay soils, all the materials mentioned above should be used together. Repeat applications of gypsum may be needed every 4–5 years but the organic matter should be topped up every 6–12 months. Gypsum has a negligible effect on soil pH, and if the clays are very acid, liming may also be necessary.

Clay soils are prone to surface compaction and this may adversely affect fern growth. This problem can be overcome by maintaining an organic mulch on the soil surface. Clay soils generally have a shallow topsoil. The depth of a garden can be increased by the simple process of creating sunken paths and mounding up garden beds with the soil taken from the paths.

Waterlogged Soils

Ferns are quite happy in wet soil, where the water is moving, however, they do dislike waterlogged soils. In such soils the water is usually stagnant (and cold) and aeration is insufficient for root growth. Waterlogged soils can be improved by the use of surface drains, or underground drains, or by using tolerant plants which can help remove excess water. A simple technique is to excavate paths which can double as surface drains and the excavated soil can be used to raise garden beds.

Sandy Soils

Sandy soils generally have a low water holding capacity and ferns growing in them may wilt frequently and severely. The obvious answer is to water frequently and to add plenty of organic material, both by digging in and applying it as a surface mulch. In these soil types, organic manures and animal manures are better than inorganic fertilizers. Sandy soils often become water repellent when they become very dry. Again this can be overcome by liberal mulching with organic material.

Alkaline Soils

Soils which have an excess of calcium salts have a high pH, and are commonly referred to as limey or calcareous soils. Unhealthy plant growth is common in calcareous soils, usually because of the unavailability of elements such as zinc, iron and manganese. Some ferns, however, grow very well in calcareous soils and these are known as the lime lovers or calciphiles (see Appendix 9).

When there are large quantities of calcium present in the soil profile it is difficult to lower the pH, however, a few techniques can improve the soil and increase the range of species which can be grown. Once again the continued heavy application of organic matter will improve the soil structure and will have some acidifying effect. Elemental sulphur and aluminium sulphate are acidifying agents, but large quantities may be necessary for significant acidification.

Acid Soils

Soils with a pH less than 5.0 benefit from the addition of lime. Lime reduces acidity, supplies calcium which is often deficient in such soils, and reduces toxic levels of manganese and aluminium. The amount of lime to be added depends on factors such as the pH, soil type and the range of ferns to be grown. Some ferns are lime haters (calcifluges) and will only thrive in its absence (see Appendix 10). The majority of ferns, however, do respond to lime in acid soils. Soils with a pH of 4.5 will need more lime to reduce the acidity by one unit, than soils at a pH of 5.5. Clay soils have a capacity to buffer the addition of lime, without the corresponding pH change that occurs as when lime is added to sandy soils. It may also be very difficult to reduce the acidity of peaty soils because of their very acid nature and very high levels of organic matter.

ORGANIC SOIL ADDITIVES

Ferns like an organically rich soil and the addition of organic matter to the soil in which they are growing is beneficial, as it is to most garden soils. Some types of organic matter, however, are more beneficial than others.

Some organic materials are principally composed of carbon compounds such as cellulose and lignin and contain very little in the way of nitrogenous compounds. If these are added to the soil, without any prior treatment, they can impoverish the soil of nitrogen and cause deficiency in the surrounding ferns. This occurs simply because the bacteria which attack the cellulose compounds need nitrogen for their functions and reproduction. As there is insufficient nitrogen in the material being attacked, they use the reserves of nitrogen in the soil and they can compete very successfully for it with the fern roots. Such materials are described as having a high carbon : nitrogen ratio. Materials of this type can be successfully used as a mulch if nitrogenous fertilizers are added to the soil at the same time or if they are composted before being added to the soil. A large range of organic materials can be added to soils where ferns are to be grown.

Leaf Mould

Ferns love leaf mould both as a top dressing (or mulch) and when it is dug in prior to planting. A wide range of leaves exists and most of them seem to be beneficial as an organic additive. Those of the oak seem to be held in high esteem by fern fanciers, but even hard ligneous leaves like those of eucalypts can be satisfactory if treated correctly. Beech leaves are also good and they may be preferred by some ferns as they have an alkaline pH. Conifer leaves and pine needles are generally unsatisfactory because of resins and their ability to mat and shed water. Even these, though, may be appreciated by some ferns whose natural habitat is coniferous forest.

Leaves can be added directly as a mulch, however, if they are to be dug in to the soil it is best if they are first partially rotted and crumbly. This is simply achieved by stacking the leaves in a frame and keeping them moist. The leaves should be allowed to pack down under their own weight. For ligneous leaves such as eucalypts a light dressing of a nitrogenous fertilizer over each 30 cm (12 in) layer will aid in their partial breakdown. The leaves are usually ready for use after being stacked for 4-6 months. If first chopped with a rotary mower the time taken can be reduced by two thirds.

