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Test Your Soil With Plants!

by John Beeby

Discover how you can
tell what fertilizers to use
to optimize your garden's health
and productivity simply by observing
the plants growing in your garden!

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To all caretakers of soil and life

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FOREWORD

For thousands of years before the advent of increased chemical use in agriculture, farmers tested their soils by evaluating the wild and cultivated plants growing in their fields. This skill has been lost during the last century, though a few out-of-print books on determining nutrient deficiencies by "reading" plant symptoms are accessible to the public. John Beeby has condensed the wisdom, skill and science from a five-foot pile of hard-to-find publications into *Test Your Soil With Plants*. Now we can begin to rediscover this very practical art without the use of expensive soil tests. The relearning *process* will take us many years to reclaim this knowledge for ourselves, while we begin to rebuild our own soils and those of the world. As more is learned, *Test Your Soil With Plants* will be further developed and expanded through experience. In the meantime, we all have a wonderful "tool" to begin this process.

John Jeavons
Willits, California
April, 1997

PREFACE

This booklet is essentially an English-Plant Dictionary. With it, a few key plant identification books, and your powers of observation and of growing specific, cultivated "indicator" crops, you will be able to analyze the soil with plants and work with them to improve the health of the soil. Improving soil and knowing that the effects will benefit not only you and your family, but the generations to come, is one of the most gratifying endeavors I have known. Enjoy!

ACKNOWLEDGEMENTS

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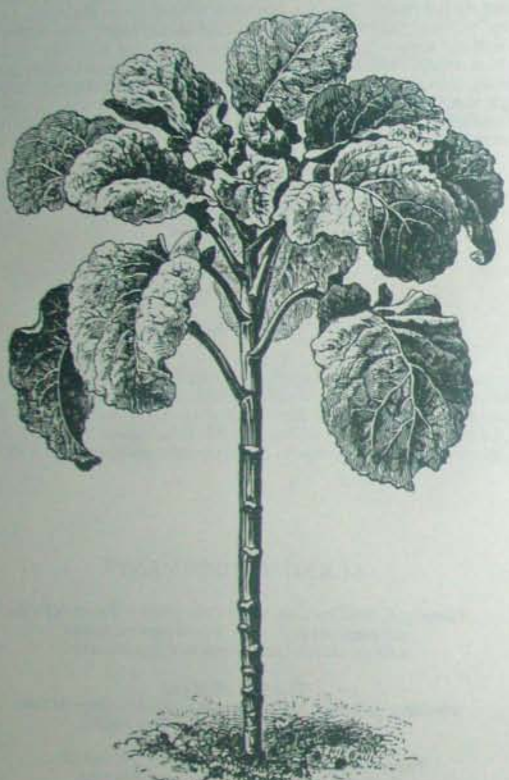
Thanks to all of you who have supported and continue to support Ecology Action, helping to make so much good work happen.

Thank you, caretakers and nurturers of soil and life. Your efforts are needed, now more than ever.



INTRODUCTION

Take a look at the ground, at just a small patch of soil and plants. Take a *good* look. It may be the last time you will be able to see that piece of ground and those plants through the same eyes.

Notice the number of different kinds of plants growing in that soil, perhaps some so small and inconspicuous you have to get down on your hands and knees to see, perhaps others that tower above you. Realize that each one of those plants, and every plant, speaks of the conditions in which it grows. The language it speaks can only be seen, not heard. Through its presence, form, color and vigor, each plant describes in general or very specific terms the history, fertility, texture, nutrient content and many other conditions of the soil. The simple fact that a particular plant is growing there is telling you something. The fact that the plant is stunted and its growing tips are withered is telling you something. The fact that its color is a deep green, but it seems not to be vigorous, is telling you something.

Now, take a look at that little patch of ground and plants again, and imagine the hundreds, maybe thousands, of pieces of information that are being communicated to you!

The Analysis of Soils -- Yesterday and Today

For hundreds of years, farmers were able to predict the agricultural value of land by observing the plants that grew on it. From their observations, they could tell two different things depending on what kinds of plants they were observing: 1) the history of the soil; and 2) the effect their farming was having on the soil. Native plants, especially perennials and trees, are indicators of the soil and climatic conditions that they have experienced over the many years of their lives. They are books that the observant and knowledgeable farmers were able to read and understand. If those observations convinced them to farm a particular piece of land, these farmers could tell by the annual and perennial crops they grew and the weeds that came up with their crops how the soil's fertility had been affected by their farming practices. This information allowed farmers to rely on their own knowledge and power of observation to effectively manage the soil.

Now, farmers, if they are able, usually send samples of the soil to a scientist who analyzes it with chemicals, not living plants. Through the chemical analysis of soil, the scientist can determine with some accuracy what nutrients and what quantities of those nutrients need to be added to balance the soil and optimize its fertility and crop production. However, there are two main disadvantages to chemical analysis of soil.

The first disadvantage is that the analysis reflects the soil's condition at only one point in time -- when the soil sample was taken. However, the presence and availability of soil nutrients, as well as organic matter, change with time, sometimes dramatically. Therefore, for true accuracy, many chemical soil tests are needed to determine what nutrients and what quantities of those nutrients need to be added to the soil.

The second disadvantage is that kits for accurately testing the soil, or reputable soil testing services that can test the soil, accurately analyze the results and recommend available, affordable and environmentally friendly fertilizers, are often too expensive and/or are not easily available to many people in the world.

Using plants to analyze the soil overcomes these two disadvantages. First, plants describe the soil and climate that they are experiencing every moment that they are alive. Need a soil test? Just go out to the farm and look at the plants! It is essentially as easy and self-reliant as that. Second, to grow the wild plants you will observe requires nothing from you. To grow the cultivated plants you will observe will only take a little digging in the soil and planting a seed that you can buy or have saved, and in many cases these cultivated "indicator" plants are simply plants that you already were planning on growing, like tomatoes, corn, potatoes, and beets. Using plants to test the soil also requires little training, no expensive equipment, and none of the toxic chemicals sometimes used in the chemical analysis of soil. Testing the soil then is possible for anyone, regardless of their access to money or technology.

The Most Modern Technology

This booklet is a synthesis of past and modern research. Within this booklet, you will find a unique and easy-to-use compilation of the old knowledge of what plants tell about the conditions of the soil in which they live. You will also find the latest knowledge of how to improve the soil's fertility with organic fertilizers -- fertilizers that can often be made from commonly found plants and animals -- so that you know the most effective, ecological and modern way to correct any soil imbalances indicated by the plants you observe.

To achieve these two goals, the booklet is divided into two primary parts. The first part is the *Wild Plant Kit*, which interprets information on soil conditions from the presence of individual, generally non-cultivated plants. You will rely on the *Wild Plant Kit* entirely when you are first assessing the agricultural potential of land that is not currently growing any cultivated plants.

The second part of the booklet is the *Cultivated Plant Kit*, which is designed to complement the assessment drawn with the *Wild Plant Kit*. The *Cultivated Plant Kit* is specifically designed to help you determine with more accuracy and speed any deficiencies and/or excesses of *soil mineral nutrients*, such as nitrogen, phosphorus, potassium, calcium, magnesium and trace elements. The advantage of the *Cultivated Plant Kit* is that you do not need to wait for the wild plant indicators to appear to determine soil mineral conditions. Instead, you simply plant seeds, grow the plants, and observe their size, shape, color and vigor. Then, with the help of the tables in the *Cultivated Plant Kit*, you can determine the soil minerals that are deficient or in abundance and add the appropriate amount of minerals in the form of purchased or home-produced organic fertilizers, such as alfalfa meal, oyster shell meal and meals from local plants or animals that concentrate certain minerals.

Note: This booklet is designed to allow you to observe plants on a *physical* level and interpret soil conditions by their presence and morphology. All you need to do is carefully observe the plants growing around you and compare your observations with those listed in this booklet. However, we are becoming increasingly aware that we humans have other, more subtle senses that allow us to communicate with plants without the need for interpretive charts. A few useful guides and sources of inspiration for beginning to learn from plants with your other senses are listed under "Appendix C: Additional Resources" on page 86 of this booklet.

Disclaimer

This booklet is a compilation of published data and observations of others. No data is included that the author knows or suspects to be inaccurate. However, because this data is not based on many years of detailed observations and experience in many different climates and soil types on the part of the author, it is important at this point in time to regard the data, the conclusions you will draw and the fertilizer recipes you will create as experimental. For this reason, after you have followed the steps described and determined the types and quantities of fertilizer you need, you may want to add these fertilizers to only a part of your farm. If you see yield improvements in this area in the coming years, you may want to consider applying this plant-based method of soil analysis and fertilizer recommendations to your entire farm. Please, if possible, be conservative in using this experimental method of soil management. The author does not take responsibility for the results of the use of this method of soil management. Ongoing research by all who use this method will greatly speed the evolution of this important, emerging technology (see Appendix A on page 83).

HOW TO USE THIS BOOKLET

Initial Test of Farm Soil

To analyze and improve soil that contains only plants that were not planted by a human:

1) Use the *Wild Plant Kit* to determine the overall soil conditions indicated by the wild plants.
2) Add the appropriate types and quantities of organic fertilizers according to the guidelines described in "Adjusting Soil Minerals" to correct any indicated imbalances.

Ongoing Test of Farm Soil

To analyze and improve soil that contains wild *and* cultivated plants:

1) Use the *Wild Plant Kit* to determine the overall soil conditions indicated by the wild plants.
2) Use the *Cultivated Plant Kit* to determine the overall soil conditions indicated by the cultivated plants.
3) Compare the two results. Add the appropriate types and quantities of organic fertilizers according to the guidelines described in "Adjusting Soil Minerals" to correct any imbalances indicated by both *Kits*.

PART I: WILD PLANT KIT

The *Wild Plant Kit* is primarily designed for use in areas that are not currently being cultivated. These areas often have a greater diversity of plant life which will give a more accurate summary of soil conditions. However, the *Wild Plant Kit* does include many plants that are commonly found in cultivated soil, so that the *Kit* will continue to be useful after you are farming that soil. The strength and even presence of wild plants can vary with the strength and presence of animal populations and various climatic and other conditions (annual rainfall, daily and nightly air and soil temperatures, fire, flooding and wind). Ideally, you will assess the potential of the soil in an average year, but since it is difficult to determine if a year is actually "average", using the *Wild Plant Kit* over several years will give you a good idea of the soil conditions you are working with and how those conditions change over time.

The presence of many plants of a single species is a much more reliable indicator of soil conditions than the presence of a single plant. A single plant of almost any species can be found in almost any soil condition -- its presence may just be an anomaly. Furthermore, the presence of several different species of wild plants is oftentimes a more reliable indicator of soil conditions than the presence of only one species. Populations of different species of plants serve to give you multiple "points of view" regarding soil conditions. By synthesizing many points of view, you are likely to draw a more accurate picture of soil conditions. Some indications may be contradictory, in which case you know to be suspicious of the truth of either indication, and some indications will be complementary, in which case you can be more confident that you are getting an accurate and complete picture of the soil conditions. With the *Wild Plant Kit*, you will be able to understand what the various wild plants are indicating and summarize these indications into a fairly accurate description of the soil conditions.

Analyzing the Soil with Wild Plants -- Step by Step

Step 1: The first thing to do is to mark off the area that you want to analyze and learn from. You can do this visually, with landmarks, with stakes and string if the area is small enough (and you have enough stakes and string), or with any other means. Your goal is to limit the area that you are analyzing and be able to return to that exact area if you choose to farm it.

Step 2: Walk the area to familiarize yourself with the most common plant varieties and communities growing in that area.

Step 3: Once you have a good sense of what the most common plants are, walk the area again. This time, bring along a blank *Wild Plant Indicator Summary Form* (or any blank piece of paper will do), something to write with, and any plant identification books you will need (some are listed in "Additional Resources" on page 86) to be able to write down the scientific names of the most common plants. How many plants to write down is up to you. The more you write down, the more likely that you will have plants in your list that indicate soil conditions (some plants grow almost anywhere, so that their presence is not indicative of a particular soil condition). You will then be able to synthesize a number of "points of view" and come up with a more accurate soil description. However, the more plants you write down, the more identifying and synthesizing of information you will have to do.

After each scientific name, you will want to write approximately how many of that kind of plant you saw in the column labeled "Number". The more prevalent plants are more likely to describe the soil conditions accurately than lone surviving plants. Therefore, when it comes time to analyze your results, you will know what indications you should weight more heavily and what indications you should consider with some skepticism.

Step 4: Before analyzing your particular area to discover what the plants are telling you, you need to familiarize yourself with three tools. The first one is the *Wild Plant Indicator Chart*, which is a list summarizing all of the past discoveries of what wild plants indicate about soil conditions. Indicator plants with a known scientific and common name are listed first, in alphabetical order by their scientific name. These plants make up the majority of the chart. Indicator plants with a common name and a possible, though unverified, scientific name, follow, in alphabetical order by their possible scientific name. Indicator plants with only a common name (because no scientific name was given in the original research paper) follow, in alphabetical order by their common name. All of the listed plants indicate particular soil conditions. These conditions are listed in abbreviated form, such as "Ca", along the top of each page of the chart.

Now, familiarize yourself with the second tool, the *Soil Conditions Described by Plants*, which describes each of these abbreviations. You will find here that "Ca" stands for calcium, for example. Read about what each column heading stands for so that you are familiar with the range of soil conditions wild plants can describe.

Now, go back to the *Wild Plant Indicator Chart*. Under each soil condition abbreviation, you will see codes. These codes signify what a particular plant is indicating about a particular soil condition. For example, if you look up the plant, scarlet pimpernel (*Anagallis arvensis*), you find that in the "Ca" (or the amount of calcium in the soil) column, there is an "H(I)". The first letter signifies what the presence of the plant is indicating about that particular soil condition. The letter in parentheses signifies the source of the information. In order to understand what the H and the I stand for, now you can familiarize yourself with the third and fourth tools, the *Wild Plant Indicator Codes* on pages 32 to 36 and the *Data Sources of the Wild Plant Indicator Chart* on pages 37 to 38. From the *Wild Plant Indicator Codes*, you can find out that, for example, H means that there is a high level of calcium in the soil (so you probably do not need to apply a calcium fertilizer to the soil). From the *Data Sources of the Wild Plant Indicator Chart*, you find, for example, that this particular piece of information is from a book called *The Value of Weeds*, written by Joy Griffith-Jones.

Additional Notes on the *Wild Plant Indicator Chart*:

--If you are using an old plant identification book and then having trouble finding the scientific name, it may be that the scientific name has been changed. Look up the old scientific name in "Old and New Scientific Names" on pages 29 to 31 and see if there is a new scientific name for the same plant. The *Wild Plant Indicator Chart* includes only the newest scientific names.

--"Ssp" after the genus signifies that all of the species in that genus indicate the same conditions.

--"Association" after a list of plants signifies that the indications given are true only when all of the plants in the list are observed living in the same area.

--Indications given by plants that are identified by *genus* and *species* in the chart have the highest probability of being accurate.

--Indications given by plants identified only by *genus* in the chart are probably accurate. However, some plants in a genus may indicate different soil conditions than other plants in the same genus. Therefore, these indications should be regarded with some degree of skepticism and should be confirmed by indications from plants identified by both *genus* and *species* before acting on them.

--Indications given by plants identified only by a *common name* in the chart should be used only with a relatively large degree of skepticism, since the same common name has been used in different regions for more than one plant. These indications should be confirmed by indications from plants identified by both *genus* and *species* before acting on them.

--You will find that some wild indicator plants *accumulate* minerals from the soil. These plants are important because they are rich sources of the minerals they are accumulating. They can be harvested, but never harvest all or even a majority of these plants from a single area as you will severely damage the ecological balance necessary for the well-being of the plants and animals living there. Once harvested, accumulator plants can be composted and added to your farm as a natural form of a specific mineral-rich fertilizer. However, keep in mind that accumulator plants generally *do not* indicate how much of the mineral they are accumulating presently exists in the soil. Other plants are often necessary for this information.

Step 5: Now that you are familiar with the *Wild Plant Indicator Chart*, the *Soil Conditions Described by Plants*, the *Wild Plant Indicator Codes*, and the *Data Sources of the Wild Plant Indicator Chart*, you are ready to begin analyzing what the plants you identified in your area are telling you!

Step 6: You have already written the scientific name for each of the most common plants in your area on the *Wild Plant Indicator Summary Form*. Now, look up each of these plants in the *Wild Plant Indicator Chart*. When you find that a plant in the *Chart* indicates a particular soil condition, copy the code(s) given in the *Chart* to the *Summary Form*. After you have gone through the entire list of plants on your *Summary Form*, all of the indications will be lined up so that you can summarize them into an overall description of the soil conditions.

Step 7: Determine the overall conditions by inspecting each soil condition column above separately. If only one indication is shown for a specific soil condition, write this indication under the appropriate column and in the "Overall Soil Conditions" row. If more than one indication is made, write the indication that is most likely true and/or in the majority under the appropriate column and in the "Overall Soil Conditions" row. Remember to factor in the number of plants you observed and whether you identified the plants by genus, species and/or common name in determining how much weight each indication should carry and which indications are most likely true. If there is no majority, write "?" under the appropriate column and in the "Overall Soil Conditions" row. If no indication is made, leave that column blank.

Step 8: When you have completed the "Overall Soil Conditions" row, look up the codes in the *Wild Plant Indicator Codes* to understand their meaning and the conditions of the soil. Instead of leaving all of the indications in code, you may want to write a paragraph describing in sentences what the "Overall Soil Conditions" row is describing in codes. If the land you are analyzing contains no cultivated crops and you are relying on the *Wild Plant Kit* exclusively for your soil analysis, you have completed your analysis.

If you are able to analyze both wild and cultivated plants growing on the land you are analyzing, do not make any conclusions yet! After you have used the *Wild Plant Kit* to analyze the wild plants, use the *Cultivated Plant Kit* on pages 42 to 57 to analyze the cultivated crops. Then, compare the overall soil conditions indicated by the *Wild Plant Kit* with those indicated by the *Cultivated Plant Kit*. Determine the overall conditions by writing down all of the conditions indicated by **both** *Kits* and synthesizing the information as is described in Steps 7 and 8 and the example on pages 39 and 40. Contradictory indications can be a rich source of information and learning but should, in the beginning, be acted upon only after much consideration and with much caution.

