NATURE'S NUTRIENTS AND DYNAMIC ACCUMULATORS

Legumes – Nature's Source of Nitrogen

You can raise some of your own nitrogen by growing leguminous plants, mainly members of the bean and pea family. Legumes gather nitrogen gas from the air through the nodules of beneficial bacteria on their roots. For me, the idea of growing my own nitrogen has always been appealing, but it turns out to be deceiving. To make good use of legumes, we need to understand exactly how the nitrogen is made and used by the plant.

The Life of a Legume

Many of the "pioneer" plants, those benevolent colonizers of disturbed, damaged, or infertile soils, are legumes. During the growing season, the nitrogen gathered by a legume's roots is banked in a temporary "savings account" in the stems and leaves of the entire plant. When the plant flowers, the demand for nitrogen overwhelms the roots, and the plant draws on its nitrogen savings account to make seed pods. Researchers have found that just before flowering as much as 60 percent of a legume's nitrogen is in the leaves, only half of it from root nodules. (See Fig. 17.1.) After seed pods formed, a mere 8 percent remains in the leaves, while 70 percent of the plant's total nitrogen has accumulated in the seeds. The roots and remaining nodules, after the seeds have matured, have even less nitrogen than the leaves – as little as 3 to 6 percent of the total accumulated by the plant. In short, legumes offer little nitrogen in a form other plants might use – they hoard it for the next generation.

A Myth: Beans Feed Corn

Many gardening books recommend planting corn and beans together so that the nitrogen-loving corn will prosper by the association. The thinking behind this axiom is ". . . the roots of legumes . . . take large amounts of nitrogen out of the air and make it available to the roots of other plants" (*Encyclopedia of Organic Gardening*, Rodale Press, 1978).

True, legumes improve the soil by adding nitrogen to it, but very little if any of the nitrogen gathered by a bean plant is going to be shared with the corn plant in the current season. The nitrogen accumulated by the bean's roots goes to its seeds. There are almost no studies to show an improved yield in corn grown with beans. I have found studies showing greater yields when a legume is intercropped with a grass (corn is in the grass family), but all are from tropical regions and not applicable