Peat Moss

Peat moss is the stable end product of sphagnum moss which has decayed over thousands of years under very acid conditions. It is very fibrous and has a high water holding capacity (peat moss can hold ten times its own weight in water, most of which is available for plant growth). It is an excellent soil additive and is appreciated by ferns. It is, however, very acid (pH 4.5-5.0) and lime loving ferns may need a lime additive. Peat moss is also very low in nutrients, but has the ability to hold added nutrients in a form

available for fern growth. Peat moss is scarce and expensive in some countries but freely available in others. It is one of the best organic ameliorants which can be added to soil.

Spent Hops

Spent hops are a useful organic soil additive for those who live near a brewery. Fresh hops can be too strong, but if the material is left in a heap and kept moist for 2-3 months it can then be used safely.

Sedge Peats

Sedge peat is derived from the organic material which has accumulated in swamps and bogs where rushes and sedges grow. In general, sedge peats are inferior in all respects when compared with peat moss. Sedge peats are extremely variable, some being quite fibrous, others black and powdery.

Some sedge peats are stable when exposed to the air while others break down and lose their structure. Sedge peats are generally less acid than sphagnum peats (pH 4-6) and are higher in nitrogen (some samples have up to 1% nitrogen). Some sedge peats may be unsuitable as soil additives because they contain high levels of salt.

Rice Hulls

Rice hulls can be a useful additive to garden soils but they do have a fairly high carbon : nitrogen ratio and can use up nitrogen reserves from the soil. Because of this, they are best composted or stored for a couple of months in a heap after sprinkling lightly with a nitrogenous fertilizer.

Peanut Shells

Peanut shells are soft and break down quite easily. They are an excellent organic material to add to soils and are commonly used in tropical regions. Heavy applications may tie up nitrogen, making necessary the use of nitrogenous fertilizers.

Seaweed

Seaweed is available in quantities on some beaches especially after storms and onshore blows. It can be used to make compost, or as a mulch, or dug into the soil. Seaweed is an excellent source of organic material and is rich in potassium. It is especially useful as an additive to sandy soils and has proved to be beneficial to ferns. Some growers hose the seaweed thoroughly before use to remove any salt.

Compost

Digging in well prepared compost is an excellent way of boosting the organic reserves of a soil. The compost can be made from a variety of organic materials including those with a high carbon : nitrogen ratio. Grinding or chopping the organic materials speeds up decomposition because it increases the surface area available for attack by the micro-organisms. Fertilizers or manures may have to be added to keep the decomposition process going. The finished compost has a neutral pH after first being acidic then alkaline. It is not a good idea to add any form of lime to the compost as large amounts of nitrogen can be lost to the atmosphere.

The basics of fern nutrition

Ferns, like other plants, must extract nutrients from the soil so that they can grow and reproduce. These nutrients or elements are present in the soil in various chemical forms and are taken up through the roots of the fern. They are essential for normal fern growth and development and though some are needed in large quantities (the major elements) others are only required in small amounts (the minor or trace elements). The elements listed below are essential for normal growth and development in most plants and it is assumed that ferns are no different.

Major Elements	*Minor Elements*
Nitrogen	Iron
Phosphorus	Manganese
Potassium	Boron
Magnesium	Zinc
Calcium	Copper
Sulphur	Molybdenum
	Chlorine
	Cobalt
	Sodium

As well as nutrients, ferns also need carbon dioxide, water and oxygen. Carbon dioxide is taken in from the air through the small pores in the fronds called stomata. Inside the frond it is converted by the process of photosynthesis into sugars, using the energy of the sun. Water and oxygen, which are vital for fern growth, are taken in through the roots.

Carbon Dioxide Enhancement

Carbon dioxide is present in the atmosphere as about 0.033% of the air. This is adequate for normal plant growth outside, but carbon dioxide can sometimes be deficient in greenhouses where ventilation is inadequate, or when cold weather necessitates them being closed. The enrichment of the atmosphere of a greenhouse to about 0.1% carbon dioxide can actually promote growth. This enrichment is carried out by injecting carbon dioxide gas directly into the atmosphere or by burning materials which release carbon dioxide, e.g. natural gas.