Wild Plant Indicator Chart

Individual plant analysis - Presence indicator

Common Name	Scientific Name	Ind	His	SU	Slo	PC	Mois	Drai	Text	Struc	OM	pH	Salt	Lime	Ca	N	P	K	Mg	Cu	Pb	Al	Zn	Se	B
yarrow	*Achillea millefolium*		A(F)		5+(F)	2(F)		WD (CF)	C(C) MC(F) 35(F)		LM(F)	AC(F)													
summer pheasant's eye	*Adonis aestivalis*									G(A)		N(A)													
purplegrass	*Agalinis besseyana*											10(O)													
purplegrass	*Agalinis tenuifolia*											4(O)													
	Agave		OG(L)																						
	Agropyron inerme						F(M)																		
quack grass / couch grass	*Agropyron repens*				5+(F)	AL(F)	MD(Q)		F(F) SF(F)	Cr(H)	LH(F)	I(F)			L(Q)							TH(Q)			
	Agropyron spicatum						F(M)																		
bunch-grass prairie	*Agropyrum-Festuca*			DW(L)																					
	Agrostis tenuis							P(F)	MF(F)		M(F)	NE(F)								A(B)					
	Alisma						MD(B)																		
pickleweed / bush sapphire	*Allenrolfea occidentalis*			DL(M) PD(M)								Al(M)	TH(K)												
	Allionia linearis		OG(L)																						
summer onion	*Allium cernuum*											10(O)													
summer onion	*Allium oxyphilum*											4(O)													
summer onion	*Allium stellatum*											11(O)													
	Alnus glutinosa						U(B)																		
rough pigweed	*Amaranthus retroflexus*			G(Q)						G(Q)															
common ragweed	*Ambrosia artemisiifolia*		OG(L)	H(F)	NS(F)	AH(F)																			
	Amphiachyris dracunculoides											Al(M)													
	Amsinckia tessellata		OG(L)																						
scarlet pimpernel	*Anagallis arvensis*									G(A)		N(A) Al(B)			H(I)										
heather family	*Andromeda*						MD(B)																		
beard grass	*Andropogon gerardii*			HF(L)																					
bunch grass	*Andropogon scoparius*			G(M) GD(N)																					
broom sedge	*Andropogon virginicus*			P(Q)							LH(Q)				L(Q)										
	Androsace occidentalis		OG(L)																						
	Antennaria canadensis					2(F)		WD(F)	C(F) 12(F)																
yellow camomile	*Anthemis tinctoria*													H(H)											
wind bent grass	*Apera spica-venti*									P(A)															
common burdock	*Arctium minus*											Ac(Q)			L(Q)		H(Q)					TF(Q)			

Common Name	Scientific Name	Ind	His	SU	Slo	PC	Mois	Drai	Text	Struc	OM	pH	Salt	Lime	Ca	N	P	K	Mg	Cu	Pb	Al	Zn	Se	B
	Argemone platyceras		OG(L)																						
jack-in-the-pulpit	*Arisaema pusillum*											4(O)													
jack-in-the-pulpit	*Arisaema stewardsonii*											1(O)													
jack-in-the-pulpit	*Arisaema triphyllum*											9(O)													
	Aristida		OG(B)																						
	Aristida bromoides		OG(L)																						
wire grass	*Aristida longiseta*			AP(M) SD(N)				WD (N)	SL(N)																
	Aristida purpurea		OG(L)																						
aristid									WS(B)																
wormwood	*Artemisia absinthium*								WS(B)									H(H)							
silver sagebrush	*Artemisia cana*		OG(L)																						
sand sagebrush	*Artemisia filifolia*		OG(L)						SL(L)																
fringed sagebrush	*Artemisia frigida*		OG(L)																						
	Artemisia maritima												TH(H)												
	Artemisia spp.		OG(B)							GD(L)			L(L)												
big sagebrush	*Artemisia tridentata*		OG(L)	G(M)								Al(H)	L(K)												
common milkweed	*Asclepias syriaca*				5+(F)	2(F)			SF12(F)		M(F)	I(F)													
asparagus	*Asparagus officinalis*												TH(B)												
cliff spleenwort	*Asplenium montanum*											1(O)													
cliff spleenwort	*Asplenium rutamuraria*											11(O)													
	Aster canescens		OG(L)																						
	Aster tanacetifolius		OG(L)																						
sea aster	*Aster tripolium*												TH(BH)												
asters																									
asters	*Aster spp.* (blue)				2-5(F)						M(F)													A(B)	
asters	*Aster spp.* (white)				5+(F)			M(F)	SF(F)		M(F)	I(F)													
milkvetch	some *Astragalus*																								
locoweed	*Astragalus mollissimus*																							A(B)	
shadscale	*Atriplex*			L(M)																				N(B)	
chamiso	*Atriplex canescens*			HF(M)									L(L)											A(B)	
saltbrush group	*Atriplex confertifolia*												TH(B)												
prostrate saltbrush	*Atriplex fruticulosa*											Al(M)													
	Atriplex lentiformis			D(M)																					
	Atriplex nuttallii												TH(L)												
	Atriplex polycarpa			HL(M)																					
wild oats	*Avena fatua*		OG(L)				M(Q)	P(Q)																	
	Baccharis wrightii		OG(L)																						
goldfields	*Baeria*											Al(M)													
	Baeria gracilis		OG(L)																						
balsam-root sunflower	*Balsamorrhiza sagittata*						F(M)																		
	Bebbia juncea		OG(L)																						

Common Name	Scientific Name	Ind	His	SU	Slo	PC	Mois	Drai	Text	Struc	OM	pH	Salt	Lime	Ca	N	P	K	Mg	Cu	Pb	Al	Zn	Se	B
English daisy	*Bellis perennis*							TS(B)				sAc(B)													
beet	*Beta*												TH(B)												
	Boerhavia intermedia		OG(L)																						
	Boerhavia torreyana		OG(L)																						
	Bouteloua aristidoides		OG(L)																						
gamma grass	*Bouteloua oligostachya*			SE(N)																					
	Bouteloua polystachya		OG(L)																						
	Bowlesia lobata		OG(L)																						
mustards	*Brassica spp.*									H(BH) Cr(H)			TH(B)												
some mustards	*Brassica spp.*											Al(B)													
charlock / wild mustard	*Brassica kaber*							P(D) WL(D)		P(D)	LH(D) HF(D)	NAl (D)	A(D)		LC(D)		A(D)	LS(D)							
	Bromus maximus		OG(L)																						
soft chess	*Bromus mollis*		OG(L)																						
red brome	*Bromus rubens*		OG(L)																						
cheat / chess	*Bromus secalinus*																								
downy brome	*Bromus tectorum*		OG(L)							C(Q)															
buffalo grass	*Buchloë dactyloides*			SE(N)																					
marsh pine grass	*Calamagrostis canadensis*											Ac(M)													
	Calandrinia menziesii		OG(L)																						
	Calliandra eriophylla		OG(L)																						
marsh marigolds	*Caltha palustris*																								
campanula	*Campanula*						M(B)																		
marsh bellflower	*Campanula aparinoides*											Al(B)			H(I)										
marsh bellflower	*Campanula uliginosa*											4(O)													
shepherd's purse	*Capsella bursa-pastoris*	X(B)										10(O)													
	Caragana								SL(B)				TH(BH)												
sedges	*Carex spp.*			AP(F)		5(F)											S(B)								
giant cactus	*Carnegia gigantea*			D(M)								AC(F)													
partridge pea	*Cassia fasciculata*		OG(L)																						
American chestnut	*Castanea vulgaris Lam., var. Americana*													L(J)											
New Jersey tea	*Ceanothus ovatus*								SL(B)																
cornflower (especially when flowers are pink [B])	*Centaurea cyanus*		OG(L)						SL(B)																
Maltese thistle	*Centaurea melitensis*		OG(L)						SL(B)																
knapweed	*Centaurea nigra*											wAc(B) Ac(H)						H(H)							
St. Barnaby's thistle	*Centaurea solstitialis*								SL(B)					H(H)											
paloverde	*Cercidium torreyanum*			D(M)																					
true chamomile	*Chamomilla matricaria*											Al(B)													

Common Name	Scientific Name	Ind	His	SU	Slo	PC	Mois	Drai	Text	Struc	OM	pH	Salt	Lime	Ca	N	P	K	Mg	Cu	Pb	Al	Zn	Se	B
wild chamomile / scented mayweed	*Chamomilla recutita*									P(A)				L(A)											
all chamomiles	*Chamomilla spp.*									H(B) Cr(H)					A(H)			A(H)							
lamb's quarters	*Chenopodium album*	X(B)	DG(L)	G(Q)						G(Q)							H(Q)	H(Q)							
wormseed	*Chenopodium ambrosioides*													H(H)											
	Chenopodium leptophyllum		DG(L)																						
goosefoot	*Chenopodiums*									H(B)															
	Chloris elegans		DG(L)																						
corn marigold	*Chrysanthemum segetum*								SL(BI)			Ac(BI)													
oxeye daisy	*Chrysanthemum leucanthemum*		G(CF)	PS(F)	2-5(F)	2(F)		I(F)	M(CF) 35(F)		M(C) LM(F)	I(F)													
chicory	*Cichorium intybus*			A(F)		AL(F)		IM(F)	F(F)	G(A)		N(A) I(F)													
slender reed grass	*Cinna latifolia*											Ac(M)													
creeping thistle / Canada thistle	*Cirsium arvense*									P(A)								A(H)							
	Cladothrix lanuginosa		DG(L)																						
springbeauty	*Claytonia caroliniana*											9(O)													
springbeauty	*Claytonia virginica*											8(O)													
blessed thistle	*Cnicus benedictus*																	A(Q)							
	Collomia linearis		DG(L)																						
forking larkspur	*Consolida regalis*									G(A)		N(A)													
lesser bindweed / field bindweed	*Convolvulus arvensis*									G(A)		N(A)													
	Coreopsis tinctoria		DG(L)																						
creosote bush	*Covillea glutinosa*			HL(M)																					
cressa	*Cressa truxillensis* or *Cressa cretica truxillensis*			PD(M)								Al(M)	TH(L)												
	Croton corymbulosus		DG(L)																						
	Croton texensis		DG(L)																						
sedges	*Cyperus*							TS(B)																	
nutgrass / yellow nutsedge	*Cyperus esculentus*						M(D)	P(D)	SL(D)			Ac(D)													
scotch broom	*Cytisus scoparius*													L(H)											
poverty oatgrass / wild oatgrass	*Danthonia spicata*			P(M)																					
	Dasylirium		DG(L)																						
jimsonweed	*Datura stramonium*										HR(Q)														

Common Name	Scientific Name	Ind	His	SU	Slo	PC	Mois	Drai	Text	Struc	OM	pH	Salt	Lime	Ca	N	P	K	Mg	Cu	Pb	Al	Zn	Se	B
wild carrot	*Daucus carota*			H(F)	I(F)				MF(F) SF12(F)		M(F)	AL(F)													
rattlesnake weed	*Daucus pusillus*		DG(L)																						
low larkspur	*Delphinium menziesii*						F(M)																		
tufted hair grass	*Deschampsia caespitosa*											Ac(M)													
	Deschampsia flexuosa						HC(M)																		
white sedge	*Dichromena colorata*											10(O)													
white sedge	*Dichromena latifolia*											1(O)													
	Dicrophyllum bicolor											Al(M)													
fox glove	*Digitalis*													L(H)											
smooth finger-grass / small crabgrass	*Digitaria ischaemum*									P(A)				L(A)											
crabgrass	*Digitaria sanguinalis*														L(Q)										
common teasel	*Dipsacus sylvestris*		G(F)		NS(F)				MF(F)																
saltgrass	*Distichlis spicata* (coast)			DL(M) PD(M)				B(B)				AIO (B)	TH(L)												
	Distichlis stricta (desert)							B(B)				AIO(B)													
	Dondia intermedia			L(M)																					
	Dondia suffrutescens												TH(L)												
	Dondia torreyana												TH(L)												
	Draba caroliniana		DG(L)																						
broad woodfern	*Dryopteris celsa*											1(O)													
broad woodfern	*Dryopteris clintoniana*											4(O)													
broad woodfern	*Dryopteris goldiana*											10(O)													
fetid marigold	*Dyssodia papposa*		DG(L)																						
blueweed / blue thistle	*Echium vulgare*							WD(F)	C(F) 35(F)			Al(B) AL(F)													
Russian olive	*Eleagnus (angustifolia?)*							S(B)								L(B)									
	Eleocharis							D(B)																	
	Encelia farinosa		DG(L)																						
trailing arbutus	*Epigaea*													L(J)											
willow herb	*Epilobium hirsutum*						MD(D)					N(D)				H(D)									
	Epilobium paniculatum		DG(L)																						
common horsetail / field horsetail	*Equisetum arvense*		A(F)				MD (B)	TS (AB)	SF(F)			Ac(I) sAc(H)													
swampy horsetail	*Equisetum palustre*						D(H)	P(H)				vAc(H)													
stink grass	*Eragrostis megastachya*		DG(L)																						
tufted lovegrass	*Eragrostis pectinacea*		DG(L)																						
turkey mullein	*Eremocarpus setigerus*		DG(L)																						
fleabane	*Erigeron canadensis*		DG(L)																						
	Erigeron divergens		DG(L)																						
rough daisy fleabane	*Erigeron strigosus*		DG(L)																						

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	Eriogonum abertianum		OG(L)																						
	Eriogonum annuum		OG(L)																						
	Eriogonum cernuum		OG(L)																						
	Eriogonum effusum		OG(L)																						
	Eriogonum microthecum		OG(L)																						
	Eriogonum nudum		OG(L)																						
	Eriogonum polycladum		OG(L)																						
	Eriogonum viminium		OG(L)																						
	Eriogonum wrightii		OG(L)																						
storksbill / redstem filaree	*Erodium cicutarium*		OG(L)				D(D)					I(D)				I(D)									
	Erodium moschatum		OG(L)																						
	Erodium texanum		OG(L)																						
	Eryngium vaseyi		OG(L)																						
	Eschscholtzia mexicana		OG(L)																						
joe-pye-weed	*Eupatorium maculatum*						M(H)	P(H)																	
snow-on-the-mountain	*Euphorbia marginata*		OG(L)																						
petty spurge	*Euphorbia peplus*									G(A)						H(A)									
buckwheat	*Fagopyrum esculentum*								WS(B)																
	Festuca idahoensis						F(M)																		
	Festuca myurus		OG(L)																						
	Festuca octoflora		OG(L)																						
perennial fescue	*Festuca ovina*																				TH(B)				
wild strawberry	*Fragaria*			AP(F)	5+(F)	AL(F)					M(F)	Ac(CF)													
	Frankenia							B(B)																	
alkali-heath	*Frankenia grandifolia campestris*			PD(M)								Al(M)	TH(L)												
	Franseria deltoidea		OG(L)																						
	Franseria dumosa		OG(L)																						
bedstraw	*Galium saxatile*														TL(B)										
bedstraw	*Galium pumilum*														H(B)										
	Galium trifidum											vAc(M)													
wintergreen	*Gaultheria*													L(J)											
huckleberry	*Gaylussacia*													L(J)											
bottle gentian	*Gentiana andrewsii*											10(O)													
bottle gentian	*Gentiana clausa*											8(O)													
bottle gentian	*Gentiana saponaria*											1(O)													
white avens	*Geum album*						M(H)	TS(BH)																	
yellow avens	*Geum aleppicum*																								
	Geum rivale		A(F)						U(P) SF(F)																
	Gilia gracilis		OG(L)																						

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	Grindelia		OG(L)																						
gumweed	*Grindelia camporum*											Al(M)													
	Guterrezia		OG(B)																						
broom snakeweed	*Gutierrezia sarothrae*		OG(L)																						
purple fringe-orchid	*Habenaria fimbriata*											4(O)													
purple fringe-orchid	*Habenaria psycodes*											8(O)													
goosefoot / barilla	*Halogeton glomeratus*											AlO(B)													
	Haplopappus gracilis		OG(L)																						
	Hedeoma hispida		OG(L)																						
common sunflower	*Helianthus annuus*		OG(L)																						
prarie sunflower	*Helianthus petiolaris*		OG(L)																						
	Hemizonia clevelandii		OG(L)																						
	Hemizonia fitchii		OG(L)																						
hepatica	*Hepatica acutiloba*											10(O)													
hepatica	*Hepatica triloba*											6(O)													
hawkweed	*Hieracium (floribundum?)* spp. (yellow)			AP(F)	5+(F)	AH(F)		WD (CF)	C(C) MC(F) 35(F)		LM(F)	vAc (BH)													
orange hawkweed	*Hieracium aurantiacum*				2-5+ (F)				I(F) 12(F)		LH(F)	Ac(C) AC(F)													
foxtail barley / squirrel-tail barley	*Hordeum jubatum*		OG(L)				M(Q)					Ac(Q) Al(M)	TH(M)		L(Q)										
	Hordeum maritimum gussoneanum		OG(L)																						
wall barley	*Hordeum murinum*		OG(L)																						
	Hymenoclea salsola		OG(L)																						
dwarf St. John's wort	*Hypericum*							TS(B)																	
common St. John's wort	*Hypericum perforatum*					AH(F)		WD (CF)	C(C) CM(F) 12(F)		LH(F)														
pinesap	*Hypopitys americana*											3(O)													
pinesap	*Hypopitys insignata*											1(O)													
pinesap	*Hypopitys lanuginosa*											8(O)													
	Hypochaeris glabra		OG(L)																						
spotted catsear	*Hypochaeris radicata*		OG(L)																						
morning glories	*Ipomea* spp.									H(B) Cr(H)															
tall morning glory	*Ipomea purpurea*									C(D)							TL(D)								
dwarf iris	*Iris cristata*											9(O)													
dwarf iris	*Iris lacustris*											11(O)													
dwarf iris	*Iris verna*											1(O)													
	Isocoma coronopifolia		OG(L)																						
rushes	*Juncus*						MD(B)	D(B)																	

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	Kallstroemia brachystylis		OG(L)																						
	Kallstroemia grandiflora		OG(L)																						
	Kallstroemia hirsutissima		OG(L)																						
	Kallstroemia parviflora		OG(L)																						
mountain laurel	*Kalmia (latifolia?)*						MD(B)							L(J)											
red sage	*Kochia*			P(M)			SL(M)						TH(B)												
	Krameria glandulosa		OG(L)																						
	Lagophylla ramosissima		OG(L)																						
	Lamarkia aurea		OG(L)																						
	Lappula texana		OG(L)																						
goldfields	*Lasthenia*											Al(M)													
yellow vetchling	*Lathyrus aphaca*									G(A)		N(A)													
heather family	*Ledum*						MD(B)																		
	Lepidium alyssoides		OG(L)																						
field peppergrass	*Lepidium campestre*											Al(B)		H(H)											
	Lepidium intermedium		OG(L)																						
	Lepidium lasiocarpum		OG(L)																						
long-winged pepper-cress	*Lepidium latipes*											Al(M)													
clasping pepperweed	*Lepidium perfoliatum*		OG(L)																						
	Lepidium ramosum		OG(L)																						
	Lesquerella gordoni		OG(L)																						
	Lespedeza repens															TL(P)									
	Lespedeza striata															TL(P)									
	Lespedeza virginiana															TL(P)									
common toadflax / yellow toadflax / butter-and-eggs	*Linaria vulgaris*								15(F)	G(A)	M(F)	N(A)													
twayblade	*Listera convallarioides*											10(O)													
twayblade	*Listera reniformis*											1(O)													
	Lithospermum ruderale		OG(L)				F(M)																		
gromwell	*Lithospernium officinale*											Al(B)													
flax lobelia	*Lobelia canbyi*											1(O)													
flax lobelia	*Lobelia kalmii*											11(O)													
	Lomatium triternatum						F(M)																		
	Lotus americanus		OG(L)																						
	Lotus humistratus		OG(L)																						
	Lotus strigosus		OG(L)																						