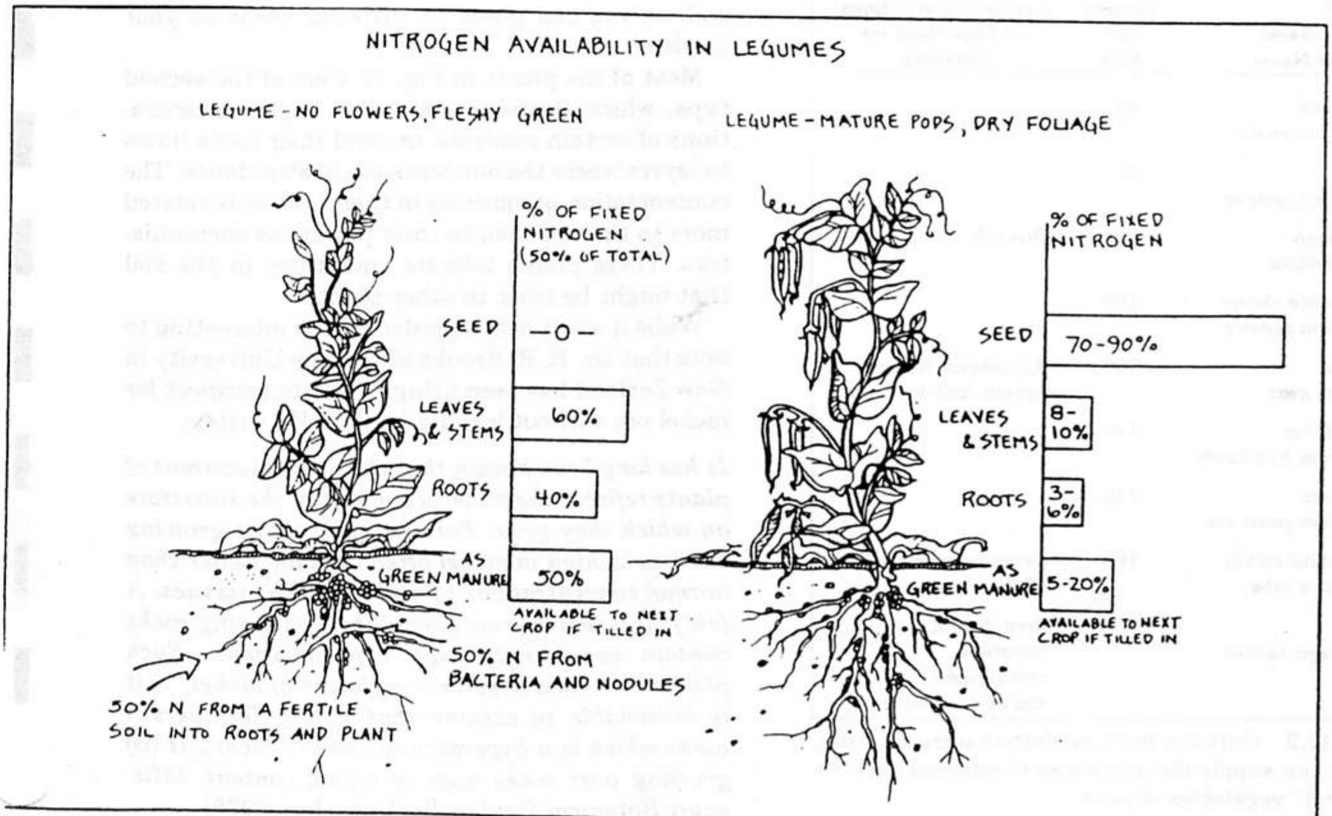

Figure 17.1 A legume offers the most nitrogen before it blooms. After the beans or seeds have been harvested, only a small amount of nitrogen remains for other plants.

Source: Designing and Maintaining Your Edible Landscape, Kourik.

to the United States. There are, however, numerous studies that substantiate the well-known and traditional practice of planting legumes in rotation with grains, corn, and cereal grains. (For details, see "A Five-Year Plan for Soil Improvement.")

Nitrogen for the Current Season

To get useful nitrogen from a legume during the current growing season, the nitrogen-fixing nodules must separate from the roots of the legume. Once released from their symbiotic association with the bean's roots, the nodules decompose and release their valuable nutrients.

Stress makes roots shed nodules. When bean plants die, the nodules separate (but too late to be of benefit to that season's corn). Drought, shading, and defoliation cause shedding, but such conditions stunt the corn. An animal grazing on a legume stimulates the shedding of nodules, but I don't know of any grazing animals that eat beans and not corn.

The amount of nitrogen gathered by a legume in one season per acre ranges from 40 pounds to as high as 250 pounds, depending on the legume. The numbers in Fig. 17.2 are not accurate to the pound (results var·· considerably from soil to soil and from climat. to climate), but the relative ranking holds true.

Nitrogen Gathered by Legumes

Legume: Common Name Botanical Name	Pounds per Acre	Vegetables with Equal or Less Need for Nitrogen
Field beans *Pisum arvensis*	40	
Peanuts *Arachis hypogae*	40	
Hairy vetch *Vicia villosa*	80	Broccoli
Dutch white clover *Trifolium repens*	100	
Soybeans *Glycine max*	100	Asparagus, lettuce, squash, and broccoli
Alsike clover *Trifolium hybridum*	140	
Red Clover *Trifolium pratense*	140	
Sweet white clover *Melilotus alba*	160	Sweet potatoes and all the above
Alfalfa *Medicago sativa*	250	Corn, beans, tomatoes, cantaloupes, and all the above

Figure 17.2 Only the most productive nitrogen-fixing legumes can supply the quantities of nitrogen that the "hungriest" vegetables require.

No legume grows well in all climates. Figure 17.3 lists the best legumes for climates around the country. For more accurate information, consult your local cooperative extension agent, the soil conservation office, local landscapers, and farmers.

Dynamic Accumulators

One of my goals as a contempor..·· organic gardener is to try to be self-sufficient w.th fertilizers. For the old-timers, cycling nutrients within a farm was a fact of life. Of course, some cheated b·· exhausting the soil and moving on. But the goo.. farmers used dynamic accumulators, or plants that amass a greater than usual amount of a particular nutrient in their foliage.