Nutrients in the Soil

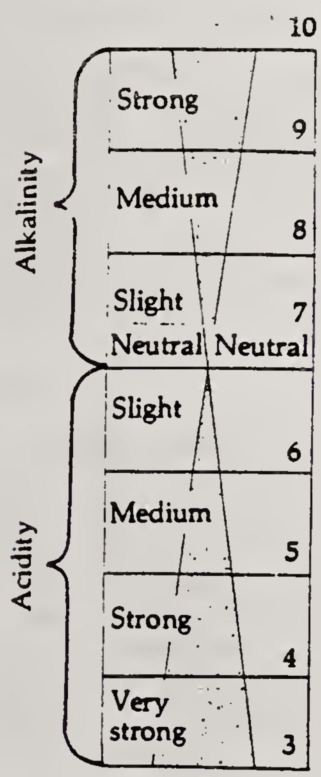
Healthy ferns need a balanced supply of all of the above elements. If only one is in short supply, growth will be reduced or malformed, despite an abundance of all the others. Most soils provide these elements in sufficient quantity for normal fern growth. Sometimes, however, they become short and we have to boost the levels present by the addition of manures or fertilizers. Sometimes an imbalance exists between different elements which disrupts growth and this is much more difficult to detect and correct. Strangely, although an element may be present in abundance in a soil, it may not be in a form available for plant growth. This is usually related to the acidity or alkalinity of the soil (see below). Waterlogging can also change the availability of elements to plants.

A rich soil promotes good growth because it has an abundance of elements present in forms which can be readily taken up by fern roots. This is particularly true of nitrogen which is required in good quantities for all plant growth. Soil reserves may be depleted by cropping, by the strong growth of grasses or weeds or by leaching following heavy rains. When soil reserves of nutrients are reduced, plant growth suffers. Normal growth resumes following the application of sufficient quantities of fertilizers or manures. Balanced applications are necessary since all plants grow better if a balance of nutrients is available to them, rather than if there is an excess of one particular element.

Acidity or Alkalinity

The acidity or alkalinity of a soil is extremely important since it critically affects the growth of ferns for the following reasons.

1. Ferns have acidity or alkalinity preferences. Many prefer to grow in acid soils, but there are a large number of species which will not tolerate such soils and will linger and die in them. These are the lime loving ferns or calciphiles and an alkaline soil is essential for their successful growth. Often an indication of their preference can be obtained from their habitat in nature and this can be confirmed by a simple test using a commercial kit (see below). Some ferns may have a very low tolerance of acidity or alkalinity yet others (the adaptable ones) will grow in a much wider range of acid or alkaline soils.
2. Extremes of acidity or alkalinity can influence the availability of some of the nutrients. Thus, in very



The soil pH scale

alkaline soils, iron and zinc may be unavailable to the ferns for growth, resulting in deficiency symptoms, and in very acid soils, manganese and aluminium may reach levels which are toxic.

The acidity or alkalinity of a soil can be measured by its pH. This is a logarithmic function of the hydrogen ions in the soil and its measure enables potential problems to be anticipated as well as allowing a direct comparison between soils. The pH scale ranges from 0–14 with 7 being neutral, 14 very alkaline and 1 very acid. Soils commonly range from pH4 to 9. The accompanying figure illustrates the pH scale. The pH of a soil can be measured accurately in laboratories using electronic apparatus. A very good field measure can be obtained by using a simple testing kit that is based on the colour changes in a mixture of dyes. These kits are generally cheap and can be quite effective.

DETAILS OF EACH ELEMENT

Nitrogen

Nitrogen is used in the fern for the formation of amino acids which are the building blocks of proteins. Nitrogen is also important in the formation of chlorophyll, which is the green pigment in fronds, essential for photosynthesis. Most of the air we breathe is composed of nitrogen (78%), but in this form it cannot be used by plants. Plants such as ferns can only absorb it from the soil as ammonium or nitrate which is released by the breakdown of organic materials. Nitrogen is readily lost from the soil by leaching following heavy rains or watering.

For vigorous growth, ferns need a steady supply of nitrogen throughout the growing season. Nitrogen encourages vegetative growth and produces a lush greenness in the fronds. If used in excess, however, it can weaken plants and may increase their susceptibility to some diseases and frost. Ferns suffering from a deficiency of nitrogen are usually stunted and have uniform, pale green or yellowish fronds which are smaller than normal.

Sources: Nitrogen is present in animal manures (see page 92), organic fertilizers (see page 90) and mixtures of inorganic fertilizers. The release of nitrogen from manures and organic fertilizers is usually slow and steady but that from inorganic fertilizers can be rapid. Nitrogen can be applied in a balanced mixture, or on its own as a specific chemical compound. These compounds are listed in the accompanying table. Applications of these materials must be used with care on ferns, especially slow growing types. They can be very useful on vigorous species (especially in the tropics) and the author has used materials such as urea with good effect on tree ferns.

Nitrogen can also be applied as a foliar spray (calcium nitrate 2 g/L [0.5 oz/gal] or urea 1.5 g/L [0.4 oz/gal]) or as a liquid fertilizer to the roots (ammonium nitrate 10 g/L [2.5 oz/gal], calcium nitrate (12 g/L [3 oz/gal]). For ferns in containers ammonium nitrate at 1 g/L (0.3 oz/gal) is adequate.