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	Lupinus affinis		OG(L)																						
	Lupinus micranthus		OG(L)																						
	Lupinus plattensis						RM(L)																		
	Lupinus pusillus		OG(L)																						
	Lupinus sparsiflorus		OG(L)																						
	Lupinus truncatus		OG(L)																						
white campion	*Lychnis alba*								SL(B)																
water horehound	*Lycopus americanus*		A(F)					IM(F)	SFU(F)		H(F)														
	Machaeranthera																							A(B)	
	Madia dissitiflora		OG(L)																						
	Madia exigua		OG(L)																						
	Malacothrix fendleri		OG(L)																						
	Malacothrix sonchoides		OG(L)																						
one-blade	*Malaxis monophyllos*											11(O)													
one-blade	*Malaxis unifolia*											1(O)													
common mallow / round leaf mallow	*Malva negleta*						FI(D)					N(D)				H(D)									
scentless mayweed	*Matricaria inodoro*											Ac(B)													
pineapple weed	*Matricaria matricarioides*									Cr(H)															
scentless mayweed	*Matricaria perforata*									P(A)															
	Medicago denticulata		OG(L)																						
burr clover	*Medicago hispida*			G(D)			M(D)	WD(D)	L(D)							L(D)									
black medic	*Medicago lupulina*		G(F) OG(L)			AH(F)		IM(F)	F(F)		LM(F)	I(F)													
bunchflower	*Melanthium latifolium*											9(O)													
bunchflower	*Melanthium virginicum*											4(O)													
white sweet clover	*Melilotus alba*															TL(P)									
	Melilotus indica		OG(L)																						
corn mint	*Mentha arvensis*							TS(A)																	
	Mentzelia decapetala																							A(M)	
annual mercury	*Mercurialis annua*									G(A)						H(A)									
monkey flower	*Mimulus*						M(B)																		
	Munroa squarrosa		OG(L)																						
	Myosurus minimus		OG(L)																						
	Navarretia leucophaea		OG(L)																						
	Nolina		OG(L)																						
evening primrose	*Oenothera biennis*		A(F)	H(F)				WD(F)	CU(F)		LH(F)														
	Oenothera primaveris		OG(L)																						
	Oonopis condensata																							A(B)	
adderstongue	*Ophioglossum arenarium*											1(O)													

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adderstongue	*Ophioglossum engelmannii*											12(O)													
adderstongue	*Ophioglossum vulgatum*											8(O)													
	Opuntia arborescens		OG(L)																						
	Opuntia arbuscula		OG(L)																						
	Opuntia bigelovii		OG(L)																						
	Opuntia calcicola											10(O)													
	Opuntia chlorotica		OG(L)																						
	Opuntia compressa											4(O)													
	Opuntia discata		OG(L)																						
	Opuntia engelmannii		OG(L)																						
	Opuntia fulgida		OG(L)																						
	Opuntia fulgida mamillata		OG(L)																						
	Opuntia humifusa											11(O)													
	Opuntia mesacantha		OG(L)																						
	Opuntia phaeacantha		OG(L)																						
plains pricklypear	*Opuntia polyacantha*		OG(L)																						
	Opuntia spinosior		OG(L)																						
	Opuntia versicolor		OG(L)																						
	Orthocarpus luteus		OG(L)																						
	Orthocarpus purpurascens		OG(L)																						
fall panicum	*Panicum dichotomiflorum*						MD(Q)			C(Q)															
switch grass	*Panicum virgatum*											vAc(M)													
	Pectis angustifolia		OG(L)																						
	Pectis prostrata		OG(L)																						
	Pectocarya linearis		OG(L)																						
	Phacelia crenulata		OG(L)																						
	Phacelia distans		OG(L)																						
	Phacelia heterophylla		OG(L)																						
mountain timothy	*Phleum alpinum*											Ac(M)													
	Phleum pratense			H(F)	NS(F)	5(F)		P(F)	F(F)		LM(F)														
moss phlox	*Phlox brittonii*											4(O)													
moss phlox	*Phlox subulata*											9(O)													
common reed	*Phragmites australis*							TS(A)																	
	Physalis lobata		OG(L)																						
butterwort	*Pinguicula elatior*											1(O)													
butterwort	*Pinguicula pumila*											3(O)													
butterwort	*Pinguicula vulgaris*											12(O)													

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	Plagiobothrys arizonicus		OG(L)																						
plantain	*Plantago*							TS(B)				Ac(B)													
	Plantago fastigiata		OG(L)																						
buckhorn plantain	*Plantago lanceolata*		G(CF)				I(D)	TS(D)	M(C) MF(F)		M(CF)	I(D) NAI(F)			A(D)		A(D)	TL(D) P(D)							
broad leaf plantain	*Plantago major*		G(F)	H(F)	NS(F)	2(F)			MF(F)																
woolly plantain	*Plantago patagonica*		OG(L)																						
arrowweed	*Pluchea sericea*			D(M)																					
mayapple	*Podophyllum peltatum*							TS(B)																	
	Polygala cruciata											vAc(M)													
prostrate knotweed	*Polygonum aviculare*		OG(L)							C(M)		sAc(BH)													
smartweed	*Polygonum hydropiper*						M(H)	P(H)																	
mild water pepper	*Polygonum hydropiperoides*						M(H)	P(H)																	
lady's thumb	*Polygonum persicaria*											Ac(BH)													
	Polygonum ramosissimum		OG(L)																						
hedge bindweed	*Polygonum scandens*						M(H)	P(H)																	
rabbitfoot grass	*Polypogon monspeliensis*		OG(L)																						
common purslane	*Portulaca oleracea*		OG(L)																						
silverweed / goosegrass	*Potentilla anserina*							TS(B)																	
silvery cinquefoil	*Potentilla argentea*											vAc(B)													
goose tansy / rough cinquefoil	*Potentilla norvegica*											Ac(B)													
sulfur cinquefoil	*Potentilla recta*			AP(F)		AH(F)			I(F)		LH(F)	I(F)													
salad burnet	*Poterium sanguisorba*											Al(B)			H(I)										
mesquite	*Prosopis*						9(?)			GD(L)															
honey mesquite	*Prosopis glandulosa*			L(M)									TH(M)												
heal-all	*Prunella vulgaris*		G(CF)		NS(F)	2(F)			M(CF) 35(F)		M(CF)														
chokecherry	*Prunus virginiana*							SD(B)																	
	Psilostrophe cooperi		OG(L)																						
wild alfalfa	*Psoralea tenuiflora*							WD(N)																	
bracken fern / brake fern	*Pteridium aquifolium* or *Pteridium aquilinum*											Ac(B)													
	Pterocarya linearis		OG(L)																						
	Ptilonella scabra		OG(L)																						
rose pyrola	*Pyrola asarifolia*											10(O)													
green pyrola	*Pyrola chlorantha*											8(O)													
green pyrola	*Pyrola convoluta*											1(O)													

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rose pyrola	*Pyrola incarnata*											2(O)													
oak	*Quercus*			G(M)																					
	Quercus brevifoba		OG(L)																						
	Quercus undulata		OG(L)																						
meadow buttercup / tall buttercup	*Ranunculus acris*			PS(F)				P(F)	M(F) 35(F)	P(A)		Ac(CF)		L(A)											
creeping buttercup	*Ranunculus repens*							TS(B)																	
wild radish	*Raphanus raphanistrum*		OG(L)																						
sumac	*Rhus integrifolia*							TS(B)																	
black-eyed susan	*Rudbeckia serotina*		A(F)					WD(F)	C(F)																
common sorrel / sour sorrel	*Rumex acetosa*									P(A)				L(A)											
red sorrel / sheep sorrel	*Rumex acetosella*							TS(B)				sAc(B) Ac(M)													
curled dock / curly dock	*Rumex crispus*		G(F)	PS(F)	NS(F)		M(H)	TS (BF)	MF(F) SF(F)	P(A)				L(A)											
broad-leaf dock	*Rumex obtusifolius*							TS(B)		P(A)				L(A)											
dock	*Rumex*											AcS(B) Ac(H)													
sheep's sorrel	*Rumex*								SL(B)																
	Sagittaria						MD(B)																		
dwarf sapphire	*Salicornia subterminalis*			PD(M)								Al(M)													
grasswort	*Salicornia spp.*							B(B)					TH(L)												
Russian thistle	*Salsola kali*		OG(L)								LH(H)		TH(BH) A(H)					A(H)							
	Salvia columbariae		OG(L)																						
	Salvia lanceolata		OG(L)																						
meadow clary	*Salvia pratensis*									G(A)		N(A)													
grasewood	*Sarcobatus vermiculatus*			PD(M)								Al(M)	TH(L)									TO(B)			
	Scabiosa columbaria											NAl(B)													
	Schedonnardus texanus		OG(L)																						
curly-grass fern	*Schizaea pusilla*											sAc(M)													
	Scirpus						MD(B)																		
stinking willie	*Senecio jacobea*						M(H)	P(H)																	
saw palmetto	*Serenoa serrulata*							P(M)																	
giant foxtail	*Setaria faberi*										H(Q)														
sida / alkali mallow	*Sida hederacea*											Al(M)													
rock catchfly	*Silene caroliniana*											5(O)													
bladder campion	*Silene cucubalus*									G(A)		Al(B) N(A)			H(I)					TH(B)			TH(B)		
rock catchfly	*Silene wherryi*											11(O)													
compass plant	*Silphiumlaciniatum*			CS(L)																					
tumble mustard	*Sisymbrium altissimum*		OG(L)																						
solomonplumes	*Smilacina racemosa*											9(O)													

Common Name	Scientific Name	Ind	His	SU	Slo	PC	Mois	Drai	Text	Struc	OM	pH	Salt	Lime	Ca	N	P	K	Mg	Cu	Pb	Al	Zn	Sc	B
solomonplumes	*Smilacina stellata*											11(O)													
solomonplumes	*Smilacina trifolia*											1(O)													
horse nettle	*Solanum carolinense?*									Cr(H)															
silverleaf nightshade	*Solanum elaeagnifolium*		OG(L)																						
black nightshade	*Solanum nigrum*									G(A)						H(A)									
buffalobur	*Solanum rostratum*		OG(L)																						
cutleaf nightshade	*Solanum triflorum*		OG(L)																						
Canada goldenrod	*Solidago canadensis*					5(F)	M(H)	P(H)	MU(F) SF12(F)		M(F)														
narrow-leaved goldenrod	*Solidago graminifolia*			A(F)		5(F)	M(H)	LM(F) P(H)	U(F)			AC(F)													
	Solidago nemoralis		A(F)	A(F)				WD(CF)	C(CF)		LM(F)														
perennial sow thistle	*Sonchus arvensis*		A(F)	A(F)	NS(F)	4(F)		P(F)	SF(F)		MH(F)	Ac(B) AL(F)						A(Q)							
spiny sow thistle	*Sonchus asper*						M(D)					N(D)				H(D)									
common sowthistle	*Sonchus oleraceus*																	A(Q)							
	Sophia pinnata		OG(L)																						
johnson grass	*Sorghum halepense*										LH(Q)	I(Q)			L(Q)										
	Sparganium						MD(B)																		
	Spartina							B(B)																	
corn spurrey	*Spergula arvensis*								SL(B)	P(A)		Ac(B)		L(A)											
fall ladies-tress	*Spiranthes cernua*											1(O)													
fall ladies-tress	*Spiranthes ochroleuca*											9(O)													
fall ladies-tress	*Spiranthes odorata*											4(O)													
	Spirostachys occidentalis												TH(L)												
tussock grass	*Sporobolus airoides*			PD(M)								Al(M)	TH(L)												
hedge nettle	*Stachys palustris*						M(H)	TS(BH)																	
marsh woundwort	*Stachys palustris*							TS(A)																	
princesplume	*Stanleya*																							N(B)	
common chickweed	*Stellaria media*	X(B)								G(A)	H(D) MF(D)	NAl(D)				H(AD)	LS(D)		A(D)						
needle-and-thread grass	*Stipa comata*			DF(L)																					
saltwort	*Suaeda torreyana*			PD(M)								Al(M)													
comfrey	*Symphytum officinale*									P(A)															
tansy or parsley fern	*Tanacetum vulgare*																	A(H)							
dandelion	*Taraxacum officinalis*		OG(Q)				FR(D)	TS(B)		G(A)	HR(D) LH(D)	N(A) NAl(D)			L(DQ)	H(D)	LS(D)	P(D) H(D)	H(D)						
	Thelypodium lasiophyllum		OG(L)																						
field pennycress / fanweed	*Thlaspi arvense*									P(A)				L(A)											

Wild Plant Indicator Chart (cont.)

Common Name	Scientific Name	Ind	His	SU	Slo	PC	Mois	Drai	Text	Struc	OM	pH	Salt	Lime	Ca	N	P	K	Mg	Cu	Pb	Al	Zn	Se	B
mountain penny cress	*Thlaspi alpestre var. calaminare*																						N(H)		
	Thysanocarpus curvipes		OG(L)																						
tissa	*Tissa leucantha*											Al(M)													
puncturevine	*Tribulus terrestris*		OG(L)																						
	Trichostema lanceolatum		OG(L)																						
	Trifolium amplectens		OG(L)																						
rabbit-foot clover	*Trifolium arvense*									P(A)		Ac(B)		L(AH)											
	Trifolium gracilentum		OG(L)																						
	Trifolium microcephalum		OG(L)																						
	Trifolium spp.		O(CF)	H(F)				I(F)	M(CF)		M(CF)														
	Trifolium tridentatum		OG(L)																						
seaside arrowgrass	*Triglochin maritima*																							A(M)	
coltsfoot	*Tussilago farfara*							TS(AB)																	
spanglegrass	*Uniola latifolia*											10(O)													
spanglegrass	*Uniola laxa*											3(O)													
stinging nettle	*Urtica dioica*										HR(Q)														
annual nettle	*Urtica urens*								SL(B)	G(A)						H(A)									
huckleberry group	*Vaccinum*	X(G)					MD(B)																		
blueberry	*Vaccinium*													L(J)											
	Vaccinium corymbosum											vAc(M)													
American hellebore	*Veratrum viride*							TS(B)																	
common mullein	*Verbascum thapsus*					2(F)		WD(F)	12(F)			1(F)													
prostrate vervain / bracted vervain	*Verbena bracteata*		OG(L)																						
	Verbesina encelioides		OG(L)																						
ironweed	*Vernonia*		OG(L)																						
thyme-leaved speedwell	*Veronica serpyllifolia*							TS(B)																	
	Vicia spp.			H(F)		5(F)		IM(F)				AC(F)													
milkvine	*Vincetoxicum carolinense*											4(O)													
milkvine	*Vincetoxicum obliquum*											9(O)													
heartsease / wild pansy	*Viola tricolor*									P(A)				L(A)											
cliff fern	*Woodsia alpina*											12(O)													
cliff fern	*Woodsia glabella*											11(O)													
cliff fern	*Woodsia ilvensis*											7(O)													

Wild Plant Indicator Chart (cont.)

Common Name	Scientific Name	Ind	His	SU	Slo	PC	Mois	Drai	Text	Struc	OM	pH	Salt	Lime	Ca	N	P	K	Mg	Cu	Pb	Al	Zn	Se	B
cocklebur	*Xanthium pensylvanicum*																H(Q)								
	Xylorhiza parryi																							A(M)	
woody aster	*Xylorrhiza (glabriuscula?)*											Al(H)												N(B)	
Great Plains yucca	*Yucca glauca*		OG(L)																						
	Zinnia pumila		OG(L)																						
march foxtail (marsh foxtail?)	*Alopecurus geniculatus?*						M(H)	P(H)																	
daisies	*Bellis perennis?*											sAc(H)		L(I)											
saltgrass	*Distichlis*						2(?)																		
funatory (fumitory?)	*Fumaria officinalis?*																	H(H)							
field madder	*Galium mollugo? or Sherardi arvensis?*													H(H)											
spurrey (spurry?)	*Spergula arvensis?*								SL(I)			Ac(I)													
white mullen (mullein?)	*Verbascum lychnitis?*													L(H)											
aster, purple stem							M(H)	P(H)																	
aster, tradescant							M(H)	P(H)																	
bindweed									SL(E)	Cr(E)															
birch-beech-maple-hemlock association				G(M)																					
bluet, mountain														H(H)											
buckwheat																P(M)									
bullrushes								D(B)																	
buttercup, creeping								TS(I)																	
Canada blue grass														H(H)											
cattails							3(?)																		
clover, red																		N(H)							
clover, yellow or hop														L(H)											
cornelian cherry														H(H)											
elderberry shrub							6(?)																		
fescue grass									WS(B)																
fingerleaf weeds												Ac(H)													
greasewood, black							8(?)																		
hare's ear mustard														H(H)											
heath (all members of family)														L(J)											

Common Name	Scientific Name	Ind	His	SU	Slo	PC	Mois	Drai	Text	Struc	OM	pH	Salt	Lime	Ca	N	P	K	Mg	Cu	Pb	Al	Zn	Se	B
hemp																P(M)									B(M)
legumes																	S(B)								
licorice								A(B)																	
marsh mallow																		H(H)							
mosses								TS(B)																	
pickleweed							5(?)																		
pine, ponderosa (western yellow)				CS(M)																					
pine, white-Norway-jack association				P(M)					SL(M)																
plantain, sea													TH(H)												
poppy, opium																		H(H)							
redshank								A(I)																	
redwood				T(M)																					
rabbit brush							7(?)																		
reed grass								A(B)																	
reeds							1(?)																		
reeds, giant								A(B)																	
rice cut grass							M(H)	P(H)																	
rose, wild								S(B)																	
rushes							3(?)																		
rye, wild								A(B)																	
saltbrush							4(?)																		
sorrel, field												sAc(H)													
spruce-fir association				P(M)																					
sundew														L(H)											
vetchling, black														L(H)											
walnut, Persian or English																									Y(M)
willows								S(B)																	
wiregrass								C(L)	SL(L)																

Wild Plant Indicator Summary Form (blank)

Scientific Name	No.	His	SU	Slo	PC	Mois	Drai	Text	Struc	OM	pH	Salt	Lime	Ca	N	P	K	Mg	Cu	Pb	Al	Zn	Se	B
Overall Soil Conditions																								

Soil Conditions Described By Plants

The following soil conditions generally describe the soil and its agricultural potential, but are not readily changeable by the farmer:

History (His) -- Land that has been grazed, cut or abandoned may or may not have agricultural potential. Land that has been overgrazed can be restored over a length of time depending on the extent of overgrazing and your skill at using soil-restorative agricultural methods. For more information on sustainable soil-restorative farming techniques, see John Jeavons, *How To Grow More Vegetables*, 5th ed. (Ten Speed Press, 1995) and the Self-Teaching Mini-Series Booklets published by Ecology Action.

Site Utilization (SU) -- This will give you a general idea of the agricultural potential of the land.

Slope (Slo) -- Sloped land that is vulnerable to water erosion will need to be terraced. Determining an area's vulnerability to water erosion is easily done by simply measuring the slope, talking with local farmers and residents, and observing for yourself the degree to which rainfall erodes the soil.

Plant Cover (PC) -- Soil that supports heavier, denser plant cover *very* generally reflects a greater crop productivity potential.

The following soil conditions describe the physical, chemical and biological nature of the soil and can be modified and improved by soil-restorative farming techniques:

Moisture (Mois) -- Soil that is continually moist or continually dry is able to produce a smaller variety of crops. Optimally, the soil continually has a balance of air and water (each of which make up approximately 25% of the soil's volume) throughout the year.