Are there plants that accumulate an element in higher concentrations than other plants, even on soils deficient in that element? Or do the accumulators in Fig. 17.4 simply grow where there are especially high concentrations of the element they supposedly concentrate? This question is hotly debated, and it is a favorite of mine. The answer probably falls somewhere in the middle, embracing two types of plants. The first type is plants that accumulate a mineral even in soils low or deficient in that particular mineral. We've already considered one example, for nitrogen – the legume family. The presence of legumes is often a clue that the soil is low in nitrogen, but this applies only to natural conditions. Legumes also grow in nitrogen-rich soil, as you can prove by growing beans in your garden.

Most of the plants in Fig. 17.4 are of the second type, which thrive in soils with high concentrations of certain minerals, or send their roots down to layers where the nutrients are in abundance. The concentration of minerals in their tissues is related more to the soil than to their powers as accumulators. These plants tolerate conditions in the soil that might be toxic to other plants.

While it won't help a gardener, it is interesting to note that Dr. R. R. Brooks of Massey University in New Zealand has been using plants to prospect for nickel ore without leaving his lab. He writes:

It has long been known that the mineral content of plants reflects the mineral content of the substrate on which they grow. For example, plants growing over rocks high in nickel often contain higher than normal concentrations of nickel in their tissues. A few plants which grow over nickel-containing rocks contain exceedingly high concentrations. Such plants are called hyperaccumulators of nickel . . . it is reasonable to assume that if one discovers a plant which is a hyperaccumulator of nickel, it [is] *growing over rocks high in nickel content.* (*Missouri Botanical Garden Bulletin*, Jan. 1978)

A similar approach has been used to locate copper and selenium deposits. (The ornate way that scientists describe this research is "geobotany and biogeochemistry in mineral exploration"!)

Accumulator plants can correct soil nutrient problems. For example, a zinc deficiency of corn in Florida was corrected by allowing zinc-accumulating "weeds" to flourish during years when the field was fallow. After these accumulators were tilled into the soil, the corn crop grew without signs of deficiency. Use Fig. 17.4 to design your soil-building program. Grow accumulator plants in or around your landscape to gather nutrients for use in the edible areas.

Phosphate Accumulators

Legumes accumulate phosphorus and help release it from the soil. For example, when alfalfa is left in the field, there is a slow improvement in the soil's supply of available phosphorus. Using alfalfa, or any of the legumes, as a cover crop or green manure is a way to enhance the cycling of phosphorus within your backyard. (Details are explained in the next chapter.) Two other important accumulators are buckwheat and mustards. All three not only dissolve and absorb the mineralized forms of phosphorus, but actually exhibit a "subsequent excretion [out of the roots] of appreciable amounts of the phosphorus [absorbed]." ("Root Interactions of Plants," W. F. Loehwing, *The Botanical Review*, 1977.) Mustard is a good-soil improving crop for the cooler part of the season, while buckwheat is an excellent soil builder for the summer. Mustards have deeper roots and a more taprootlike structure. They are useful in improving the drainage and tilth of deeper, clay soils. Buckwheat has a more fibrous and somewhat shallower root system. The large quantities of fiber deposited in the soil by buckwheat roots help to loosen a clay soil and improve the moisture and nutrient retention of a sandy soil. All three of these plants – alfalfa, mustard, buckwheat – deserve an important