		Rate of Use	
Nitrogen Compound	*% Nitrogen*	*per square metre*	*per square yard*
Ammonium nitrate	35	250 g	9 oz
Calcium nitrate	15	500 g	18 oz
Ammonium sulphate	20	500 g	18 oz
Potassium nitrate	13	500 g	18 oz
Sodium nitrate	15	500 g	18 oz
Urea	46	150 g	5 oz

Phosphorus

Phosphorus is virtually used in every important process in plants. It is particularly significant in the

storage and supply of energy in respiration and photosynthesis. It is also important for root growth and reproduction. Phosphorus is deficient in the soils of many parts of the world. In some soils which are rich in iron or aluminium it may be present but is fixed in a form unavailable for plant growth. Phosphorus does not move readily through the soil and is not leached by rain or watering.

Phosphorus encourages strong growth in ferns and is important for a sturdy root system. Ferns deficient in phosphorus may be stunted with very dark green fronds and a reduced root system.

Sources: Phosphorus is present in animal manures (see page 92), organic fertilizers (see page 90), and mixtures of inorganic fertilizers. Phosphorus can also be applied as a specific fertilizer using materials such as superphosphate or ground rock phosphate. Ammonium phosphate, potassium phosphate and monocalcium phosphate are soluble compounds and can be used for foliar applications or as liquid fertilizers where rapid uptake is needed.

Potassium

Potassium is important for the lengthening of tissues such as stipes and stems, and also plays a major role in protection against disease by thickening the outer cell walls of plant tissues. It is also significant in chlorophyll formation, reproduction and root development. Potassium is commonly deficient in sandy soils and in soils that are cropped regularly.

Potassium is important for root development and disease resistance in ferns. Ferns deficient in potassium may show marginal patches or a border of dead tissue on the older fronds.

Sources: Potassium is present in animal manures (see page 92) and mixtures of inorganic fertilizers. Wood ash (3–10%) and seaweed (25%) are also a good source of potassium. Specific chemicals which can be used to supply potassium include potassium sulphate, potassium chloride and potassium nitrate. These are readily soluble. Liquid seaweed extracts are rich in potassium and can be useful for potted ferns.

Calcium

Calcium is an important element used in cell wall construction, cell division and protein formation. It is also very important for the development of a healthy root system. Calcium is commonly deficient in acid soils, especially the sandy types.

Ferns need calcium for sturdy growth and it is of special importance for the lime loving types. Ferns deficient in calcium develop stunted, distorted fronds which tend to die back from the tip. The root system is also reduced.

Sources: Calcium is present in some organic fertilizers (see page 90). It is also readily applied using ground limestone, hydrated lime, dolomite or gypsum. The first three are best used on acid soils since they also reduce the acidity. Gypsum does not alter the pH and also supplies sulphur (for details on forms of lime see page 93). Crushed egg shells and sea shells can be useful sources of calcium in potting mixes (see page 94).

Magnesium

This element is vital for photosynthesis since it is an important component of chlorophyll. Magnesium may be deficient in acid, sandy soils but is usually readily available in soils with a high clay content. It may be leached from sandy soils by rainfall or watering. Ferns deficient in magnesium may show a chlorosis on the older fronds with the main veins remaining dark green.

Sources: Magnesium can be applied as magnesium sulphate to the soil or as a foliar spray, 10–15 g/L (2–3 oz/gal) or by the use of dolomite. Successive foliar sprays may be necessary to correct severely deficient plants. Dolomite is useful on acid soils because it also reduces acidity.

Sulphur

Sulphur is an important constituent of some amino acids and chlorophyll, and is a necessary element in the formation of roots. Sulphur is commonly available in the organic matter of soils and is released as the organic matter breaks down. It may be deficient in sandy soils where the organic matter is low and the sulphur is readily leached.

Sulphur deficiency is not common and affected plants are a uniform pale green (similar to those deficient in nitrogen).

Sources: Sulphur, as a component of fertilizers such as superphosphate, or magnesium and potassium sulphate is frequently applied to ferns. It can also be applied as elemental sulphur or gypsum. It should be noted that elemental sulphur increases soil acidity and therefore perhaps should not be applied to acid soils. Gypsum on the other hand does not affect soil pH.

Iron

This element is needed in continuous small amounts for the functioning of chloroplasts and in enzymes. Iron is usually present in abundance in soils, however, it is not always available to plants because of interaction with other elements, particularly lime. In alkaline or calcareous soils a condition known as lime-induced iron chlorosis is common. Ferns that grow naturally on calcareous soils seem to handle this situation satisfactorily, however, those used to growing in acid soils may suffer severely. The symptoms in ferns are pale green to yellow new fronds with prominent dark veins. In severe cases brown patches appear in the fronds, which may eventually die.

Sources: The particular iron fertilizer used depends on the soil pH. Ferric sulphate is used if the soil pH is between 5 and 6, ferrous sulphate if between 6 and 7 and iron chelates if the pH is above 7. Iron chelates are mainly used to correct lime-induced iron chlorosis and are effective if applied to the soil around the plant and watered in.