Drainage (Drai) -- Soil that has poor drainage can produce only crops able to live under that condition. Optimally, soil is well-drained so that the majority of the water that falls onto the soil passes through the soil and does not remain to waterlog the crops.

Texture (Text) -- Texture describes what the soil is made of -- its composition of clay, silt and sand particles. Most soil, regardless of its texture, can be made into fair to good agricultural land assuming necessary soil nutrients and climatic conditions are present. Soil that is extremely rocky can be improved by removing rocks that are bigger than your fist, which can be used to build walls, terraces, tool sheds, or homes.

While there are wild plants that indicate soil texture, there are two very simple tests that you can quickly use to determine soil texture accurately. These are described in detail below.

Determining Soil Texture Quickly and Simply

Method #1 - The Ribbon Test

Step 1: Place approximately 25 g (about 1 ounce) of soil in your palm. Add water drop by drop, and knead the soil so that it takes on the consistency of moist putty that is not too dry or too wet.

Step 2: If the soil does not remain in a ball when it is squeezed, your soil is **SAND**. If it does, go to step 3.

Step 3: Place the ball of soil between your thumb and forefinger and, gently pushing the soil with your thumb, squeeze it upward to form a ribbon of uniform thickness and width. Allow the ribbon to extend over the forefinger and break from its own weight. If you are unable to form a ribbon, your soil is **LOAMY SAND**. If you are able to, continue to step 4.

Step 4: If you can only make a weak ribbon less than 2.5 cm (1 inch) long before the ribbon breaks, go to step 5. If your ribbon is 2.5-5 cm (1-2 inches), go to step 6. If it is greater than 5 cm (2 inches), go to step 7.

Step 5: Excessively wet a small pinch of soil in palm and rub with forefinger. If the soil feels very gritty, it is **SANDY LOAM**. If the soil feels very smooth, it is **SILT LOAM**. If it is neither gritty nor smooth, it is **LOAM**.

Step 6: Excessively wet a small pinch of soil in palm and rub with forefinger. If the soil feels very gritty, it is **SANDY CLAY LOAM**. If the soil feels very smooth, it is **SILTY CLAY LOAM**. If it is neither gritty nor smooth, it is **CLAY LOAM**.

Step 7: Excessively wet a small pinch of soil in palm and rub with forefinger. If the soil feels very gritty, it is **SANDY CLAY**. If the soil feels very smooth, it is **SILTY CLAY**. If it is neither gritty nor smooth, it is **CLAY**.

Method #2 - The Glass Jar Test

Step 1: Fill a wide-mouth quart jar approximately 1/4 full of soil.

Step 2: Add water up to 1 inch from the top. Put a strip of masking tape up one side of the jar.

Step 3: Add 20 ml (4 teaspoons) of an 8% solution of Calgon to separate the sand, silt and clay. (To make an 8% solution, mix 2-1/4 teaspoons of Calgon per 1/2 cup of water.)

Step 4: Mix for 20 minutes by rotating the jar end over end.

Step 5: Set the jar down, let it stand for 40 seconds, mark the sediment level, and label it "40 sec". It is the sand that has settled.

Step 6: At the end of 30 minutes, mark the sediment level in the jar, and label it "30 min". Note how slowly the soil particles are settling. The clay is still in suspension. The layer between 40 seconds and 30 minutes is the silt.

Step 7: Store the jar where it will not be disturbed for several days or weeks.

Step 8: When the water appears clear, indicating that all of the soil is out of solution (this will take a few days to a few weeks), study the soil in the jar carefully. The sand will be easily identifiable as it will be very near the 40-second mark.

Step 9: Measure the total depth of soil in the jar, as accurately as possible. (If you measure in metric, measure in millimeters. If it is more convenient to measure in inches, measure to 1/16th of an inch.) Then measure the depth of each layer, and record these measurements.

Step 10: Using the following bulk density factors, calculate the percentage by weight of the sand, silt and clay in the sampled soil by the following method:

a. Multiply the depth of each separate layer by its bulk density to obtain a weight relationship (WR) for that layer. You will calculate a WR for sand, silt and clay for a total of 3 WR's.

Sand = 1.5 bulk density
Silt = 1.3 bulk density
Clay = 1.2 bulk density

b. Add the 3 WR's to obtain a total weight relationship (TWR).

c. Divide each WR by the TWR and multiply the result by 100 to obtain the percentage by weight of each separate layer.

SAMPLE CALCULATION:

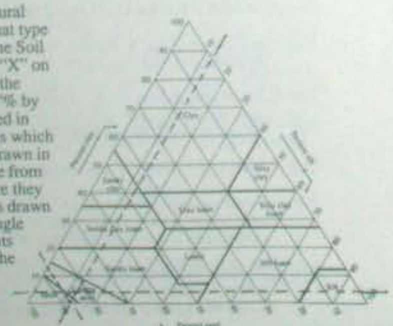
Sand layer measured 3 inches
Silt layer measured 1/2 inch (0.5 inch)
Clay layer measured 3/16 inch (0.19 inch)

a. WR for sand = 3 x 1.5 = 4.5
WR for silt = 0.5 x 1.3 = 0.65
WR for clay = 0.19 x 1.2 = 0.228

b. TWR = 4.5 + 0.65 + 0.228 = 5.378

c. % by weight for sand = (4.5 / 5.378) x 100 = **83.7**
% by weight for silt = (0.65 / 5.378) x 100 = **12.1**
% by weight for clay = (0.228 / 5.378) x 100 = **4.2**

Step 11: Now, use the "Soil Textural Triangle" to determine what type of soil you have. To use the Soil Textural Triangle, put an "X" on each of the three sides of the triangle according to the "% by weight" that you calculated in Step 10. Then, draw lines which run parallel to the lines drawn in the Soil Textural Triangle from the X's to the point where they connect. The dotted lines drawn in the Soil Textural Triangle correspond to the percents by weight calculated in the sample above. In this case, the soil is a **LOAMY SAND**.



Structure (Struc) -- Structure describes the extent to which the soil particles are organized. Healthy soil microorganisms are able to bind soil particles into aggregates called "peds". A fertile soil is a soil with lots of peds and therefore good structure, among other characteristics. The peds which make up this structure allow more air and water to move through the soil and are critical for good crop health and productivity.

Organic Matter (OM) -- Organic matter is the food that the soil microorganisms need in order to build good soil structure. Soil high in organic matter that has been composted aerobically (with air) generally has greater agricultural potential than soil that is low in organic matter.

pH -- pH is a measure of the acidity of the soil, with 7 being neutral, below 7 being acidic and above 7 being alkaline. Most cultivated crops prefer to grow in soil with a pH of 6.0 to 7.5, with 6.5 being approximately optimal.

The following soil conditions relate to the availability of major soil minerals which can be modified by leaching the soil with water, adding organic fertilizers and compost to the soil, and cultivating only when the soil's structure does not allow sufficient air into the soil:

Salt -- Many civilizations have become extinct because the salt level in their farmland increased to such an extent that their staple crops could no longer be grown. Soils with high salt levels are less productive than soils that have low salt levels but still an adequate supply of necessary plant nutrients. The soil components that are considered salts are sodium, calcium, magnesium, chloride, carbonate and bicarbonate. 80% of salt accumulation in the soil is due to the use of salty irrigation water.

Lime -- Lime is a form of calcium which is a necessary plant nutrient. Soils low in calcium will, in general, be more acidic and less productive.

Calcium (Ca) -- Soils low in calcium will, in general, be more acidic and less productive. Low soil calcium occurs after heavy leaching rains, in soils with very high potassium levels, or in very dry soils.

Nitrogen (N) -- Soils low in nitrogen will, in general, be more acidic and less productive. Low soil nitrogen is often caused by excessive leaching of sandy, light soils.

Phosphorus (P) -- Soils low in phosphorus can be either acidic or alkaline and will generally be less productive. Temporary phosphorus deficiencies occur in cold, wet soils.

Potassium (K) -- Soils low in potassium will, in general, be more acidic and less productive. Low soil potassium is often caused by excessive leaching of sandy, light soils.

Magnesium (Mg) -- Soils low in magnesium will, in general, be more acidic and less productive. Soils high in magnesium can also be less productive. Low soil magnesium can occur in soils with very high potassium levels, or in very light soils that are prone to leaching.

The following soil conditions relate to the availability of* minor soil minerals *which can be modified by adding organic fertilizers and adjusting the soil pH through the addition of compost and organic fertilizers. In many soils, there are sufficient quantities of these minor nutrients, but the soil pH can make them unavailable to plants:

Copper (Cu) -- Soils low in copper will be less productive than soils with proper amounts. Oats are especially sensitive to low levels of copper in the soil. Low soil copper occurs most often in muck or peat soils.

Lead (Pb) -- Lead is considered a non-essential plant mineral. Soils high in lead will be less productive and can produce crops that contain levels of lead that are toxic to humans and animals.

Aluminum (Al) -- Aluminum is considered a non-essential plant mineral. Soils high in aluminum are generally acidic and will be less productive.

Zinc (Zn) -- Soils low in zinc will be less productive than soils with proper amounts. Low zinc level in the soil stunts corn, beans, sorghum, cotton, potatoes, and tomatoes. Low soil zinc often occurs in wet soils in early spring and is often due to a heavy application of phosphorus-rich fertilizer.

Selenium (Se) -- Soils low in selenium will be less productive than soils with proper amounts. However, soils high in selenium will also be less productive and can produce crops that contain levels of selenium that are toxic to humans and animals.

Boron (B) -- Soils low or high in boron will be less productive than soils with proper amounts. However, small grains tolerate a low level of soil boron. Low soil boron often occurs in soils with a pH greater than 6.8.

The following minor soil minerals are not indicated by plants in the* Wild Plant Kit, *but are by plants in the* Cultivated Plant Kit*:

Iron -- Soils low or high in iron will be less productive than soils with proper amounts. Low soil iron occurs in soils with a pH greater than 6.8.

Manganese -- Soils low or high in manganese will be less productive than soils with proper amounts. Low soil manganese occurs in soils with a pH greater than 6.7.

Molybdenum-- Soils low or high in molybdenum will be less productive than soils with proper amounts. Low soil molybdenum occurs in very acidic soils.

Old and New Scientific Names

Botanists, at times, agree to change the scientific name of a plant in order to reflect their new understanding of the various plant families. Below is a list that can be used to determine the new scientific name from the old one. The *Wild Plant Indicator Chart* contains only new scientific names.

Old	New
Acnida tuberculata	*Acnida altissima*
Allionia nyctaginea	*Mirabilis nyctaginea* var. *chiliana*
Alsine media	*Stellaria media*
Amaranthus blitoides	*Amaranthus graecizans*
Amaranthus graecizans	*Amaranthus albus*
Ambrosia elatior	*Ambrosia artemisiifolia*
Andropogon furcatus	*Andropogon gerardii*
Apargia autumnale	*Leontodon autumnalis*
Aspris caryophyllea	*Aira caryophyllea*
Aster paniculatus	*Aster simplex*
Bidens involucrata	*Bidens polylepis*
Bigonia radicans	*Campsis radicans*
Bivonea stimulosa	*Cnidoscolus stimulosus*
Blitum capitatum	*Chenopodium capitatum*
Boebera papposa	*Dyssodia papposa*
Brassica alba	*Brassica hirta*
Brassica arvensis	*Brassica kaber*
Brassica campestris	*Brassica rapa*
Bromus hordeaceus	*Bromus mollis*
Capriola dactylon	*Cynodon dactylon*
Carara didyma	*Coronopus didymus*
Cassia chamaecrista	*Cassia fasciculata*
Cenchrus carolinianus	*Cenchrus longispinus*
Cenchrus pauciflorus	*Cenchrus longispinus*
Centaurea picris	*Centaurea ripens*
Chaetochloa lutescens	*Setaria glauca*
Chaetochloa verticillata	*Setaria verticillata*
Chaetochloa viridis	*Setaria viridis*
Chamaenerion angustifolium	*Epilobium angustifolium*
Cirsium lanceolatum	*Cirsium vulgare*
Conyza canadensis	*Erigeron canadensis*
Cuscuta arvensis	*Cuscuta pentagona*
Cuscuta racemosa	*Cuscuta indecora*
Delphinium simplex	*Delphinium strictum*
Dicksonia punctilobula	*Dennstaedtia punctilobula*
Digitaria humifusa	*Digitaria ischaemum*
Echinochloa muricata	*Echinochloa pungens*
Eragrostis cilianensis	*Eragrostis megastachya*
Eragrostis major	*Eragrostis megastachya*
Eragrostis minor	*Eragrostis poaeoides*
Eragrostis pilosa	*Eragrostis pectinacea*
Erigeron ramosus	*Erigeron strigosus*
Erucastrum pollichii	*Erucastrum gallicum*
Eupatorium purpureum	*Eupatorium maculatum*
Eupatorium urticaefolium	*Eupatorium rugosum*

Old and New Scientific Names (cont.)

Old	New
Euphorbia hirsuta	*Euphorbia vermiculata*
Euphorbia maculata	*Euphorbia supina*
Euphorbia nutans	*Euphorbia maculata*
Euphorbia preslii	*Euphorbia maculata*
Euphorbia virgata	*Euphorbia esula*
Gaertneria discolor	*Franseria discolor*
Galinsoga parviflora	*Galinsoga ciliata*
Geum strictum	*Geum aleppicum*
Ginannia lanata	*Holcus lanatus*
Gnaphalium decurrens	*Gnaphalium macounii*
Gnaphalium polycephalum	*Gnaphalium obtusifolium* var. *digitalis*
Gonolobus laevis	*Ampelamus albidus*
Holcus halepensis	*Sorgum halepense*
Hydrocotyle rotundifolia	*Hydrocotyle sibthorpioides*
Hymenophysa pubescens	*Cardaria pubescens*
Hypericum prolificum	*Hypericum spathulatum*
Iresine paniculata	*Iresine celosia*
Jatropha stimulosa	*Cnidoscolus stimulosus*
Lappula floribunda	*Hackelia floribunda*
Lappula virginiana	*Hackelia virginiana*
Lepachys pinnata	*Ratibida pinnata*
Lepidium apetalum	*Lepidium densiflorum*
Lepidium draba	*Cardaria draba*
Leptilon canadense	*Erigeron canadensis*
Linaria cymbalaria	*Cymbalaria muralis*
Linaria elatine	*Kicksia elatine*
Linaria minor	*Chaenorrhinum minus*
Malva rotundifolia	*Malva neglecta*
Matricaria suaveolens	*Matricaria matricarioides*
Muhlenbergia mexicana	*Muhlenbergia frondosa*
Myrica asplenifolia	*Comptonia peregrina*
Nepeta hederacea	*Glechoma hederacea*
Norta altissima	*Sisymbrium altissimum*
Notholcus lanatus	*Holcus lanatus*
Oxalis corniculata	*Oxalis europaea*
Oxalis filipes	*Oxalis florida*
Oxybaphus hirsutus	*Mirabilis hirsuta*
Oxybaphus linearis	*Mirabilis hirsuta*
Oxybaphus nyctagineus	*Mirabilis nyctaginea*
Parsonia petiolata	*Cuphea petiolata*
Paspalum angustifolium	*Paspalum laeve*
Penstemon laevigatus	*Penstemon digitalis*
Phytolacca decandra	*Phytolacca americana*
Plantago arenaria	*Plantago indica*
Poinsettia dentata	*Euphorbia dentata*
Potentilla canadensis	*Potentilla simplex*
Potentilla monspeliensis	*Potentilla norvegica*
Potentilla pumila	*Potentilla canadensis*
Pteris aquilina	*Pteridium aquilinum*

Old and New Scientific Names (cont.)

Old	New
Radicula austriaca	*Rorippa austriaca*
Radicula palustris	*Rorippa islandica*
Radicula sylvestris	*Rorippa sylvestris*
Rhus toxicodendron	*Rhus radicans*
Rosa rubiginosa	*Rosa eglanteria*
Rubus villosus	*Rubus flagellaris*
Rudbeckia hirta	*Rudbeckia serotina*
Salsola pestifer	*Salsola kali*
Scabiosa arvensis	*Knautia arvensis*
Sedum triphyllum	*Sedum purpureum*
Setaria lutescens	*Setaria glauca*
Silene anglica	*Silene gallica*
Silene inflata	*Silene cucubalus*
Silene latifolia	*Silene cucubalus*
Sinapis alba	*Brassica hirta*
Sinapis arvensis	*Brassica kaber*
Sisymbrium incisum	*Descurainia richardsonii*
Sisymbrium sophia	*Descurainia sophia*
Sium cicutaefolium	*Sium suave*
Solidago serotina	*Solidago gigantea*
Spiraea salicifolia	*Spiraea alba*
Syntherisma ischaemum	*Digitaria ischaemum*
Syntherisma sanguinale	*Digitaria sanguinalis*
Taraxacum laevigatum	*Taraxacum erythrospermum*
Tecoma radicans	*Campsis radicans*
Tithymalus cyparissias	*Euphorbia cyparissias*
Toxicodendron radicans	*Rhus radicans*
Toxicodendron vernix	*Rhus vernix*
Tragopogon dubius	*Tragopogon major*
Valerianella locusta	*Valerianella olitoria*
Verbena bracteosa	*Verbena bracteata*
Veronica tournefortii	*Veronica persica*
Vincetoxicum nigrum	*Cynanchum nigrum*
Vincetoxicum officinale	*Cynanchum vincetoxicum*
Xanthium canadense	*Xanthium orientale*
Xanthium commune	*Xanthium orientale*
Xanthium pensylvanicum	*Xanthium orientale*

Wild Plant Indicator Codes

INDICATOR (Ind)
X = not indicative of any soil condition

HISTORY (His)
A = abandoned sites
G = grazed or cut grasslands
OG = overgrazed land

SITE UTILIZATION (SU)
A = poor pasture crop potential
AP = average crop-producing potential
CS = suitable for growing cool-weather, short-season crops, and for grazing and timber production
D = humid (irrigation) farming potential when land is drained
DF = dry-farming potential
DI = dry-farming impossible
DL = humid (irrigation) farming potential when land is drained and salts are leached out
DW = dry-farming potential during winter rainfall
G = good for agriculture
GC = land has good potential to produce corn (and likely other crops)
GD = if this plant's growth is pure and dense, forming a close cover, it indicates that the land has a favorable water supply, combined with rather high fertility, and is probably well-suited for agriculture. Deep-rooted crops are the best crops to grow here. Soil is highly susceptible to wind erosion, and all precautions to prevent this must be taken.
H = land could continue to produce pasture crops
HF = humid farming potential
HL = humid (irrigation) farming potential where native cover is luxuriant; success doubtful on lands of rock outcrop or with rock layers or hardpan
L = humid (irrigation) farming potential when salts are leached out
P = poor farming potential
PD = poor farming potential if plant is growing luxuriantly and densely
PS = land could be used for pastures with shrubs
SD = shallow- or deep-rooted crops can be grown here
SE = shallow-rooted, early-maturing crops can be grown here. Rainfall tends to be minimal and the limiting factor, but land is generally fertile given adequate water.
T = better for timber production than tillage

SLOPE (Slo)
I = Indefinite indicator
NS = no slope
2-5 = 2% to 5% slope
5+ = greater than 5% slope

PLANT COVER (PC)
2 = low density of coverage
3 = low to medium density of coverage
4 = medium to high density of coverage
5 = high density of coverage
AH = this plant avoids high coverage density
AL = this plant avoids low coverage density

MOISTURE (Mois)
1 = good quality water very close to the surface
2 = water table at or near the surface
3 = marshland or water very near the surface
4 = water near the surface, but the quality of water may be poor
5 = salty water at or just below the surface
6 = water about 10 feet down
7 = water no more than 15 feet below the ground
8 = mineralized water exists 10 to 40 feet down
9 = water to be found from 10 to 50 feet beneath the ground
D = dry
DT = drought-tolerant
F = soil moisture constant enough to support fungus that causes foot rot of winter wheat and winter barley
FI = fresh or intermediate (may persist in the soil for short periods of time)
FR = fresh, recently entered soil
HC = when this plant is growing densely, it indicates that the soil has a high water-holding capacity
I = indefinite indicator
M = moist
MD = moist; soil doesn't dry out
RM = rich, moist soil
SL = soil moisture too limited during summer for satisfactory farming
U = lively underground stream

DRAINAGE (Drai)
A = on sandy land, indicates dense, impervious clay or sandy loam layer that accumulates fresh water
B = brackish water; may need to drain before suitable for agriculture
C = considerable amount of water in the deeper layers
D = springs and/or fresh water from lakes 3 to 9 feet below the surface
I = indefinite indicator
IM = imperfect
P = poor
PS = poor drainage in the subsoil layer
PT = poor drainage in the topsoil layer
S = water available a few feet down, probably lying atop an impermeable clay
SD = this plant depends on snowdrifts for moisture and grows on southeast slopes
TS = poor drainage in the topsoil and subsoil layers
WD = well drained
WL = waterlogged; would be a place where slime molds would like to grow

TEXTURE (Text)
12 = stoniness class 1 to 2
35 = stoniness class 3 to 5
C = coarse
CU = coarse muck
F = fine/clay
I = indefinite indicator
L = loam (cont.)