GREEN MANURE PLANTS

Common Name	Legume	Soil Preference	Lime Requirements (Low, Medium or High)	Adapted to Soils of Low Fertility	Relative Longevity of Seed	Seeding Rate (lbs. per acre)	Seeding Rate (lbs. per 1000 sq. ft.)	Depth to Cover Seed	N.E. and N.C. States	Southern and S.E. States	Gulf Coast and Florida	Northwestern States	Southwestern States	When to Sow	When to Turn Under	Comments
Alfalfa	Yes	Dry Loams	L		Long	15	1	½	•			•		Spring 2nd Year at 1st Blossom	Spring or Early Fall	Fixes nitrogen in soil. Deep roots bring trace elements to surface
Barley	No	Loams	L		Long	100	2½	¾	•			•	•	Spring Fall	Summer Spring	Not good on sandy or acid soils. Sow spring varieties in north, winter varieties in milder climates.
Beans – Mung	Yes	Widely Adaptable	L	•	Short	70	2	1		•	•		•	Spring or Summer	Summer or Fall	Warm weather crops. Do not sow until ground is warm and weather is settled.
Beans – Soy	Yes	Loams	M		Short	90	2½	1½	•	•	•	•	•	Spring or Summer	Summer or Fall	
Beans – Velvet	Yes	Loams	L	•	Short	120	4	2			•			Spring or Summer	Summer or Fall	
Begger Weed	Yes	Sandy Loams	L	•		15	⅓	⅓			•			Spring or Early Summer	Summer or Fall	Seeding rate is for scarified seed. Treble the amount if unhulled seed is used
Brome Grass, Field	No	Widely Adaptable	L		Long	30	1	½	•					Fall Spring	Spring Fall	Good winter cover. Easy to establish. Hardier than rye. More heat tolerant
Buckwheat	No	Widely Adaptable	L	•		50	1½	¾	•			•		Late Spring and Summer	Summer or Fall	Quick growing. Plant only after ground is warm.
Bur Clover	Yes	Heavy Loams	M		Long	30	1	½		•	•	•	•	Fall	Spring	Not winter hardy north. One of the best winter crops where mild winters prevail.
Chess or Cheat Grass	No	Loams	L		Long	40	1	¾					•	Fall	Spring	
Clover – Alsike	Yes	Heavy Loams	M		Long	8	¼	½	•			•	•	Spring Fall	Fall Spring	Less sensitive to soil acidity and poorly drained soils than most clovers
Clover – Crimson	Yes	Loams	M	•	Medium	30	1	½	•	•	•	•	•	Fall Spring	Spring Fall	Not winter hardy north. A good winter annual from New Jersey southward
Clover – Subterranean	Yes	Loams	M		Medium	30	1	½		•	•	•	•	Fall	Spring	
Corn	No	Widely Adaptable	L		Medium	90	2½	1	•	•	•	•	•	Spring or Summer	Summer or Fall	Do not sow until ground is warm
Cow-Pea	Yes	Sandy Loams	L	•	Short	90	2½	1½		•	•		•	Late Spring or Early Summer	Summer or Fall	Withstands drought and moderate shade well. Do not sow until weather is warm and settled.
Crotalaria	Yes	Light Loams	L	•	Long	15	½	¾		•	•		•	Spring or Summer	Summer or Fall	Does well on acid soils. Resistant to root knot nematode. Sow scarified seed.
Fenugreek	Yes	Loams	L		Long	35	1	½					•	Fall	Spring	
Guar	Yes	Widely Adaptable	L	•	Long	40	1½	1					•	Spring or Early Summer	Summer or Fall	Thrives on warm soils. Do not plant too early.
Indigo, Hairy	Yes	Sandy Loams	L	•	Short	10	⅓	½		•	•		•	Spring or Early Summer	Summer or Fall	
Kale, Scotch	No	Widely Adaptable	H	•	Long	14	⅓	½	•	•	•	•	•	Summer or Fall	Spring	Can be eaten after serving as winter cover. In Northern areas interplant with winter rye for protection. Except in deep south, plant in summer for good growth before frost.
Lespedeza – Common	Yes	Loams	L	•	Short	25	1	½		•				Early Spring	Summer or Fall	Easy to establish on hard, badly eroded soils. Good on acid soils of low fertility.
Lespedeza – Korean	Yes	Loams	L	•	Short	25	1	½		•				Early Spring	Summer or Fall	
Lespedeza – Sericea	Yes	Loams	L	•	Medium	25	1	½		•			•	Early Spring	Summer or Fall	
Lupine – Blue	Yes	Sandy Loams	L		Short	100	2½	1			•			Spring Fall	Summer Spring	Less popular than the yellow lupine and blue lupine. Good on sour and acid soils.
Lupine – White	Yes	Sandy Loams	L		Short	120	2½	1	•		•			Spring Fall	Summer Spring	
Lupine – Yellow	Yes	Sandy Loams	L		Short	80	2	1	•		•			Spring Fall	Summer Spring	
Millet	No	Sandy Loams	L		Long	30	1	½	•					Late Spring or Summer	Summer or Fall	Sow only after ground is warm, a week or ten days after normal corn planting time. Fast growing.
Mustard, White	No	Loams				8	¼	¼	•					Spring	Summer	

continued

Figure 17.3 Choose the cover crop plants best suited to your yard's soil and climate from this chart of options.