Manganese

This element is required in small quantities for enzyme systems and is also used in photosynthesis.

It is commonly deficient in alkaline soils rich in organic matter. In very acid soils or those subject to water-logging manganese may be present in toxic amounts.

Ferns suffering from manganese deficiency may show curled or cupped fronds and chlorotic patches with the veins remaining green.

Sources: Very small amounts of manganese sulphate can be applied to the soil or used as a foliar spray, i.e. 2 g/L (0.4 oz/gal).

Boron

This element is required in small amounts for cell construction in actively growing parts such as meristems and root tips. Boron is frequently deficient in calcareous soils. On the other hand, soils formed from coastal sediments may have boron present in toxic amounts.

Ferns suffering from boron deficiency may show thickened, malformed fronds.

Sources: Small amounts of borax, i.e. 2-4 g/10 m^2 (0.05-0.15 oz/10 yd^2) can be applied or used as a foliar spray (boric acid at 1 g/L [0.2 oz/gal]).

Zinc

This element is of prime importance in plants for the production of growth hormones responsible for leaf and stem development and expansion. Zinc deficiency is common in calcareous soils and may also occur in heavily leached sands. Ferns with zinc deficiency produce markedly shortened, malformed fronds which may show irregular yellowish interveinal areas when young.

Sources: Small amounts of zinc sulphate can be added to the soil or applied as a foliar spray, i.e. 0.5 g/L (0.03-0.1 oz/gal).

Copper

This element is required in small quantities for use in enzyme systems. It is occasionally deficient in sandy soils and more frequently in calcareous soils. Ferns with copper deficiency may show wilting and dieback of young fronds or malformations.

Sources: Small amounts of copper sulphate readily correct this deficiency (about 10 g/10 m^2 [0.4 oz/10 yd^2]) or as a foliar spray of copper oxychloride 0.5 g/L (0.1 oz/gal).

The requirements of ferns for the elements molybdenum, chlorine, cobalt and sodium are uncertain.

Fertilizers, manures and lime

Despite some widely held beliefs to the contrary, ferns do respond to the artificial application of nutrients in the form of fertilizers and/or manures. The amount of these materials to be applied and the frequency of their application will vary with such factors as the richness of the soil and its organic content, the heaviness and frequency of rainfall and other climatic factors such as the temperature. Strong growing ferns need more nutrients and respond to manures and fertilizers more vigorously than do weaker or slow growing ferns.

Most ferns appreciate well-rotted animal manures or organic fertilizers such as bone meal, hoof and horn and blood and bone. Inorganic fertilizers can be very useful for strong, vigorous ferns such as tree-ferns, but should be used carefully on weak growing ferns. They are best applied in conjunction with organic mulches. Liquid fertilizers can be beneficial especially for ferns in containers, so too are organic extracts.

Fertilizers can be applied by digging into the soil prior to planting or by placing directly into the hole at planting time; slow release fertilizers are excellent for the latter method. After the ferns are established, fertilizers can be applied as regular top dressings on the soil surface, with several light applications in the growing season being preferable to one heavy application. The fertilizer should not be applied right against the active growing region or burning may result. The best times to apply fertilizers and/or manures is in spring or early summer while the plants have a long growing period ahead of them. An ideal time is when the fern is just starting on a flush of growth. Late applications of fertilizer or manures may interfere with the plants dormancy producing late growth and reducing its ability to survive a cold winter.

ORGANIC FERTILIZERS

Traditionally, organic fertilizers have been used in fern growing along with animal manures. As the name suggests, these materials are organic in origin and are composed of waste materials such as blood, blood and bone, bone meal, hoof and horn etc. All supply the major elements of nitrogen, phosphorus and calcium and, as well, have organic components which are useful in maintaining soil structure.

Organic fertilizers are favoured for ferns because they release their nutrients in a slow, gentle manner over quite a period of time; burning or plant damage is a rare occurrence. They are ideal for including in the hole at planting time or as a side dressing to maintain growth. They can also be added to potting mixes and are generally very beneficial to the growth of ferns in containers. Unfortunately, nowadays, they are not as commonly available as they used to be and are becoming more expensive. The nutrient composition of the commonly used organic fertilizers is shown in the accompanying table and a few details on each fertilizer follow.