Wild Plant Indicator Codes (cont.)

TEXTURE (Text) (cont.)
M = medium
MC = medium coarse
MF = medium fine
MU = medium muck
SF = stone-free
SFU = stone-free muck
SL = sandy/light
U = muck
WS = windswept sand hills where there are fewer clay particles on the crests than on the hollows and slopes.

STRUCTURE (Struc)
C = surface or lower soil compacted
Cr = surface crusted or plow pan
G = good
GD = good, deep soil
H = hard, crusted soil
P = poor

ORGANIC MATTER (OM)
H = high level of soil organic matter
HF = moderate to high level of fermented organic matter
HR = moderately high level of raw organic matter in soil
LH = low humus
LM = low to medium level of soil organic matter
M = medium level of soil organic matter
MF = moderate level of fermented organic matter

pH
1 = Probable pH range of 4.1 to 5.0 but may be pH 4.1 to 6.0
2 = Probable pH range of 4.1 to 5.0 but may be pH 4.1 to 6.9
3 = Probable pH range of 5.1 to 6.0 but may be pH 4.1 to 6.0
4 = Probable pH range of 5.1 to 6.0 but may be pH 4.1 to 6.9
5 = Probable pH range of 5.1 to 6.0 but may be pH 4.1 to 7.0
6 = Probable pH range of 5.1 to 6.0 but may be pH 4.1 to 7.9. This plant is therefore a poor indicator of soil pH.
7 = Probable pH range of 5.1 to 6.0 but may be pH 5.1 to 6.9
8 = Probable pH range of 6.1 to 6.9 but may be pH 5.1 to 7.0
9 = Probable pH range of 6.1 to 6.9 but may be pH 5.1 to 7.9. This plant is therefore a fairly poor indicator of soil pH.
10 = Probably pH 7.0 but may be pH 6.1 to 7.9
11 = Probable pH range of 7.1 to 7.9 but may be pH 6.1 to 7.9
12 = Probable pH range of 7.1 to 7.9 but may be pH 7.0 to 7.9
Ac = acid soil
AC = pH 4.6 to 6.4
AcS = acid if soil is swampy
Al = alkaline soil
AL = pH 7.4 to 7.8
AlO = plant only grows in alkaline soil
N = neutral soil (cont.)

Wild Plant Indicator Codes (cont.)

pH (cont.)
NAc = neutral to acid soil
NAl = neutral to alkaline soil
NE = pH 6.5 to 7.3
I = indefinite indicator of soil pH
sAc = slightly acid soil
vAc = very acid soil

SALT
A = plant accumulates salt from the soil
L = low level in soil
TH = plant tolerates high salt content in soil

LIME
H = high level in soil
L = low level in soil

CALCIUM (Ca)
A = plant accumulates calcium from the soil
H = high level in soil
L = low level in soil
LC = low level in soil if plant has clubroot
TL = plant tolerates low level

NITROGEN (N)
H = high availability
I = indefinite indicator of soil nitrogen
L = low level in soil
P = if plant is pale green, nitrogen is deficient in soil
TL = plant tolerates low level

PHOSPHORUS (P)
A = plant accumulates phosphorus from the soil
H = high level in soil
LS = low level in soil if plant is stunted
S = rock phosphate lies close to soil surface
TL = plant tolerates low level

POTASSIUM (K)
A = plant accumulates potassium from the soil
H = high level in soil
LS = low level in soil if plant is stunted
P = content in plant's leaves is proportional to potassium content in soil
TL = plant tolerates low level

MAGNESIUM (Mg)
A = plant accumulates magnesium from the soil
H = high level in soil

Wild Plant Indicator Codes (cont.)

COPPER (Cu)
A = plant accumulates copper from the soil
TH = plant tolerates high level

LEAD (Pb)
TH = plant tolerates high level

ALUMINUM (Al)
TF = plant tolerates high level (and high level of iron)
TH = plant tolerates high level
TO = toxic to plant

ZINC (Zn)
N = needed for growth of plant
TH = plant tolerates high level

SELENIUM (Se)
A = plant accumulates selenium from the soil
N = needed for growth of plant

BORON (B)
B = high concentrations in soil are indicated by brown spots first appearing along the margin and later in the tissue between the veins, and then progressing toward the midrib
Y = high concentrations in soil are indicated by yellowing along the margins and between the veins of more mature leaves

Data Sources of the Wild Plant Indicator Chart

(letters in Chart correspond to sources listed below)

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C. Dale, Hugh M. "Weed Complexes on Abandoned Pastures as Indicators of Site Characteristics." *Canadian Journal of Botany* 44 (1966), pp. 11-17.

D. Whitehurst, Ron. *Reading Weeds: Plant Indicators in Field, Garden and Vacant Lot*. Draft, April 20, 1992. (P.O. Box 60695, Palo Alto, CA 94306) (Includes drawings.)

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O. Wherry, Edgar T. "Divergent Soil Reaction Preferences of Related Plants." *Ecology* VIII, no. 2 (April 1927), pp. 197-206.

Data Sources of the Wild Plant Indicator Chart (cont.)

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An Example: Using the Wild Plant Kit

After walking the land and marking its borders with stakes, I take with me my best plant identification books and a blank *Wild Plant Indicator Summary Form* and walk the land again. This time, when I observe a plant that I know to be prevalent on the land, I look it up in my books and write its scientific name on the *Summary Form*. I continue to walk the land until I have listed all that I can of the most common plants by their scientific or, if necessary, common name on the *Form*, and then I head home.

Back at home, I proceed to look up all of the plants on my *Form* in the *Wild Plant Indicator Chart* and record all of the soil conditions their presence indicates on the *Form*. Then, looking at the indications, I summarize them in the row marked "Overall Soil Conditions". The completed form is titled "EXAMPLE", on page 41. Now, let's take a closer look at how I came up with the "Overall Soil Conditions" for this example and what the "Overall Soil Conditions" are really telling me.

In the "History" column, three plant species indicate that the soil has been overgrazed, and one plant species indicates that the soil was grazed or cut grasslands. Most likely the soil has been overgrazed and is somewhat worn-out. However, I know that the soil is in a residential area, so while it may have been many years since it was grazed, it is likely that the soil is similar to soil that has been overgrazed in that it is most likely low in nutrients and somewhat compacted. From walking the land, I know that at least the surface of the soil is compacted.

In the "Site Utilization" and "Slope" columns, only one plant has anything to say about these conditions, and both indications appear to be accurate.

No indications are given regarding plant cover.

Slightly contradictory indications are given regarding moisture, but only slightly. Most likely, the soil is periodically wet or is able to retain its moisture fairly well, a condition which lends itself well to growing crops.

However, indications describe the soil's drainage as poor and, more specifically, poor in the topsoil and subsoil. So, at some times of the year, the soil may retain its moisture too well, and plants may become waterlogged. Deep soil preparation and compost will be essential for healthy plant growth.

The texture of the soil is described by the presence of one plant species as being medium to fine and stone-free, both of which correlate to my physical observations of the soil.

One plant, *Taraxacum officinale*, indicates that the soil's structure is good, and another, *Rumex crispus*, indicates that it is poor. Interestingly, both indications come from populations that were not particularly strong -- there were not as many members present in these populations as in other populations that I listed. So, what may be being communicated is that the soil's structure is good in some areas and poor in others.

Only one plant, *Taraxacum officinale*, indicates anything regarding the soil's organic matter, so this is taken to be accurate, but we need not overly concern ourselves about it, especially since, as mentioned above, this plant did not show a strong presence on the land.

The soil pH seems to be neutral, which is good, and no remedial action needs to be taken.

The soil appears to be low in lime and calcium, which are closely related, so it is likely that the addition of a fertilizer containing calcium would be beneficial.

The soil appears to be high in nitrogen.

In this example, we see from the "Overall Soil Conditions" that we must decide whether to add phosphorus fertilizer and not potassium or magnesium fertilizer to the soil for the coming growing season. However, this is a complex decision. This complexity is not uncommon in soil testing with plants and is a part of this example, not to frighten you away, but to give you a sense of how you can work with this complexity and make a decision you can be reasonably confident about. *Taraxacum officinale* indicates that soil phosphorus levels may be low only if the plants are stunted, which they were. *Taraxacum officinale* also indicates that the soil probably has adequate quantities of potassium. (The fact that the content of potassium in the leaves is proportional to that in the soil is, at this point in plant indicator technology, of passing interest only since testing the composition of potassium in the leaf would require sophisticated laboratory training and equipment which is unavailable to most people in the world.) However, since only a weak population of a single plant species gives these indications, we must be somewhat wary of their accuracy.

It is possible that the soil is not deficient in phosphorus since that the indication is true only when the plant is stunted. It may be that the plant samples were stunted for another reason, such as compacted soil, cold weather or wildlife grazing. If this is true, no ill effects will result this growing season if no phosphorus fertilizer is added. However, adding phosphorus fertilizer at the rate described on page 77 would likely be the safest step to take, if such a fertilizer is available, since it is still possible that phosphorus is deficient in the soil. In general, if your overall indications describe a deficiency and an appropriate fertilizer is available, the fertilizer can always be applied safely at the rates described in "Application Rates for Organic Fertilizers and Composted Manures" on pages 77 to 79. However, with detailed consideration and experience, you may be able to avoid adding a fertilizer if the evidence in favor of it is weak.

Now we will decide if we can afford not to add a potassium fertilizer to the soil. The moisture and drainage indications in this example describe a soil that does not seem prone to leaching. This observation corroborates the unlikelihood that potassium has leached from the soil and is low. Since this evidence is still somewhat weak, finding more indicator plants in the area to increase the number of points of view you have may be extremely useful. If no further evidence is found, it is probably safe not to add potassium fertilizer. Adding fertilizers should be considered only when there is at least some supporting evidence of a deficiency in the soil.

Now we will decide if we can afford not to add a magnesium fertilizer to the soil. *Taraxacum officinale* indicates that the soil has sufficient magnesium for good plant growth. Since adding too much magnesium to the soil can be particularly harmful, there seems to be no good reason to add a magnesium-rich fertilizer when the evidence, though weak, does not indicate a deficiency. If the indication of a single plant species did suggest a deficiency, the fact that the soil is close to neutral and not acidic contradicts this and therefore suggests that not adding a magnesium-rich fertilizer would not affect yields or overall soil fertility.

With the synthesis of all of these indications, we now know more about the state of the soil and what types of fertilizers we should add in order to increase the soil's overall health and productivity. However, because we will also use cultivated plants to analyze the soil in this example, we will wait until we have confirmed our conclusions with the *Cultivated Plant Kit*. This example continues on page 58, after the *Cultivated Plant Kit* has been described.

EXAMPLE: Wild Plant Indicator Summary Form

Scientific Name	No.	His	SU	Slo	PC	Mois	Drai	Text	Struc	OM	pH	Salt	Lime	Ca	N	P	K	Mg	Cu	Pb	Al	Zn	Se	B
Sonchus oleraceus	100+																A							
Lactuca serriola	30+																							
Tragopogon porrifolius	20																							
Taraxacum officinale	6	OG				FR	TS		G	HR/LH	N/MA			L	H	LS	P/H	H						
Raphanus sativus	3																							
Malva neglecta	20+					FI					N				H									
Avena fatua	500+	OG				M	P																	
Rumex crispus	4	OG	PS	NS		M	TS	ME/SF	P				L											
Hypochaeris radicata	10	OG																						
Overall Soil Conditions		OG	PS	NS		M/FI	TS	ME/SF	?	HR/LH	N		L	L	H	LS		H						

PART II: CULTIVATED PLANT KIT

The *Cultivated Plant Kit* consists of three parts. The first part is an outline of how to use the Cultivated Plant Kit step-by-step.

The second part is the *Cultivated Plant Indicator Chart*. It is broken down into two parts: the first lists general symptoms, and the second lists specific symptoms, of particular indicator crops you can easily grow. These crops can be grown in representative sites around the mini-farm. Very little area, and possibly no additional area, is needed to grow out these indicator crops. Since most of the crops are edible, you will be able to determine soil mineral quantities and eat or sell the results, so that no extra area is required to test and learn from your soil. The *Chart* as a whole allows you to interpret your observations of the crops you are growing and understand what actions you can take to improve the soil.

The third part is the *Cultivated Plant Indicator Summary Form*. This allows you to record your analysis and cross-check your conclusions with the information you gather from the *Wild Plant Kit* (if you are using it also to analyze the soil). By recording your analysis, you will have the opportunity to learn how the soil is reacting to the amendments you add over time. You can then customize your soil management strategies based on your past experiences.

Because the *Cultivated Plant Kit* is plant-based and the seeds needed to grow the crops you will observe can all be open-pollinated and therefore propagated and collected by yourself, it can be reused indefinitely and without further cost.

Using the Cultivated Plant Kit in Your Garden and Farm

The *Cultivated Plant Kit* allows you to assess the current fertility of agricultural land by observing the size and color of cultivated plants.

Step 1: Draw a map of the outside border of your farm on a piece of paper.

Step 2: Are there areas on your farm that are hotter, wetter, windier or just more productive? These different areas indicate microclimates. Draw lines on your map that define the different microclimates on your farm.

Step 3: In each of these microclimate areas (or in the entire farm, if you have only one microclimate) shown on the map, write the number of square feet you will be farming in that microclimate. For every 2,000 square feet of growing area, you will need to grow at least 10 square feet of each of the following crops:

Tropical climates: Corn; potato or sugar beet; cotton or tea; clover (if possible)

Temperate climates (plant in *spring*): Corn; clover or flax; apple or gooseberry or strawberry; tomato; pea

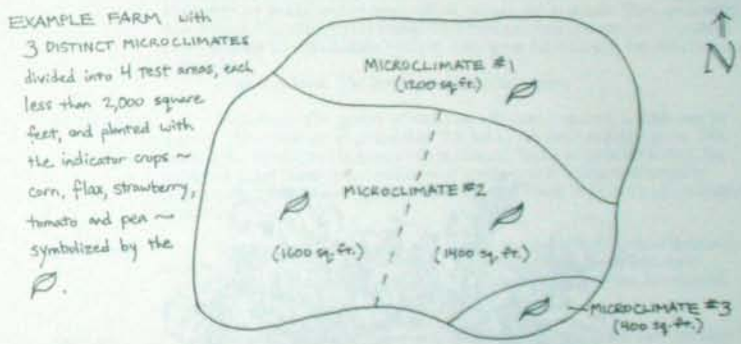
Temperate climates (plant in *fall*): optional — choose suitable fall/winter crops from the Cultivated Plant Indicator Chart, Part 2, that you can use to help you to cross-check the conclusions you made in the spring and summer.

The "test areas" that you use to grow these crops can be each of the entire 2,000-square-foot areas on your farm or plots that could be as small as 40 square feet in a tropical climate or 50 square feet in a temperate climate.

Step 4: On the actual farm, establish the borders of each of the test areas, regardless of their size, that you will use to grow the indicator plants.

Step 5: Prepare all the soil identically in each microclimate area, including the test areas (unless you have previously tested and analyzed the soil in each area using this booklet or by another means and know what specific fertilizers are needed). If you have the results from plant- or chemical-based soil tests done the previous season or year, add the recommended fertilizer amounts. Record the type and quantity of fertilizer you are using for each of the microclimate areas on a blank *Cultivated Plant Indicator Observation and Summary Form*.

You may find it easiest to use one *Form* for each test area. If you have more than one test area, name or number the areas to keep your records straight.



Step 6: Plant as many of the indicator crops listed above and in the Cultivated Plant Indicator Chart as possible according to the season and climate, making sure there is at least 10 square feet of each crop in every 2,000 square feet of each microclimate. Record each crop you planted in the Observation and Summary Charts of the *Cultivated Plant Indicator Observation and Summary Forms* (using, ideally, one *Form* per test area).

Step 7: Grow the indicator crops. Record all of your observations for each crop, including the date of your observation, on the Observation Chart of the *Form*.

Step 8: At the end of the season, use the *Cultivated Plant Indicator Chart* to determine what your observations indicate. However, before concluding that any particular crop indicates that a particular nutrient is deficient, check *False Indicators* on pages 56 to 57 to verify that the symptoms were not caused by something else. This can be difficult to determine. If you suspect the indication to be false, you should indicate that on the *Form*, perhaps as a question mark after the suspect indication.

Step 9: Then, synthesize the information in the "Overall Condition" row just as you did in the Wild Plant Kit, as described in steps 7 and 8 on page 6 and in the example on pages 39 and 40.

Step 10: If you are also using the Wild Plant Kit to analyze your soil, compare the Overall Conditions you have just determined to the "Overall Soil Conditions" indicated by the *Wild Plant Kit*. As described on page 6, use the same technique for synthesizing the information as you did when synthesizing the information given by the *Wild Plant Kit* and *Cultivated Plant Kit* individually.

Step 11: Read and understand the importance of any deficient nutrient as described in "Soil Conditions Described by Plants" on pages 24 to 28. Apply fertilizers to correct an imbalance or deficiency as described in "Adjusting Soil Minerals" on pages 66 to 80.

Cultivated Plant Indicator Chart

Below are the symptoms that appear in certain crops (called indicator crops) that indicate a specific soil nutrient deficiency. When soil nutrient deficiency symptoms appear, they are generally indicating that the level of a specific nutrient is so low as to significantly reduce crop yields.