Figure 17.3 continued

GREEN MANURE PLANTS

Common Name	Legume	Soil Preference	Lime Requirements (Low, Medium or High)	Adapted to Soils of Low Fertility	Relative Longevity of Seed	Seeding Rate (lbs. per acre)	Seeding Rate (lbs. per 1000 sq. ft.)	Depth to Cover Seed	N.E. and N.C. States (Areas For Which Best Adapted)	Southern and S.E. States	Gulf Coast and Florida	Northwestern States	Southwestern States	When to Sow	When to Turn Under	Comments
Oats	No	Widely Adaptable	L		Long	100	2½	1	•	•	•	•	•	Spring Fall	Summer or Fall Spring	Winter oats (sown in fall) are suitable only where mild winters prevail.
Pea, Field	Yes	Heavy loams	M		Short	90	2½	1½	•	•	•	•	•	Early Spring Fall	Summer Spring	Sow in fall only where winters are mild. Distinctly a cool weather crop.
Pea, Rough	Yes	Sandy loams	L	•	Medium	60	1½	1		•				Fall	Spring	
Pea, Tangier	Yes		M		Medium	80	2½	1	•				•	Spring	Summer	
Rape	No	Loams	L			8	½	½	•			•		Spring or Summer	Summer or Fall	
Rescue Grass	No	Widely Adaptable	L		Long	35	1	¾		•			•			Adapted to mild winters and humid climates.
Rye, Spring	No	Widely Adaptable	L		Long	90	2	¾	•	•				Spring	Summer	
Rye, Winter	No	Widely Adaptable	L		Long	90	2	¾	•	•				Fall	Spring	One of the most important winter cover crops. Can be sown late
Rye-Grass, Italian	No	Widely Adaptable	L		Long	35	1	¾	•	•	•	•	•	Fall Spring	Spring Summer	An important winter cover crop where winters are mild. In severe climates sow in spring or summer
Sesbania	Yes	Widely Adaptable	L	•	Long	25	1	¾		•	•		•	Spring or Summer	Summer or Fall	Quick grower. Is better adapted to wet soils and will grow at higher altitudes than crotalaria
Sorghum	No	Light Loams			Long	90	2½	¾	•	•			•	Late Spring or Summer	Summer or Fall	Do not sow until ground is warm and weather is settled. More drought resistant than corn.
Sudan Grass	No	Widely Adaptable	L		Long	35	1	¾	•	•	•	•	•	Late Spring or Summer	Summer or Fall	Rapid grower. Do not sow until ground is warm and weather is settled.
Sunflower	No	Widely Adaptable	L			20	¾	¾	•	•	•	•	•	Spring or Summer	Summer or Fall	Intolerant of acid soils
Sweet-Clover, Common White	Yes	Heavy loams	H		Long	15	½	½	•	•		•	•			Quite winter hardy. Best results are from fall sowing
Sweet-Clover, Annual (Hubam)	Yes	Loams	H		Long	15	½	½	•			•				A true annual. Best results from spring sowings
Sweet-Clover, Yellow	Yes	Loams	H		Long	15	½	½	•	•		•	•			Stands dry conditions better than common white sweet clover
Sweet-Clover, Yellow Annual	Yes	Loams	H		Long	15	½	½	•	•	•	•	•			Most useful south of the cotton belt as winter cover. North not winter hardy. Makes short summer growth
Vetch, Common	Yes	Widely Adaptable	L		Medium	60	1½	¾	•	•	•	•	•	Spring Fall	Fall Spring	Not winter hardy where severe cold is experienced. Needs reasonably fertile soil
Vetch, Hairy	Yes	Widely Adaptable	L	•	Long	60	1½	¾	•	•	•	•	•	Spring Fall	Fall Spring	The most winter hardy vetch. Best sown in fall mixed with winter rye or winter wheat.
Vetch, Hungarian	Yes	Heavy loams	L		Long	60	1½	¾	•	•		•	•	Spring Fall	Fall Spring	Next to hairy vetch the most winter hardy of the vetches. Not winter hardy where winters are severe. Needs fairly fertile soil.
Vetch, Purple	Yes	Loams	L		Long	60	1½	¾	•	•	•	•	•	Spring Fall	Fall Spring	Least hardy of the vetches. Suited for winter cover in mild climates only
Vetch, Woolly Pod	Yes	Widely Adaptable	L		Long	60	1½	¾	•	•	•	•	•	Spring Fall	Fall Spring	
Wheat, Winter	No	Loams	L		Long	100	2½	¾	•			•		Fall	Spring	