Constituents of Commonly Used Organic Fertilizers

	% Nitrogen	*% Phosphorus*	*% Calcium*
Dried blood	12–15	–	–
Meat and bone	5–6	13–16	4–5
Blood and bone	4–7	4–7.5	5
Bone meal	2–4	2–8	3–5
Bone flour	0.5–1	6–12	2–4
Hoof and horn	12–14	1–2	3–5
Fish meal	7–9	3–8	–
Sewage sludge	4–6	2–4	–

Dried Blood

This material is obtained from abattoirs and killing works. It contains only nitrogen but is quite rich in this compound and promotes good, steady growth. It has a few drawbacks in that it is smelly, attracts dogs, rats etc. and may go mouldy if applied too thickly. These days dried blood is becoming very

difficult to obtain. Application rates are about 50 g/m^2 of soil (2 oz/yd^2).

Blood and Bone

This material is a mixture of dried blood and crushed bone and supplies nitrogen, phosphorus and calcium. It is an excellent fertilizer for ferns, and is very commonly used by fern enthusiasts. It can be incorporated into the soil or potting mix or applied as a side dressing. It releases the nutrients slowly over a period of time and promotes steady growth. Blood and bone has a few drawbacks, one of the worst being the smell which prohibits its use on indoor ferns. It also attracts dogs and other carrion eaters such as rats and these animals may severely damage ferns in their efforts to get at the blood and bone. If applied too thickly to the soil surface, blood and bone may go mouldy and the resulting fungus can spread to sensitive ferns. It is commonly applied at about 50-100 g/m^2 of soil (2-4 oz/yd^2).

Meat and Bone

Most of the remarks made under blood and bone apply here especially the smells, attraction to vermin and the growth of moulds. This material is richer in phosphorus than blood and bone.

Bone Meal

This material is simply crushed bone and may be either of a floury or a gritty texture. It has proved to be quite useful for ferns especially if added to a potting mix. The nitrogen level is too low for strong growth and may need supplementing. Unlike dried blood and blood and bone, bone meal does not have an offensive smell or attract dogs. It can be safely used at a rate of 100-150 g/m^2 of soil (4-6 oz/yd^2).

Bone Flour

This material is made by finely crushing bones that have been extracted for glue production. As well as being more finely ground than bone meal it is richer in phosphorus but poorer in nitrogen, as protein is extracted in the glue making process. It can be used at similar rates to those of bone meal.

Hoof and Horn

This is a crushed mixture of animal bones, hooves and horns. It is an excellent fertilizer for ferns being quite rich in nitrogen, with a useful component of phosphorus and calcium. It releases the nutrient steadily over a fairly long period and promotes good growth. Hoof and horn is an excellent additive to potting mixes for ferns and can also be used as a dressing for plants in the ground. It does not smell or attract animals. It is usually applied at 50 g/m^2 of soil (2 oz/yd^2).

Fish Meal

This is ground up fish which may have been processed for a chemical use such as oil extraction. It is an excellent fertilizer but is smelly and attracts dogs, cats and vermin.

Sewage Sludge

Sewage sludge is frequently available from sewage disposal centres. It is an excellent fertilizer for vegetables and fruits but its effect on ferns is unknown to the author.

INORGANIC FERTILIZERS

Inorganic fertilizers are manufactured chemicals which supply one or more nutrients for plant growth. They are usually simple inorganic salts and are nearly all freely soluble in water, i.e. they dissolve readily when applied to the soil, following rain or watering, and supply nutrients quickly to plants. Inorganic fertilizers are widely used in agriculture and horticulture and are a cheap means of supplying nutrients for plant growth.

Manufactured fertilizers are regarded by some people as unnatural and as having an adverse effect on the growth of plants. This is not so, but it is true that they have no organic component and therefore are of no benefit to the structure of the soil or the microbial flora and fauna. If used in conjunction with heavy mulches or organic matter, however, this drawback is eliminated and a maximum response is obtained from their application.

Complete Fertilizers

As the name suggests, these fertilizers supply a range of nutrients for plant growth. They are virtually inorganic fertilizers which have been mixed together in different combinations. Some complete fertilizers only supply nitrogen, phosphorus and potassium, whereas others may supply all the major and some of the minor elements. By changing the ratios of nutrients, these complete fertilizers can be used for different purposes, e.g. high nitrogen, low phosphorus and potassium for frond growth; or low nitrogen, high phosphorus and potassium for root growth and sporing.

Complete fertilizers are very useful as maintenance dressings for established ferns, either in pots or in the garden, but they should be used sparingly and not at high rates without prior testing. This is especially true for potted plants because rapid solubility of the fertilizers can result in burning of the roots, with resultant damage to the fronds. Complete fertilizers are excellent for maintaining the growth of ferns under established trees where root competition is a major problem. In the tropics, where leaching of soil nutrients is severe, they are very useful for maintaining growth and colour in vigorous ferns such as *Nephrolepis* and tree ferns. In these conditions they can be applied as a surface dressing every 6-8 weeks during the growing season at a rate of about 50-100 g/m^2 of soil (2-4 oz/yd^2).