This chart is divided into two parts. Part I describes the symptoms that generally appear on any crop when a particular nutrient level is very low in the soil. Part II is a much more accurate diagnostic tool. Here you will find more detailed descriptions of symptoms that appear on specific crops when a particular nutrient is deficient.

Cultivated Plant Indicator Chart, Part I - General Symptoms

Nutrient	General Symptoms
nitrogen	*Deficiency:* The growth of both tops and roots is slow and stunted, and the tops are spindly. The shoots are short and thin. The leaves are yellowish-green when they are young, and become yellow, orange, red or purple. They are smaller than normal. The older leaves change color first and drop prematurely. The plants look generally thin and lacking in vigor. They grow more slowly, and their maturity is delayed. *Overabundance:* The leaves are often bluish-green.
phosphorus	*Deficiency:* The growth of both tops and roots is stunted, and the tops are spindly. The shoots are short and thin. The leaves are small and dark green. The plants grow slowly, and their maturity is delayed. Under extreme deficiency, the leaves are a dull bluish-green and become purple or dull bronze with purple or brown spots. Older leaves may turn dark brown or black. Fruit and seed production is reduced.
potassium	*Deficiency:* The symptoms may vary depending on the degree of deficiency and the type of plant affected. Often, the leaf color is bluish-green with some yellow or pale green between the leaf veins. Older leaf margins may be scorched. Stalks are often weak.
calcium	*Deficiency:* The young leaves do not emerge or unfold, and their tips may be hooked back or stick together to form a ladder-like structure. The leaf margins can be irregular and ragged, with brown scorching or spotting effects. In cases of extreme deficiency, the growing points die. Stem elongation is then restricted by the death of the growing point. The root tips die. The roots may appear gelatinous, and their growth restricted.
magnesium	*Deficiency:* The older leaves turn pale green and then yellow between the veins (an effect called chlorosis). The lower leaves can also turn reddish-purple along the edges and tips. Continued deficiency causes the younger leaves to become affected. The older leaves may fall with prolonged deficiency.
sulfur	*Deficiency:* The symptoms are similar to those that occur when nitrogen is deficient except that generally only the young leaves turn pale green and then yellow while the older leaves remain green. A distinctive symptom, though one that cannot be observed without experience, is that the stem growth is less restricted than it is in the case of nitrogen deficiency.

Cultivated Plant Indicator Chart, Part I - General Symptoms (cont.)

Nutrient	General Symptoms
boron	*Deficiency:* The terminal growing tips are brittle and damaged. The stems are shortened and hard. The leaves and/or stems are distorted. The young leaves turn pale green, yellow, then brown and die. The leaves are often scorched, curled, and/or mottled. The roots grow poorly.
iron	*Deficiency:* Pale green, yellow or white areas appear between the veins for the full length of the youngest leaves. The leaves may be completely bleached, and their margins and tips may be scorched when this nutrient is extremely deficient.
manganese	*Deficiency:* The youngest leaves show yellow mottled areas which are not as intense as with iron deficiency. Eventually, the leaves turn entirely pale.
zinc	*Deficiency:* The young leaves turn pale green and then yellow between the leaf veins. Death in some parts of the leaf and purplish coloration are common. The leaves are small, deformed and/or unusually thick. The plants have fewer leaves, less distance between where the leaves emerge from the stem, and reduced fruit production.
copper	*Deficiency:* The leaves wilt and turn bluish-green, then pale green and yellow. The leaves curl and may be elongated. The plants may lose their leaves and may not flower. The seed head usually will not stay erect.
molybdenum	*Deficiency:* The young leaves turn pale green and then yellow and become deformed and very narrow. The area between the leaf veins may be yellow on the older leaves.

Cultivated Plant Indicator Chart, Part 2 - Specific Symptoms

(indicating a deficiency unless otherwise noted)

Scientific Abbreviations of Nutrients Used in this Chart

B= Boron	Mb = Molybdenum	P = Phosphorus
Ca = Calcium	Mg = Magnesium	S = Sulfur
Cu = Copper	Mn = Manganese	Zn = Zinc
Fe = Iron	N = Nitrogen	
K = Potassium	Na = Sodium	

Indicator Crop	Symptoms	Nutrient
alfalfa	White or brown spots appear on the leaves. Eventually, the white spots turn brown. The leaf margins are brown or pale green to yellow.	**K**
	The center of the leaf, between the veins, is yellowish, but the leaf margins are green.	**Mg**
	The growing points die, and the stems are thick and stiff. The leaves are primarily pale green to yellow, but may include other colors.	**B**
apple	The bark is reddish. The fruits are red on their upper half and whitish on their bottom half. (Green fruit may indicate that nitrogen is in excess.)	**N**
	The fruit is green, with soft flesh and an acid flavor, and does not store well.	**P**
	The leaf margins are scorched. The area between leaf veins is pale green to yellow. The fruits remain green, appear immature and are slightly acidic and woody to taste.	**K**
	The growing points die. Eventually, the shoot dies back, and the leaves become scorched and ragged. The leaf margins roll forward. The leaves nearest the tips are first affected.	**Ca**
	The area between the leaf veins turns pale green, and limp and thin to touch, or purplish. The leaf area near the midrib or near the margin eventually dies. The area of death then progresses toward the midrib. In some examples, death in the leaf margin may be difficult to distinguish from potassium deficiency symptoms.	**Mg**
	The leaves are brilliant orange and red.	**S**
	The fruits are oddly shaped, with cracking, roughening and pitting in the skin. The fruit's center is corky and brown. The bark is split and rough.	**B**
	The leaves turn pale green to yellow between the veins beginning at the leaf margins and progressing inward until only the veins remain green. Strongly growing shoots may be only slightly affected, which is a distinguishing symptom from iron deficiency, where the loss of green color is most obvious in the young leaves closest to the tips.	**Mn**
barley	The leaves are mottled pale green and white when potassium is extremely deficient. Barley is the most susceptible cereal crop.	**K**
	The leaves are slightly pale green with yellow streaks. Under severely deficient conditions, brown spots appear between the leaf veins. The lower leaves turn brown and die.	**Mn**

Cultivated Plant Indicator Chart, Part 2 - Specific Symptoms (cont.)

Indicator Crop	Symptoms	Nutrient
barley (cont.)	No symptoms when boron is deficient, but the leaves are elongated and have brown blotches when boron is in excess.	B
bean	The leaves are pale, and the margin area has collapsed. The stems and/or the connection between the stems and leaves (petioles) are collapsed near the growing points. There may be many underdeveloped pods and seeds.	Ca
	The young leaves may have spots. However, the more reliable symptoms are visible on the seeds. When the seed coat is removed and the two halves (cotyledons) are separated, there is a brown spot on the flat surface of each half. These flat areas may be hollowed out under severe deficiency.	Mn
	The plant is stunted. The cotyledon leaves have small, reddish-brown spots.	Zn
	The growing points die, and the stems are thick and stiff. The leaves are pale green to yellow.	B
beet	In young plants, the new leaves develop weakly and may turn brown or die. In older plants, the outermost leaves appear wilted and lie on the ground. These leaves are scorched, yellowish and dull. The growing point dies and the crown is covered with small, sometimes deformed leaves. The root rots from the side but usually not to the core. Brown lesions may appear around the rotted area. This is what is called "blackheart."	B
	The leaves are a deep red.	Mn
	The leaves are yellow between their veins and brown on their edges.	Zn
beet, sugar	The growing point dies.	Ca
	At first, the leaves are slightly pale green and then turn yellow. Eventually, the leaf margins and the area between the veins of the leaves die as if they were scorched. The older leaves wither.	Mg
	The younger leaves are mottled pale green and yellow, while the older leaves are normal.	Fe
	The leaves seem more upright and triangular due to the leaf margins curling upward. The area between leaf veins is pale green to yellow. Eventually, brownish lesions appear between the veins, and the brown tissue may die and fall out, leaving small holes.	Mn
	In young plants, the new leaves develop weakly and may turn brown or die. The crown rots. In older plants, the outermost leaves appear wilted and lie on the ground. These leaves are scorched, yellowish and dull. The growing point dies, and the crown is covered with small, sometimes deformed leaves. The crown rots, forming a large black hollow.	B
	The leaves are dark green, dull, wilt quickly under drought, and grow more horizontally than normal from the crown of the plant.	Na

Cultivated Plant Indicator Chart, Part 2 - Specific Symptoms (cont.)

Indicator Crop	Symptoms	Nutrient
brassicas	The leaves are bluish-green and pale green to yellow between the veins. The leaf margins are scorched and curled. The leaves grow slowly and are tough.	K
	The tips of young leaves hook, then the growing points die. Seedlings are mottled yellow.	Ca
broccoli	The older leaves are mottled yellow, then have yellow, orange, red and/or purple areas.	Mg
Brussels sprouts	The growing tips become distorted and die.	Mb
cabbage	The growing tips become distorted and die.	Mb
carrots	The connections between the stem and the young leaves collapse.	Ca
	The growing points die, and the leaves are distorted and pale green.	B
cauliflower	The older leaves are mottled yellow, then have yellow, orange, red and/or purple areas.	Mg
	The head fails to develop or is brown. The leaf margins are mottled. The stem is hollow. The young leaves are distorted.	B
	The head is small, open and loose. The growing tips become distorted and die.	Mb
celery	The leaves have brown blotches. The stems are distorted, brittle and have brown streaks. The affected areas later become dark brown. The young heart leaves may die.	B
cereals	The plants tiller poorly. The stems may be reddish or purplish. The heads are small.	N
	The plants tiller excessively. The stems are short and thin, and many do not flower. The heads and grains are small. The leaves are bluish-green or pale green, and the leaf tips and margins may be brown.	K
	The older leaves have spots.	Mn
	New growth shoots from the tips do not emerge, especially in the tillers.	Ca
	The leaves have yellow spots resembling beads on a string that later are yellow intermittent streaks.	Mg
	The younger leaves are yellowish-gray, and their margins and tips wither. The leaves may not unfold and tend to wilt. Fewer heads are formed, and those that form are short and distorted, with tips that are pale and not properly developed. The plants are bushy and green.	Cu
	The young plants are purplish. The older leaves die. The mature plants produce gray straw.	Zn

Cultivated Plant Indicator Chart, Part 2 - Specific Symptoms (cont.)

Indicator Crop	*Symptoms*	*Nutrient*
cherry	The leaves are pale green or yellowish and scorched.	K
	The leaves are very red or purple with dead areas.	Mg
	The leaves turn pale green to yellow between the veins beginning at the leaf margins and progressing inward.	Mn
citrus	The leaves show water-soaked areas between the veins, which later develop into yellow spots. The undersides of the leaves have brown gummy deposits. The trees may lose all their leaves.	Mb
clover	The plants are dwarfed with thin stems. The leaves are sparse, dull bluish-green or green, and have purplish or bronze spots that eventually turn yellow.	P
	White or brown spots appear on the leaves. Eventually, the white spots turn brown. The leaf margins are brown or pale green to yellow.	K
	The leaf margins are scorched, and the connections between stems and leaves (petioles) and stems bearing flowers (pedicels) are collapsed.	Ca
	(red and white clover) The growing points die and the stems are thick and stiff. The leaves are pale green to yellow, but may include other colors.	B
	The plants are dwarfed and grow in a rosette pattern.	Zn
corn	The leaf shows a V-shaped pattern of yellowing (with the point of the V at the tip of the leaf).	N
	The ears are pointed and poorly developed. The edges of leaves are bronze to yellow.	K
	The leaves show yellow spots resembling beads on a string that later turn into yellow intermittent streaks. The leaves may be purplish or reddish.	Mg
	The youngest leaves have white irregular spots between their veins.	B
	The leaves have narrow yellow stripes.	Mn
	The leaves are yellowish-white on either side of the midrib (center vein) or have broad, green and yellow striping at their bases. The plant is stunted, with less distance between where the leaves emerge from the stem. Silk emergence is delayed and irregular.	Zn
cotton	The leaves are extremely red.	S
	The plant is stunted.	Zn
currants	(black currant) The leaves are purplish, then become scorched around the margin.	K
	(red currant) The leaves are scorched and pale green to yellow.	K
	The growing points die. Eventually, the shoot dies back, and the leaves become scorched and ragged. The leaf margins roll forward. The leaves nearest the tips are first affected.	Ca
	(black currant) The leaves are purple except their margins which remain green. The leaves curl downward.	Mg

Indicator Crop	*Symptoms*	*Nutrient*
currants (cont.)	(black and red currant) All leaves are slightly pale green to yellow between the veins.	Mn
flax	The shoots are thin, and there are few shoots branching from the side of the stem. The stems are yellowish and reddish near their bases. Flowers and fruits are few and ripen prematurely.	N
	The same symptoms as for nitrogen deficiency, but the leaf color is dull green.	P
	The plants are short, and leaves are pale green, eventually turning brown at the tip.	K
	The shoots near the tips and flower-bearing stems collapse. The tip leaves are yellowish.	Ca
	The space between the leaves along the stem is smaller. There is much side-shooting near the base of the plants.	Zn
gooseberry	The leaves are purplish, then become scorched around the margin.	K
	The growing points die. Eventually, the shoot dies back, and the leaves become scorched and ragged. The leaf margins roll forward. The leaves nearest the tips are first affected	Ca
	A red band runs around the leaf margin which fades to a pale yellow.	Mg
	The leaves are brilliant orange and red.	S
hops	The plant is stunted, with thick, rigid shoots. The distance between one set of leaves and the next is unusually small. There are many laterals. The leaves are distorted, and the shoots die early. A distinct symptom is that young buds appear on the crown of the plant (at ground level).	B
johnson grass	The plant dies. (This plant is particularly sensitive to iron deficiency .)	Fe
kale	The older leaves are mottled yellow and then turn brilliant yellow, orange, red and/or purple.	Mg
	The area between the leaf veins is marbled pale green to yellow. With severe deficiency, the area is pale yellow.	Mn
leek	The leaf turns brown, beginning at the very tip and progressing downward.	K
legumes	The leaves dry out, turn papery and are mottled pale green to yellow.	Mb
lettuce	The growing tips become distorted and die.	Mb
mangold	The growing points die.	Ca

Indicator Crop	***Symptoms***	***Nutrient***
mangold (cont.)	In young plants, the new leaves develop weakly and can turn brown or die. In older plants, the outermost leaves appear wilted and lie on the ground. These leaves are scorched, yellowish and dull. The growing points die, and the crown is covered with small, sometimes deformed leaves. The root rots from the side. Brown lesions may appear around the rotted area.	B
	The leaves are dark green, dull, wilt quickly under drought and grow more horizontally than normal from the crown of the plant.	Na
oats	Under slight manganese deficiency, the leaves are pale green and have gray spots that become more visible as the severity of the deficiency increases. Under severe manganese deficiency, the basal portion of the leaf is somewhat yellowish. Then, gray spots and streaks appear on the basal part of the leaf and the leaf margins on the older leaves in the early spring, when the plants are 4 to 6 inches high. Severely affected leaves turn brown, usually in the basal half of the leaf, and eventually break over and hang down, twisting into a spiral at times in the process. The tip portion of the leaf may remain green. The leaf eventually turns entirely brown and withers. By midsummer, the plant may recover, but grain formation is less than normal.	Mn
	Under severe deficiency, the plants do not form grain.	Mb
onion	The leaves turn brown, beginning at the tip and progressing downward.	K
	The leaves have narrow yellow stripes.	Mn
	The bulb is soft, with thin, pale-yellow scales.	Cu
parsnip	The growing points die.	Ca
	The growing points die, and the leaves are distorted and pale green.	B
pea	The leaves are pale, and their tissue is collapsed. The stems and/or where the leaf meets the stem (petiole) are collapsed near the growing points. The pods and seeds are undeveloped.	Ca
	The center of the leaf, between the veins, is yellowish, but the leaf margins are green.	Mg
	Under severe deficiency, the leaves are pale green, but under less severe conditions, the plants may appear normal. However, symptoms are visible on the seeds. When the seed coat is removed and the two halves (cotyledons) are separated, there is a brown spot on the flat surface of each half. These flat areas may be hollowed out under severe deficiency.	Mn
	The growing points die, and stems are thick and stiff. The leaves are pale green to yellow.	B
peach	The leaves are pale green or yellowish and scorched.	K
	The fruit is distorted and may exude resin.	B

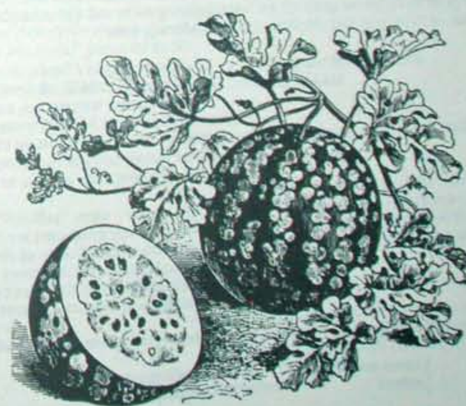
Indicator Crop	***Symptoms***	***Nutrient***
peach (cont.)	The leaves turn pale green to yellow between the veins beginning at the leaf margins and progressing inward until only the veins remain green. Strongly growing shoots may be only slightly affected, which is a distinguishing symptom from iron deficiency, where the loss of green color is most profound in the young tip leaves.	Mn
pear	The leaves are very dark brown between the veins, starting near the midrib and proceeding towards the margins, though the margins remain green. However, in some varieties, the first symptom is death in the leaf margins.	Mg
	The leaves turn slightly pale green to yellow between the veins beginning at the margins and progressing inward. The loss of green color is less profound than that when iron is deficient, making this a distinguishing symptom.	Mn
plum	The leaves are pale green or yellowish and scorched.	K
	The leaves are yellowish near the center or edge and may have some dead areas.	Mg
	The leaves turn pale green to yellow between the veins beginning at the leaf margins and progressing inward until only the veins remain green. Strongly growing shoots may be only slightly affected, which is a distinguishing symptom from iron deficiency, where the loss of green color is most profound in the young tip leaves.	Mn
potato	The leaves do not show typical purple or bronze coloration symptoms, but their color is dull, and they curl forward, especially near the margins where they are scorched. Fewer tubers are produced.	K
	The shoots are spindly, and the plants are unusually bushy. The leaves near the shoot tips have light green or yellow margins which are rolled forward toward the top surfaces parallel to the midrib. Few or no tubers are produced.	Ca
	The leaves wither and hang down the stem or fall off. Many leaves are lost.	Mg
	The tip leaves lose their luster, turn pale and tend to be small and roll upward. The leaves have black-brown spots, especially along the veins.	Mn
	The plant is stunted.	Zn
	The growing points are distorted and die. The leaves are grayish-yellow and look dirty.	B
	The growing tips become distorted and die.	Mb
raspberry	The area between the leaves is brown.	K
	The center and margin of the leaves have yellow patches separated by a green band, or the leaves are yellow first on their edges and then between their veins.	Mg
	The area between the leaf veins is pale green to yellow over most of the cane.	Mn

Cultivated Plant Indicator Chart, Part 2 - Specific Symptoms (cont.)