Used by permission. From: *Improving Garden Soil with Green Manure* by Richard Alther and Richard (Dick) Raymond, published by Garden Way Publishing. This and other gardening books may be purchased from Storey Communications, P.O. Box 105, Pownal, VT 05261.

role in the design and maintenance of your edible landscape.

Potassium Accumulators

Dynamic accumulators can increase your landscape's supply of potash, an element as difficult to liberate from its mineral state in the soil as phosphorus. Once a plant has freed an element from its mineral form and used it to grow, you can recycle the element for the growth of other plants in a number of ways—composting, mulching, cover cropping, and green manuring. An interesting example of a potash accumulator is the bracken fern (see Fig. 17.4), used as a source of potash for washing in the early 1900s in England. (Many current detergents are potassium based.) "During the summer the leaves were collected green, dried and then burned and the resulting ash . . . was then moistened and moulded into balls, which were used in washing; but the cheapness of soda has now killed this industry." (*The Story of the Bracken Fern*, H. C. Long.) Alan Chadwick, the father of biodynamic French intensive gardening, had his students collect green bracken ferns each spring which were then composted for root crops. He was probably practicing English folklore, and with good reason: green bracken ferns average 25 percent potash and can contain as much as 55 percent. From weed to asset!

Calcium Accumulators

Oak leaves are dynamic accumulators of calcium. It's fascinating that there can be high levels of calcium in the leaves even when the soil has barely detectable or very low levels of available calcium. Alan Chadwick appreciated the value of oak leaves—he taught his students to line the bottom of seed flats with oak leaves and broken eggshells as sources of calcium. A better way to make calcium available to plants is to mix oak leaves with a nitrogen fertilizer, compost them, and use the finished compost in the seed flats or in your edible landscape.

Fig. 17.4

DYNAMIC ACCUMULATORS

Name	Botanical Name	Sodium	Iodine	Flourine	Boron	Silica	Sulfur	Nitrogen	Magnesium	Calcium	Potassium	Phosphorus	Manganese	Iron	Copper	Cobalt
Alfalfa	*Medicago sativa*							X						X		
Arrowroot										X						
Bladderwrack			X						X					X		
Borage	*Borago officinalis*					X					X					
Bracken, eastern	*Pteridium aquifolium*										X	X	X	X	X	X
Bridal bower												X				
Broom drops									X							
Buckwheat	*Fagopyrum esculentums*											X				
Burdock	*Arctium minus*													X		
Calamus							X				X	X				
Caragreen		X					X			X						
Caraway	*Carum carvi*											X				
Carrot leaves	*Daucus carota*								X		X					
Cattail	*Typha latifolia*							X								
Century											X					
Chamomile, corn	*Anthemis arvensis*									X	X					
Chamomile, German	*Chamomilla recutita*									X	X	X				
Chickweed	*Stellaria media*										X	X	X			
Chicory	*Cichorium intybus*									X	X					
Chives	*Allium sp.*	X								X						
Cleavers	*Galium aparine*	X								X						
Clovers	*Trifolium sp.*							X				X				
Clover, hop	*Medicago lupulina*							X				X				
Clover, rabbit foot								X				X				
Clover, red	*Trifolium protense*							X				X				
Clover, white	*Trifolium repens*							X				X				
Coltsfoot							X		X	X	X			X	X	
Comfrey	*Symphytum officinale*					X		X	X	X	X			X		
Dandelion	*Taraxacum vulgare*	X				X			X	X	X	X		X	X	
Devil's bit	*Veratrum californicum*		X						X					X		
Docks	*Rumex sp.*									X	X	X		X		
Dock, broad leaved	*Rumex obtusifolias*									X	X	X		X		
Dulse		X	X						X	X				X		
Eyebright	*Anagallis arvensis*						X				X					
Fat hen	*Atriplex hastata*									X				X		
Fennel	*Foeniculum vulgare*	X					X				X					
Flax, seed	*Linum usitatissimum*									X						
Garlic	*Allium sativum*			X			X					X				
Groundsel	*Senecio vulgaris*													X		
Horsetails	*Equisetum sp.*					X			X	X				X		X
Horsetail, field	*Equisetum arvense*					X			X	X				X		X
Horsetail, marsh						X			X	X				X		X
Iceland moss			X													
Irish moss														X		
Kelp		X	X					X	X	X				X		
Lamb's quarters	*Chenopodium album*							X		X	X	X	X			
Lemon Balm	*Melissa officinalis*											X				
Licorice root, leaves								X				X				
Lupine	*Lupinus sp.*							X				X				
Marigold, flowers	*Tagetes sp.*											X				
Meadow sweet	*Astilbe sp.*	X					X		X	X		X		X		