Slow-release Fertilizers

Slow-release fertilizers are excellent for container-grown ferns because their nutrients are released gradually rather than in one short burst. They can be included in a potting mix or applied as a dressing on the top of the potting mix of established ferns. All slow-release fertilizers are manufactured chemicals and they release their nutrients over a given period of time. Slow-release fertilizers in the simple form can be slowly

soluble chemicals such as ureaformaldehyde. Most commonly, they are inorganic fertilizers coated with slowly soluble materials such as polymers or sulphur compounds. They are available in a variety of shapes and preparations from coarse lumps to granular pellets, rounded prills and even large tablets or plant pills.

Slow-release fertilizers are an ideal means of maintaining steady growth in ferns. In potting mixes, they are best distributed evenly through the mix, whereas for ferns in the ground they should be applied in small concentrations on the surface or buried shallowly. Some slow-release fertilizers only supply nitrogen, while others contain nitrogen, phosphorus, potassium and a few even include trace elements. Some of the polymer coated types operate on a timed release system with different coatings giving release rates from 3–4 months to 12-14 months. By mixing combinations of the different release rates, a steady release of nutrients can be maintained over a long period.

Liquid Fertilizers

Liquid fertilizers are a very popular form of promoting the growth of ferns in containers. There are many different commercial preparations available which are similar in their composition and effects on fern growth. Most of these consist of a balanced mixture of inorganic chemicals, although some organic extracts may also prove useful (see below). Liquid fertilizers must be readily soluble and easy to use. It is this solubility and ready availability to fern roots which makes them so suitable for ferns in containers or where a rapid response is needed for a fern in the ground. Application rates as recommended by the manufacturer should be followed.

Inorganic salts that are soluble in water can be applied in a liquid form. These can be specific chemicals used to correct a deficiency (e.g. potassium sulphate to supply potassium) or simply to promote strong growth (e.g. ammonium or calcium nitrate — see page 87 for rates).

Foliar Fertilizers

Some nutrients can be readily taken in through the leaves of plants, and hence ferns can be fed by foliar fertilizers through their fronds as well as their roots. Commercial mixtures are available for this purpose and should be used at the recommended strength. They are applied by spraying a dilute mixture onto the leaves. Some of the elements are absorbed rapidly within a few hours of application. The best time for foliar feeding is late in the evening or early in the morning when humidity is high. Uptake of nutrients is fastest in young fronds or those recently expanded, so be sure to wet them well. The fronds should be sprayed to run-off; any excess which drips on the soil can be taken up by the roots. The addition of a wetting agent at the recommended rate can help the material spread and stick to the fronds. A light spraying of water in between applications of nutrients can increase the uptake of remaining nutrients. Foliar feeding is best carried out during the warm, growing months at intervals of 2–4 weeks.

ORGANIC EXTRACTS

A few commercial products are available which are not strictly fertilizers but which, nevertheless, promote the growth of ferns. These are extracts of organic materials such as seaweed and fish. Seaweed extracts are used for a variety of plants and some specialist fern growers such as those growing maidenhairs and Boston ferns, swear by their use. Seaweed is rich in potassium, but growers claim that the growth responses from seaweed extracts are more than just an effect of this element. Fish emulsion is also used by fern growers and is also extremely popular with orchid enthusiasts. It has proved to be particularly beneficial to epiphytic species. One drawback of fish emulsion is the strong, distinctive smell which permeates the air where it has been used.

ANIMAL MANURES

Using animal manures to mulch or top dress ferns has the double benefit of providing plant nutrients as well as organic matter which is beneficial to soil structure and the microbial flora and fauna. The manures must, however, be old (at least 4–6 months) or well-rotted, because fresh manures can cause burning or result in soft, weak growth. Manures are very beneficial for problem soils. On sandy soils they provide important organic material and increase the water holding capacity and on clay soils they help aggregate the particles and improve drainage. Manures can also be used to make compost which can then be applied as a mulch or soil additive. Some manures, such as sheep manure, may contain grass and weed seeds and should be composted first.

Animal manures vary considerably in their chemical composition but all contain nitrogen, phosphorus and potassium. When fresh or in the early stages of decomposition, some are very rich in ammonia (e.g. chicken and horse manure). In this fresh form the ammonia will badly damage plant roots and can also be lost easily to the atmosphere. The chemical composition of commonly used animal manures is shown in the accompanying table.

Manure	*% Nitrogen*	*% Phosphorus*	*% Potassium*
Chicken	0.8–1.0	0.7–0.85	0.2–0.4
Horse	0.6–0.8	0.1–0.3	0.4–0.6
Cow	0.5–0.6	0.1–0.2	0.4–0.5
Pig	0.5–0.6	0.3–0.4	0.3–0.4
Sheep	0.8–0.9	0.3–0.4	0.8–1.0

Liquid Manures

Almost any animal manure may be applied to the soil around ferns in a liquid state. These liquid applications have the same advantages as liquid fertilizers but the disadvantages of being messy and smelly and hence are generally unsuitable for use indoors. Liquid manure can be simply made by adding solid animal manure to a drum of water and leaving it to steep until the nutrients are dissolved (usually 3–5 days is sufficient). The liquid fraction can then be removed and watered on direct or diluted further if it is very strong. The drum can be maintained by adding more manure and topping up with water as required. Liquid manure is best used as a side dressing every 6–8 weeks during the growing season and should not be applied so heavily that the roots become saturated.