Indicator Crop	Symptoms	Nutrient
rutabaga	The plant appears normal, but the root has brown areas near its center. Under severe deficiency conditions, the center of the root may be hollow. The root is fibrous and somewhat bitter.	B
rye	The leaves are a slight pale green with yellow streaks. Under severe deficiency conditions, white spots appear between the leaf veins.	Mn
sorghum	The leaves are bronze to yellow from tip to base.	K
	The plant is stunted.	Zn
strawberry	The crowns die, and the leaf tissue collapses.	Ca
	The leaves are similar to raspberry leaves deficient in magnesium, but the strawberry leaves are also very orange, red or purple.	Mg
	The leaves are brilliant orange and red.	S
	The area between the leaves is pale green to yellow, while the veins remain green.	Fe
tea	The shoot growth is restricted. The leaves are small, stiff, brittle, curl upward and are pale green or yellow. The plant may lose many of its leaves.	S
tomato	The plant is woody and grows slowly. The leaves are bluish-green. The margins of the lower leaves turn pale gray and eventually are scorched and curl upward. The leaves may also be bronze. Small yellow and orange patches may appear on some of the leaflets. The fruits may ripen unevenly, with greenish-yellow patches.	K
	The stems, leaves and flower clusters die back. The fruit is affected with blossom end rot (brown area that grows and becomes shriveled on the bottom of the fruit).	Ca
	The lower leaves are the first to have yellow patches, and the edges may roll upward. The areas between the leaf veins then die. Eventually, the entire leaf dies and either falls off or hangs vertically from the stem. Where there is extreme magnesium deficiency, all but the youngest leaves are pale green or yellow.	Mg
	The younger leaves are mottled pale green to yellow, with less intensity and definition than appear when iron is deficient.	Mn
	The growing points die. The plants are bushy with stiff stems. The leaves are purplish, reddish and yellowish. The fruit skin is pitted.	B
	The leaves near the tips of the plant show pale green mottling that is most severe near the leaf midrib and towards the bases of the leaflets.	Fe
	The leaves are bluish-green.	Cu
	The plant is stunted. The leaves are mottled pale green to yellow. The leaves dry out and have a papery appearance.	Zn
turnip	The leaves are dark green, dull, wilt quickly under drought and grow more horizontally than normal from the crown of the plant.	Na

Cultivated Plant Indicator Chart, Part 2 - Specific Symptoms (cont.)

Indicator Crop	Symptoms	Nutrient
turnip (cont.)	The plant appears normal, but the root has brown areas near its center. Under severe deficiency conditions, the center of the root may be hollow. The root is fibrous and somewhat bitter.	B
water grass	The plant dies. (This plant is particularly sensitive to iron deficiency .)	Fe
wheat	The tips of the leaves are bronze.	K
	The leaves are slightly pale green with yellow streaks. Under severe deficiency conditions, white spots appear between the leaf veins.	Mn



False Indicators

Before we conclude that a soil is deficient in a certain mineral, we must consider first that the indication is not, in fact, indicating a nutrient deficiency but some other soil or climate condition(s). The false indicators have been divided into two sections: false indicators that are *not* nutrient related and false indicators that *are* nutrient related.

The following information on false indicators that are not nutrient related is from *The Diagnosis of Mineral Deficiencies in Plants by Visual Symptoms* by T. Wallace (London: Her Majesty's Stationery Office, 1961), though the organization and formatting has been substantially changed in order to make it more usable for our purposes.

Non-Nutrient False Indicators

Apparent Deficiency	***Symptom***	***Possible Actual Cause***
Nitrogen	Yellow, red and purple leaves	Low temperatures / frosts; drought; waterlogging; subsoil hardpan; lack of organic matter; excess weeds; potato eelworm; wireworms, cutworms and other organisms injuring roots and stems; apple canker; bark injuries to trees
Phosphorus	Red and purple leaves	Low temperatures / frosts; drought; waterlogging; subsoil hardpan; lack of organic matter; excessive friability; wireworms, cutworms and other organisms injuring roots and stems; apple canker; bark injuries to trees
Potassium	Scorched leaf margins	Low temperatures / frosts; drought; wind; waterlogging; subsoil hardpan; lack of organic matter; wireworms, cutworms and other organisms injuring roots and stems; aphids; root and foot rots on clovers and dwarf beans; botrytis on gooseberries; potato virus diseases; bark injuries to trees
Magnesium	Death of tissue between leaf veins and yellowing	Apple canker; virus "yellows" of sugar beet (distinguishing symptoms are the asymmetrical distribution of the yellow and scorched patches on the leaves and the orange tinting produced by the virus); potato virus diseases; bark injuries to trees
Calcium	Leaf tips roll	Potato stem canker *(Rhizoctonia)*
Manganese	Leaves are pale green Lesions	Waterlogging Leaf stripe diseases
Iron	Leaves are pale green	Waterlogging

Non-Nutrient False Indicators (cont.)

Apparent Deficiency	***Symptom***	***Possible Actual Cause***
Boron	Leaves are distorted and sprout laterally from the stem's growing points	Midges, root flies and weevils damaging growing points and leaf/stem connections (petioles); aphids
Zinc	Leaves are pale green and/or purple with dead areas	Cool, wet weather

OTHER: Red spiders cause dull bronzing and suppress many deficiency symptoms. Black currant leaf spot *(Pseudopeziza Ribis)* completely masks all deficiency leaf symptoms late in the season.

Nutrient False Indicators

Symptoms that seem to indicate that a particular nutrient is deficient in the soil can actually result from the deficiency or excess of other nutrients and not reflect the amount of the particular nutrient available in the soil. In order to account for these types of false indicators, you need to grow as many different cultivated indicator plants as you can. Only in this way can you cross-check your conclusions and be sure that they are correct.

Note: The actual cause of a symptom may be an excess of a particular nutrient that does not result in any distinguishing symptoms. Therefore, you cannot cross-check your conclusion and be sure. However, this knowledge will not be essential for creating the fertilizer program that is right for your soil. For more information about modifying nutrients that may be in excess, see "Adjusting Soil Minerals," pages 66 to 80.

Indication Given by Chart	***Possible Actual Cause***
Low aluminum	High soil pH
Low calcium	High magnesium, high potassium, high sodium and/or low soil pH
Low copper	High soil pH
Low iron	Low potassium, high phosphorus, high cobalt, high chromium, high nickel, high copper, high manganese, high zinc and/or neutral or high soil pH.
Low magnesium	Low phosphorus, high boron, high potassium and/or low soil pH
Low manganese	High soil pH
Low molybdenum	Low soil pH
Low phosphorus	Low magnesium, high aluminum and/or low soil pH
Low potassium	Low soil pH, high nitrogen, high phosphorus, high boron, high sodium and/or high chlorine
Low sulfur	Low soil pH
Low zinc	High phosphorus

The Example Continued (from page 39):

Using the Cultivated Plant Kit

When spring came to the land that I analyzed using the *Wild Plant Kit*, I planted it with corn, flax, strawberries, tomatoes and peas, among other food-, compost- and income-producing crops. I am fairly familiar with most of these plants, which made it easier to observe differences in their growth. I recorded these observations on a blank "Cultivated Plant Indicator Observation and Summary Form", shown on the following page.

The symptoms that are most obvious were those relating to a deficiency of soil calcium. Most obvious was the blossom end rot, a largish, brown spot on the base of the tomato fruit, although it did appear on only one fruit that I observed. None of the symptoms of calcium deficiency appeared in the peas, which may suggest that the deficiency is not severe.

It is a little confusing to distinguish a potassium deficiency from a phosphorus deficiency in flax, but the facts that not all of the leaves were yellow and that the most severely affected area was the tip region of some of the flax plants suggested that it was a phosphorus deficiency. However, I did not observe thin shoots, a lack of side branching, or sparse, prematuring flowers and fruits. This may be due to my lack of experience with flax, or to the possibility that phosphorus is not sufficiently deficient to cause these effects.

The yellowness of the corn leaves may indicate a deficiency of nitrogen, but it is likely that this is a false indication brought on by the cold weather (recorded in the "Other Observations" section) since no distinct V-shaped pattern was observed. However, the yellow striping may indicate that there is not enough available manganese in the soil. The soil pH appears to be neutral (from the *Wild Plant Kit* conclusions), which suggests that manganese may not be in the soil. Since the deficiency is not simply due to unavailability, the addition of a manganese-containing fertilizer will likely be needed to remedy this situation. However, corn ear and residue yields were good and did not seem particularly bothered by what may be a lack of manganese. I will continue to watch out for symptoms of manganese deficiency and may even plant some oats in the fall, which show distinct symptoms when manganese is deficient (see "Oats" in the "Cultivated Plant Indicator Chart, Part 2" on page 52).

This example continues on page 61 when I will compare my results from *the Wild Plant Kit* and the *Cultivated Plant Kit* and synthesize them into a summary of the soil's current condition.

EXAMPLE: Cultivated Plant Indicator Observation and Summary Form

Date 4/96 - 9/96
Test Plot Number or Name Redwood City Garden
Fertilizers and Quantities Added before Planting Crops 16.6 lbs of alfalfa meal / 100 sq. ft.

Observation Charts

Crop	Date	Observations (look for changes in color, form and vigor in the leaves, growing tips, fruit and overall plant)
Pea	6/7/96	The leaves of a few plants seem unusually yellow.
Tomato	6/15/96	Brandywine drops most of its flowers.
Flax	7/15/96	The leaves appear duller than normal.
Corn	7/16/96	Some of the leaves are pale-green, and some are yellow. Some of the leaves have thin yellow stripes.
Corn	8/1/96	The leaves continue to be pale-green and yellow, and the older leaves eventually dry up.
Tomato	8/3/96	One fruit has blossom end rot.
Flax	8/3/96	The tip leaves are yellowish on some plants.
Flax	8/4/96	The tips of some plants are wilted, even though it does not seem very hot and the soil seems moderately moist.

Date	Other Observations (winds, droughts, floods, frosts, pests)
7/10-13	Unusually cold mornings
7/1-8/1	Strong winds in the mid- to late afternoon.

Summary Chart

Crop	Calcium	Nitrogen	Phos-phorus	Potas-sium	Magne-sium	Copper	Zinc	Boron	Sulfur	Manga-nese	Iron	Molyb-denum
Tomato	L											
Flax	L		L									
Pea	L?											
Corn										L?		
Overall Condition	L		L									

Cultivated Plant Indicator Observation and Summary Form (blank)

Date__________
Test Plot Number or Name__________
Fertilizers and Quantities Added before Planting Crops__________

Observation Charts

Crop	Date	Observations (look for changes in color, form and vigor in the leaves, growing tips, fruit and overall plant)

Date	Other Observations (winds, droughts, floods, frosts, pests)

Summary Chart

Crop	Calcium	Nitrogen	Phos-phorus	Potas-sium	Magne-sium	Copper	Zinc	Boron	Sulfur	Manga-nese	Iron	Molyb-denum
Overall Condition												

The Example Continued (from page 58):

Comparing Indications from the Wild and Cultivated Plant Kits

The principal indications offered by the *Wild Plant Kit* and not contradicted by the *Cultivated Plant Kit* are that the soil is compacted, may have some clay that will hold not only water but also nutrients, and may be low in humus.

Both *Kits* indicate that the principal nutrients that the soil is lacking are calcium and phosphorus. There may be a lack of manganese in the soil, but I will not take immediate action on this until I have more consistently observed symptoms suggesting this.

In this example, there were no major contradictory indications. Had there been, I would probably have taken no action on either of the indications. For instance, if the *Wild Plant Kit* indicated a potassium deficiency, but the *Cultivated Plant Kit* indicated a sufficient supply of potassium, I would not add fertilizer containing potassium until such indications were more consistent and not contradicted by other indications.

We will now look at how to improve present soil conditions in order to increase the soil's fertility and optimize its production. This discussion, as with the previous ones, will be followed by a continuation of this example in which I create my own fertilizer recipe that I will use to apply the appropriate fertilizers the following spring (since I live in a temperate climate that receives most of its rain during the winter).

EXAMPLE: Summary of Wild and Cultivated Plant Indicator Observations

His	SU	Slo	PC	Mois	Drai	Text	Struc	OM	pH	Salt	Lime	Ca	N	P	K	Mg	Cu	Pb	Al	Zn	Zn	Se	B	S	Mn	Fe
09	PS	NS		M/FI		MF SF	?	HR LH	N		L	L	H	L		H									L?	

Pure Nutrients Needed:

Fertilizers Chosen	Amount Needed Per 100 Square Feet

Summary of Wild and Cultivated Plant Indicator Observations (blank)

His	SU	Slo	PC	Mois	Drai	Text	Struc	OM	pH	Salt	Lime	Ca	N	P	K	Mg	Cu	Pb	Al	Zn	Zn	Se	B	S	Mn	Fe

Pure Nutrients Needed:

Fertilizers Chosen	Amount Needed Per 100 Square Feet

PART III: IMPROVEMENT OF SOIL CONDITIONS

See page 70 for an important caution regarding maximum total amounts of fertilizers to be added.

History (His) — While you cannot improve the history of the soil, you can greatly improve worn-out soil and maintain healthy soil with good soil management.

Site Utilization (SU) — Keep in mind that these guidelines for land usage are *only* guidelines. If your analysis suggests that your land is extremely poor and it seems impossible to farm, do not necessarily give up. Land that many considered unproductive (i.e. only fair for grazing) is producing up to double the U.S. average yields and sometimes more in Willits, CA. Undoubtedly others using Biointensive sustainable mini-farming to farm and revitalize poor soil are having similar results.

Slope (Slo) — Terraces have made sloped land more easily tillable throughout the ages. For information on building terraces, see "How To Farm Your Hilly Land Without Losing Your Soil," The "Forestry for People" Series (The Philippines Bureau of Forest Development).

Plant Cover (PC) — This will generally increase as soil health is improved with sustainable soil-restorative farming practices (see John Jeavons, *How To Grow More Vegetables*, 5th ed., for details).

Moisture (Mois) — Double-dig the soil to the depth of 2 feet. Add at least 1.6 cubic feet and no more than 8 cubic feet of cured compost (that is 50% soil by volume) per 100 square feet per year. Grow deep-rooted crops able to thrive with the moisture present in the soil. Generally, be sure not to irrigate with more than 20 to 30 gallons per 100 square feet per day.

Drainage (Drai) — Double-dig the soil to the depth of 2 feet. Add at least 1.6 cubic feet and no more than 8 cubic feet of cured compost (that is 50% soil by volume) per 100 square feet per year. (If you have already added 8 cubic feet of cured compost [that is 50% soil by volume] per 100 square feet per year as indicated in the "Moisture" category or in any other category, do *not* add additional cured compost for this category.) On close, off-set spacings, grow deep-rooted crops able to thrive with the moisture present in the soil. Drainage can also be improved by adding sand which increases the soil's pore space. However, this can be a costly and labor-intensive endeavor. If the ground water table is high, it may be difficult to grow crops sensitive to water-logging. Even more costly and labor-intensive is to bury perforated drain pipes covered with gravel and then soil in order to carry away excess water in the soil.

Texture (Text) — (See pages 24 to 27 to understand the difference between texture and structure.) Generally, modification of a soil's texture is not necessary if drainage is adequate. If you strongly want to modify the soil's texture, modify only a very small area of your garden or farm, compare the results of a crop grown on the modified area with results of the same crop grown on unmodified soil, and then decide if you want to modify a larger area.

Structure (Struc) — (See pages 24 to 27 to understand the difference between texture and structure.) The soil microorganisms that create soil structure need air, water, organic matter and minerals to thrive (in that order of priority). Double-dig the soil to the depth of 2 feet to give those microbes air. Add at least 1.6 cubic feet and optimally 6 to 8 cubic feet of cured

compost (that is 50% soil by volume) per 100 square feet per year to give them organic matter. On close, off-set spacings, grow deep-rooted crops which have a high content of carbon in their mature residues (like grain crops). Harvest, compost this residue and add the cured compost back to the soil. Repeat this cycle of deep soil preparation, compost production and addition until the soil structure is similar in consistency and appearance to chocolate cake.

Organic Matter (OM) — In general, the techniques are the same as for improving soil structure, described above. Soil with a lot of anaerobically decomposed organic matter (like more mucky and swampy soils) can be improved by deeply cultivating the soil to add air and allowing the remaining organic matter to decompose aerobically, provided the soil is not continually wet.

pH — The pH of a soil will slowly move towards optimum as sufficient cured compost is added to the soil over several years. The humus generated from carbon-rich compost modifies the soil pH and can make unavailable soil minerals more available for plant usage. The soil pH can also be modified through the addition of specific organic fertilizers. Sulfur-containing fertilizers are generally used to lower the soil pH. Calcium-containing fertilizers are generally used to raise the soil pH. Guidelines for adding these fertilizers are described in "Adjusting Soil Minerals" on pages 66 to 80.

Salt — Salt can be flushed from the soil in areas that have good drainage and a sufficient quantity of water containing very little salt to flood the land and wash the salts past the root zones of most crops. Salts will accumulate less rapidly in small-scale, intensively managed land, since less water is needed to produce the same amount of crops per unit of area, less evaporation occurs due to the living-mulch effect of the mature plant leaves touching, and more plants per unit of area are extracting salt from the soil.

See" Adjusting Soil Minerals" for a description of improving the following soil conditions (nutrients): Lime, Calcium, Nitrogen, Phosphorus, Potassium, Magnesium, Copper, Lead, Aluminum, Zinc, Selenium, Boron, Iron, Manganese, Molybdenum.

Adjusting Soil Minerals

As with all soil analyses, there is a lag time between finishing your analysis (perhaps in the fall) and adding the appropriate fertilizers to improve your soil (perhaps in the spring). When you use the *Wild Plant Kit* and the *Cultivated Plant Kit*, you will be essentially analyzing your soil throughout the year with your observations and knowledge of what those observations mean. However, *when the growing season comes, you will add fertilizers based on last year's observations*. Then, you will continue to make and record your observations during the year, analyze them at the end of the year, and fertilize appropriately the next year.

However, for the first two years of testing your soil with the *Cultivated Plant Kit*, do not add any fertilizers based on your observations and analyses. Simply record your observations, analyze them if you wish, and, regardless of the results, if possible, add at least 4 cubic feet of cured compost (that is 50% soil by volume) per 100 square feet per growing season. It is quite possible for a garden to produce 4 cubic feet of cured compost (that is 50% soil by volume) for every 100 square feet of growing area per year. Growing your own compost is an essential part of sustainable farming, in order to replenish the soil's supply of organic matter and not have to import organic matter (such as straw, leaves or manure with bedding) produced by another soil that that soil needs composted and returned to it to maintain its own health. However, when you are beginning to grow your own compost material, you may find that you produce less than 4 cubic feet for every 100 square feet. In this case, simply use what you have. Do not feel compelled to import organic matter or compost, which depletes another soil, because even small amounts of compost will gradually improve soil fertility until you are producing 3 to 4 cubic feet of compost (that is 50% soil by volume) for every 100 square feet.

During these first two years while you are adding compost, you may notice that the indications from the plants you are growing to test your soil may change. This is a result of the additions of cured compost altering the soil pH, the availability of soil nutrients, and perhaps even the soil's structure and drainage, among other responses. Therefore, by the end of the second year, indications of soil nutrient deficiencies will more likely reflect a lack of those nutrients rather than the unavailability of those nutrients. Then, in the beginning of the third year's growing season, add the nutrients that, in the second year, were indicated deficient in the soil.