continued

continued

DYNAMIC ACCUMULATORS

Name	Botanical Name	Sodium	Iodine	Flourine	Boron	Silica	Sulfur	Nitrogen	Magnesium	Calcium	Potassium	Phosphorus	Manganese	Iron	Copper	Cobalt
Mistletoe									X							
Mullein, common	*Verbascum sp.*						X		X		X			X		
Mustards	*Brassica sp.*						X					X				
Nettles, stinging	*Urtica urens*	X					X	X		X	X			X	X	
Oak, bark	*Quercus sp.*										X					
Oat Straw						X										
Parsley									X	X	X			X		
Peppermint	*Mentha piperita*								X		X					
Pigweed, red root	*Amaranthus retroflexus*									X	X	X		X		
Plantains	*Plantago sp.*					X	X			X	X			X	X	
Primrose	*Oenothera biennis*								X							
Purslane	*Portulaca oleracea*									X		X		X		
Rest harrow		X					X		X	X				X		
Salad burnet	*Poterium sanguisorba*													X		
Sanicle											X					
Sarsparilla			X													
Savory	*Satureja sp.*											X				
Scarlet Pimpernel	*Anagallis arvensis*									X						
Shepherd's purse	*Capsella bursa-pastoris*	X					X			X						
Silverweed										X	X				X	
Skunk cabbage	*Navarretia squarrosa*								X							
Sorrel, garden	*Rumex sp.*	X								X		X				
Sorrel, sheep	*Rumex acetosella*	X								X		X				
Sow thistle	*Sonchus arvensis*								X		X				X	
Spurges	*Euphorbia sp.*				X											
Strawberry, leaves	*Fragaria sp.*													X		
Tansy	*Tanacetum vulgare*										X					
Thistle, Canada	*Cirsium arvense*													X		
Thistle, creeping	*Sonchus arvensis*									X	X			X		
Thistle, nodding	*Carduus nutans*													X		
Thistle, Russian	*Salsola pestifer*													X		
Toadflax	*Linaria vulgaris*								X	X				X		
Tobacco, stems/stalk	*Nicotiana sp.*							X								
Valerian	*Valeriana officinalis*					X										
Vetches	*Vicia sp.*							X			X	X			X	X
Watercress	*Nasturtium officinale*	X		X			X		X	X	X	X		X		
Waywort		X					X				X					
Willow, bark	*Salix sp.*								X							
Willow, black	*Salix sp.*	X														
Wintergreen	*Gaultheria procumbens*								X							
Yarrow	*Achilea millefolium*							X			X	X			X	

The above data are from the following sources:

Cocannouer, Joseph. *Weeds: Guardians of the Soil.* New York: Devin-Adair, 1950.
Easey, Ben. *Practical Organic Gardening.* London: Faber & Faber, 1955.
Gibbons, Euell. *Stalking the Healthful Herbs.* New York: McKay Publishing, 1966.
Hill, Stuart. *Weeds as Indicators of Soil Conditions.* MacDonald Journal, June 1977.
Pfeiffer, Ehrenfried. *Weeds and What They Tell.* Springfield, IL: BioDynamic Farming and Gardening, n.d.
Rateaver, Gargyla and Gylver. *The Organic Method Primer.* Pauma Valley, CA: B. and G. Rateaver, 1973.

Additional citations in numerous scientific journals were graciously provided by Ron Whitehurst, horticultural author and consultant.

Figure 17.4