LIME AND LIMING

Lime is of major importance to ferns, not only because it provides the element calcium, but also because it can reduce soil acidity and thus affect the availability of other elements for plant growth. Thus in very acid soils, levels of aluminium and manganese may be toxic, whereas deficiencies can occur in magnesium, calcium, sulphur and potassium. Lime is also useful in soils for maintaining structure (this is especially important in clay soils) and for bacterial and other microbial growth. It also offsets the acidity produced by chemical reactions when certain fertilizers are added to the soil, e.g. ammonium sulphate. Ferns in general seem to benefit from an annual dressing of lime with the exception of the lime haters, e.g. *Cryptogramma crispa* (see Appendix 10).

Forms of Lime

There are different forms of lime which can be used to raise the pH of soils. Lime occurs naturally as calcium carbonate and this may be present as limestone, seashells, marl or chalk. The lime commonly available for gardens is usually crushed or ground limestone. This is the easiest form to handle. When it is exposed to a hot, red flame the substance known as quicklime or calcium oxide is produced. Quicklime is extremely caustic to handle and it also causes rapid decomposition of animal and vegetable remains in the soil. It is therefore of considerable value in very acid soils or those very rich in stable, organic, fibrous materials such as peat soils. Quicklime takes up water from either the soil or the air to become slaked lime or calcium hydroxide. Over time, this calcium hydroxide reacts either with carbon dioxide in the atmosphere, or carbonic acid in the soil to form calcium carbonate once more. Dolomitic limestone is a mixture of calcium and magnesium carbonates and is mined from natural sources. Marble is metamorphosed limestone but is quite insoluble even when crushed, so it has limited value in supplying calcium.

The various forms of lime differ in their ability to reduce soil acidity. Quicklime is the most efficient, followed by slaked lime then ground limestone. Quicklime, however. is an unpleasant material to use and ground limestone is the commonest form applied to gardens. Dolomite is about half as effective as ground limestone in raising the pH, but can be valuable, as it also supplies the element, magnesium. In some countries, e.g. Spain and Portugal, Africa, USSR and USA, large natural deposits of calcium phosphate occur (termed phosphate of lime). When ground, these are a useful means of supplying phosphorus and calcium to the soil, but have a negligible effect on pH.

The amount of lime to be added to a soil to change the pH varies with the degree of acidity (see Acidity or Alkalinity page 86) and the soil type (see Acid Soils page 84). It is best to consult people with local experience before applying lime in any large quantities.

Limestone or Limerock

This is the naturally occurring rock which may be all calcium carbonate or have some other materials as impurities. Small limestone nodules, which occur naturally (e.g. in coastal sands), or limestone chips which can be obtained by breaking limestone with a hammer are useful for sprinkling around lime-loving ferns or adding to potting mixes. They should not be used to replace lime however, since their solubility is very slow and the amount of calcium they provide is minimal.

Chalk

This is a deposit of calcium carbonate usually mixed with clay and having other materials present. It may be hard, but usually crumbles on exposure to the air. It can be dug up, weathered and mixed with soil in the same way as lime.

Marl

These are materials which contain calcium carbonate bonded or mixed with other naturally occurring materials. Marls may be clayey, sandy, stony, chalky or shelly, depending on the material with which they are mixed. Some deposits are even found in peats. Marls frequently contain other useful plant nutrients such as phosphorus and potassium. They were amongst the earliest ameliorants to be added to soils and can be very beneficial. The amount of lime each contains varies with the location of the deposit and the type of marl. Chalk marl for example is much richer in calcium carbonate than is sandy marl. Clay marls can be of benefit in increasing the water holding capacity of sandy soils and sandy marls can open up heavy clays improving aeration and water penetration. Marls rich in shells may be advantageously added to potting mixes for ferns.

Calcareous Sands

These are a common form of calcium carbonate and may be found in inland regions or coastal districts where the deposits are rich in shells. They can be added to acid soils or used in potting mixes.

Egg Shells

These are a readily available form of calcium but should be crushed or powdered before use. A simple technique is first to dry the shells in an oven and then crush them in a mincer or blender. The powder can then be sprinkled on the soil or added to a potting mix.

Sea Shells

These are a convenient source of calcium for those who live near the sea. The shells are best broken or pounded before use. Some growers exclusively use oyster shells and claim that they are superior to any other shells.