The *quality* of a symptom (for example, the yellowness of the leaf or the number of side shoots from the stem) may, in many cases, describe the precise amount of a particular nutrient that needs to be added to the deficient soil. However, plant indicator technology has not yet been advanced to this degree of precision. When a symptom of nutrient deficiency is observed, we usually do not know how deficient that particular nutrient is (there are exceptions to this, as seen in the *Cultivated Plant Indicator Chart*, but even these exceptions are not precise quantifications). Therefore, when we add the deficient nutrient to the soil, we need to add it in *small quantities over several years*.

There is an advantage to this "slow and steady" technique of soil improvement. The addition of nutrients that are deficient in the soil may change the availability of other nutrients in the soil. Adding large quantities of nutrients radically alters the soil's chemistry and biology, and the soil may take several seasons or years to reach a chemical and biological equilibrium. If we add large amounts of fertilizer before equilibrium is reached, we will only add to the chaos and will have difficulty predicting the precise long-term effects on the soil's fertility. If, instead, we add only small but still effective amounts of fertilizer, we will gradually and more predictably be able to bring soil nutrients into balance and increase the soil's long-term fertility. It is just like making a good soup -- it is more easily done by adding small quantities of spices than handfuls at a time.

After the first two years, you will select specific fertilizers that your soil needs, as described on pages 68 to 70. Then, you will add these fertilizers slowly and in small amounts, as shown in the charts on pages 71 to 80. If you feel that you need to increase the quantities of soil nitrogen, phosphorus, potassium and/or calcium at a faster rate and have solid supporting evidence to do so, you can choose to increase the recommended quantities of these fertilizers by up to 30%.

Increasing them by more than this is strongly not recommended, since it may adversely affect the availability of other soil nutrients in unpredictable ways.

As described above, this soil improvement process emphasizes the importance of adding compost to allow unavailable nutrients to become more available. In many cases, a nutrient deficiency is really only a compost deficiency. However, in some cases, a soil simply does not contain major and/or minor nutrients in sufficient quantity for optimal productivity. In these cases, the nutrients must be added to the soil in the form of fertilizers derived from minerals, plants or animals containing the missing nutrients. This booklet focuses on fertilizers that are considered "organic" in the sense that they are often produced from plants or animals, are gentle on the soil (do not cause acidification and the excessive loss of soil organic matter, as in the case of some "chemical" fertilizers), and can often be produced locally with local resources and only human and solar energy.

Symptoms may also indicate that a soil nutrient is in excess. In the case of salts (sodium, calcium, magnesium, chloride, carbonate and bicarbonate), these quantities can be reduced by leaching the soil that has been provided with adequate drainage with low-salt water to carry the nutrients beyond the root zone of the crops you are growing. (Keep in mind that this process is not selective and will carry away all other available, water-soluble soil nutrients as well.) Other excesses, such as aluminum and iron, may be reduced by a change in soil pH caused by the addition of cured compost and an organically, properly managed soil. In this case, the minerals are not removed from the soil, only made unavailable. Other excesses are not changeable in a small amount of time and can only be changed through the course of many years while they leach and/or gasify from the soil and/or are taken up by the plants which could be composted and added to land deficient in the nutrients your soil has in excess.

Adding Soil Nutrients with Compost and Organic Fertilizers

Optimally, every year you will be able to add 6 to 8 cubic feet of compost (that is 50% soil by volume) that you have produced yourself to every 100 square feet in your garden or farm. This quantity of compost typically contains enough nitrogen for good production of all crops, assuming the soil has good structure and a high content of organic matter that will hold the nutrients contained in the compost. Furthermore, this quantity of compost will sufficiently *maintain* the soil's supply of organic matter and will help prevent the soil's nutrients from leaching.

You can decide to add less compost than 6 to 8 cubic feet depending on the soil's organic matter level described by your soil analysis and on the amount of compost you have available. Generally the use of more than 8 cubic feet of compost does not produce increased yields and may facilitate certain insect and disease problems. (If, for some reason, there are indications that more than 8 cubic feet of cured compost should be added, you should add this amount only if you are able to grow the plants used to produce that compost, so that you will not be depleting another soil in the process, as mentioned earlier.) Also, you should try not to add less than 1.6 cubic feet of cured compost (that is 50% soil by volume) per 100 square feet annually, unless your soil contains extremely high amounts of fully decomposed organic matter and perhaps it is the first year that you will farm and you have not had a chance to produce sufficient compost by growing and composting sufficient amounts of compost crops. See *How To Grow More Vegetables* by John Jeavons (Berkeley, CA: Ten Speed Press, 1995) for a discussion on sufficient compost crop production.

However, there are two reasons why we may not be able to count on compost alone to maintain and improve the fertility of the soil we farm. First, if we harvest and sell crops and we are unable to return all of the nutrients those plants contained and took from the soil, then we are selling and losing soil nutrients. In this case, we cannot simply compost and expect the soil to retain its fertility. These soil nutrients, in some way, must be replenished. One way of doing this is with organic fertilizers. Another way of doing this is by recycling the waste of those who consume the crops (see *Future Fertility: Transforming Human Waste into Human Wealth* by John Beeby [Willits, CA: Ecology Action, 1995]).

Second, if the soil is found to be deficient in a certain mineral, growing crops in this soil, composting their residues and adding the compost to the soil will not add the deficient nutrient to the soil. Plants grown in a soil deficient in a particular nutrient will not contain that nutrient (or will contain less than normal amounts of that nutrient) in their residues. Compost made from the residues will likewise not contain this nutrient. Therefore, this nutrient must be obtained from some outside source. Again, organic fertilizers are a good choice for this purpose.

Add the compost in the spring if the majority of your rain comes in the winter, or in the fall if the majority of your rain comes in the spring and summer. If your climate allows for year-round growing, you may find that you need to add this quantity of compost before each growing season. (To learn how to produce the quantities of compost material and compost you will need each year, see *How To Grow More Vegetables* by John Jeavons [Berkeley, CA: Ten Speed Press, 1995] for yields of biomass of various crops. See page 119 of *Future Fertility: Transforming Human Waste into Human Wealth* by John Beeby [Willits, CA: Ecology Action, 1995] for the formula to convert the dry weight of compost material to an approximate volume of cured compost produced.)

If organic fertilizers need to be added based on the results from the *Wild Plant Kit*, the *Cultivated Plant Kit*, or the synthesis of the two, we need to know which organic fertilizers to use. The first organic fertilizer we will consider is a nitrogen-rich organic fertilizer. If you have determined that your soil does not need any more nitrogen than what is contained in the compost you will add (which is to say that the soil is not deficient enough in nitrogen to cause visible symptoms in the crops grown), then you may want to skip this section.

Selecting the Best Nitrogen Fertilizer

Most commonly, your soil's structure is not yet good enough to sufficiently hold the nitrogen in the cured compost, and additional nitrogen is needed. Yet, there are many different organic fertilizers to choose from, each produced from a different plant or animal source. Any dried and ground leguminous plant, like alfalfa, soybeans (which is also generally high in magnesium) or clover, is a good source of nitrogen. Manure, once it is composted and smells sweet, is another good source. The blood of butchered animals, dried and powdered, is a third major source. But how do you decide which one is best for you?

The most important basis for your decision is probably obvious: What is available? If you live in an industrialized country, you probably have easy access to most organic nitrogen fertilizers through distributors or even your local gardening shop. If you cannot buy any organic fertilizers, then your only option is to make them. I recommend making a leguminous meal from dried alfalfa or other leguminous plant or plants. Alfalfa is recommended due to its high yield. Clover residue yields are much lower than those of alfalfa, and soybean residue (and seed) yields are lower still. To produce these fertilizers, grow the plants, harvest them (cutting 2 to 3 inches above the growing crown, in the case of perennials), dry them and then pulverize them by hand or machine. The smaller the final pieces are, the quicker the nitrogen will become available.

If you are able to buy or make more than one kind of organic nitrogen fertilizer, how do you choose which one to use? You choose the nitrogen fertilizer that contains other nutrients that the soil needs. If the soil needs only nitrogen, then you are free to use any organic nitrogen fertilizer. If the soil needs only nitrogen and phosphorus, for example, then, if you can, you will choose a nitrogen fertilizer that contains phosphorus as well. An example of this sort of fertilizer is fish meal. See the table "Adjusting Nitrogen, Phosphorus and Potassium with Organic Fertilizers and Composted Manures" on pages 71 and 72 to choose the organic nitrogen fertilizer that best meets the soil's needs based on your plant indicator results.

Selecting All Other Fertilizers

After choosing the organic nitrogen fertilizer you will use, choose the best suited organic potassium and phosphorus fertilizers you will use *only if the plants you observed indicated that these two elements are deficient in the soil.* Just as you choose your nitrogen fertilizer, your choice of potassium and phosphorus fertilizers will be based on your access to them and the nutrients that they contain. It is important that the fertilizers you use contain *only* nutrients that the soil needs and contain no nutrients that the soil already has in excess. The table "Adjusting Nitrogen, Phosphorus and Potassium with Organic Fertilizers and Composted Manures" will help you select the best fertilizer. This table lists the various organic fertilizers you can use to improve various combinations of nitrogen, phosphorus and potassium deficiencies.

After choosing the best nitrogen, phosphorus and potassium fertilizers, if there are other soil-nutrient conditions that you want to improve, use the tables "Adjusting pH with Organic Fertilizers and Composted Manures", "Adjusting Calcium, Magnesium and Sulfur with Organic Fertilizers and Composted Manures", and "Adjusting Boron, Copper, Iron, Manganese, Molybdenum and Zinc with Organic Fertilizers" to select the best organic fertilizers for your purpose. Remember that you will probably have the most success in adjusting the availability of minor soil nutrients, such as copper, molybdenum, and zinc, by first adjusting the soil pH to within the range of 6.0 to 7.0 (until you are satisfied that you need to add small amounts of these nutrients through small additions of composted manure). If you strongly suspect that this strategy is inadequate to improve the soil you are farming based on continued observations of minor-nutrient deficiency symptoms, you can take a sample of the soil to a laboratory, have it analyzed chemically, and get a recommendation for a minor nutrient fertilizer and the application rate. However, if you do not have access to a chemical soil test, and you are sure that a deficiency exists, you can adjust the levels of minor nutrients by applying the fertilizers recommended on page 76 at the rates recommended on page 79. Be sure to apply minor-nutrient fertilizers as evenly as possible. An area of soil with an overapplication of minor nutrients can contain levels of nutrients so high that crop yields can suffer dramatically and the crops themselves can be toxic to those who eat them.

After selecting the organic fertilizers you will use this year to improve the soil, you are ready to apply them at the rates recommended in the chart, "Application Rates for Organic Fertilizers and Composted Manures" on page 77. Simply look up the fertilizers you have chosen, and add them at the rate recommended in the chart. *Each application rate is designed for 100 square feet annually.* To fertilize a larger area, multiply the rate by the number of times your farm is greater than 100 square feet. For example, if your growing area is 1/8 acre that is in beds, first calculate how many times bigger your farm is than 100 square feet. One acre is approximately 311 beds that are 5 feet by 20 feet (100 square feet total) surrounded by a foot-wide path, so 1/8 of an acre is approximately 311 / 8 or 39 beds. 39 beds is 39 x 100 or 3,900 square feet. Now, divide 3,900 square feet by 100 square feet (the amount designed for in the application rates) and you find your farm is 3,900 / 100 or 39 times the area designed for in the application rates. (Notice that the number of 100-square-foot beds you have is also the number of times greater than 100 square feet that your farm or garden is.) So, if you want to apply alfalfa meal, then you would multiply 16.6 pounds by 39 and find that you need 647 pounds of alfalfa meal, which you would spread evenly over the 1/8 acre. This method will work for any area and any fertilizer listed in the table or any other application rate.

IMPORTANT

No one fertilizer, including compost and manure, should be applied at a rate higher than recommended on pages 77 to 79 in this publication. While this may seem obvious, it can commonly happen if you have selected the same fertilizer to improve two different soil conditions. For example, you may choose to add wood ashes and crushed granite to increase the soil's potassium content and to increase the soil's calcium and magnesium contents. To make these improvements, you need to add *only one application* of wood ashes and crushed granite at the prescribed rate of 1.5 pounds of wood ashes and 5.5 pounds of crushed granite given on pages 77 and 71, respectively.

Adding a minor-nutrient-containing fertilizer must always be done with caution and even trepidation. In order to be confident that no harm will come from the addition of a minor-nutrient-containing fertilizer, it is best to have a number of correlating symptoms and indications -- more than you would normally require before adding a major-nutrient-containing fertilizer to the soil. While an overapplication of any fertilizer can be detrimental to the soil's health, an overapplication of a fertilizer containing concentrated amounts of a minor nutrient, such as boron, copper or zinc, can actually toxify the soil and render it unable to produce significant crop yields. Remember that in many cases, an apparent nutrient deficiency is simply a case of the nutrient being present but unavailable. Time and compost will improve this situation. Well-made compost added patiently and persistently is one of the most effective and sustainable fertilizers known.

Adjusting Nitrogen, Phosphorus and Potassium with Organic Fertilizers and Composted Manures

See "Application Rates of Organic Fertilizers and Composted Manures" on pages 77 to 79 for the amounts of the following fertilizers to add. **If a quantity is given in this table, use it rather than the amount recommended in "Application Rates of Organic Fertilizers and Composted Manures".** This modification will ensure more optimal nutrient balancing and will prevent the application of excessive amounts of certain nutrients.

Soil Condition	***Fertilizer***
Low Nitrogen Sufficient Phosphorus Sufficient Potassium	Any organic nitrogen fertilizer (Those that contain less phosphorus and potassium relative to nitrogen may be optimal, given a choice of fertilizers. However, these fertilizers tend to be derived from butchered animals.)
Sufficient Nitrogen *Low Phosphorus* Sufficient Potassium	Phosphate rock **or** Colloidal soft phosphate (good for sandy soils)
Sufficient Nitrogen Sufficient Phosphorus *Low Potassium*	Wood ashes *and* Crushed granite (5.5 pounds) **or** Crushed granite
Low Nitrogen *Low Phosphorus* Sufficient Potassium	Soybean meal *and* Bone meal (0.15 lb) or phosphate rock (0.1 lb) or collodial soft phosphate (0.17 lb) **or** Linseed meal **or** Cottonseed meal **or**

(continued)

Adjusting Nitrogen, Phosphorus and Potassium with Organic Fertilizers and Composted Manures (cont.)

Soil Condition	Fertilizer
Low Nitrogen *Low Phosphorus* Sufficient Potassium (continued)	Fish meal **or** Composted chicken, cow or steer manure (Composted sheep or horse manure can be used, but they contain less phosphorus.) **or** Alfalfa meal *and* Phosphate rock (0.2 pounds) or colloidal soft phosphate (0.4 pounds)
Low Nitrogen Sufficient Phosphorus *Low Potassium*	Alfalfa meal **or** Composted dairy cow, steer, pig, sheep or horse manure (Composted chicken manure may be added but contains less potassium than what is probably needed.) **or** Blood meal or hoof and horn meal or fish meal *and* Wood ashes (at normal rate) and crushed granite (5.5 pounds), or crushed granite alone (at normal rate)
Low Nitrogen *Low Phosphorus* *Low Potassium*	Alfalfa meal *and* Phosphate rock (0.2 pounds) or colloidal soft phosphate (0.4 pounds) **or** Fish meal *and* Wood ashes (at normal rate) and crushed granite (5.5 pounds), or crushed granite alone (at normal rate)

Adjusting pH with Organic Fertilizers and Composted Manures

Soil Condition	Fertilizer
Low pH	Crushed clam and/or oyster shells **or** Crushed eggshells **or** Calcium carbonate lime **or** Dolomitic lime (if soil is low is magnesium)
High pH	Mined sulfur **or** Epsom salts (if soil is low in magnesium) **or** Gypsum (if soil is low is calcium) **or** Potassium sulfate (if soil is low in potassium) **or** Potassium magnesium sulfate (if soil is low in potassium and magnesium)

Adjusting Calcium, Magnesium and Sulfur with Organic Fertilizers and Composted Manures

Soil Condition	Fertilizer
Low Calcium Sufficient Magnesium Sufficient Sulfur	Crushed clam and/or oyster shells **or** Calcium carbonate lime **or** Crushed eggshells
Sufficient Calcium *Low Magnesium* Sufficient Sulfur	Magnesium oxide **or** Composted animal manure (relatively poor source of magnesium but can be helpful where no other magnesium fertilizer is available)
Sufficient Calcium Sufficient Magnesium *Low Sulfur*	Mined sulfur **or** Potassium sulfate (if soil is low in potassium) **or** Composted animal manure (relatively poor source of sulfur but can be helpful where no other sulfur fertilizer is available; optimally used if soil is low in nitrogen)
Low Calcium Sufficient Magnesium *Low Sulfur*	Gypsum (good also if soil pH is high)

Adjusting Calcium, Magnesium and Sulfur with Organic Fertilizers and Composted Manures (cont.)

Soil Condition	Fertilizer
Low Calcium *Low Magnesium* Sufficient Sulfur	Wood ashes **or** Dolomitic lime
Sufficient Calcium *Low Magnesium* *Low Sulfur*	Epsom salts (magnesium sulfate) *and* 0.35 lb of magnesium oxide or composted animal manure **or** Potassium magnesium sulfate (if soil is also low in potassium) *and* 0.16 lb of magnesium oxide or composted animal manure
Low Calcium *Low Magnesium* *Low Sulfur*	Combine a *Low Calcium*/Sufficient Magnesium/Sufficient Sulfur fertilizer with a Sufficient Calcium/*Low Magnesium*/*Low Sulfur* fertilizer **or** Combine a Sufficient Calcium/ *Low Magnesium*/ Sufficient Sulfur fertilizer with a *Low Calcium*/ Sufficient Magnesium/ *Low Sulfur* fertilizer **or** Any other combination of two fertilizers from different categories above that together supply calcium, magnesium and sulfur. Avoid using a combination of fertilizers that both contain calcium, magnesium and/or sulfur. For example, epsom salts and gypsum would be a less desirable combination since both contain sulfur, and, if both were applied at the recommended rates on page 78, the soil would receive a double application of sulfur -- twice as much as it needs.

Adjusting Boron, Copper, Iron, Manganese, Molybdenum and Zinc with Organic Fertilizers

VERY IMPORTANT: Add these fertilizers only when: 1) you are absolutely sure from all of the evidence you have gathered that a deficiency exists in the soil; and 2) you have read the recommended approach described on pages 69 to 70. Spread the fertilizers as evenly as possible over the soil to prevent overapplying and potentially creating a toxic condition, in some area of the soil.

Soil Condition	***Fertilizer***
Low Boron	Borax
Low Copper	Copper sulfate or Copper oxide
Low Iron	Ferrous sulfate
Low Manganese	Manganous sulfate
Low Molybdenum	Ammonium molybdenum or Sodium molybdenum
Low Zinc	Zinc sulfate

If these fertilizers are not available to you, an alternative approach is to add properly aged manure from any animal fed with crops that were not deficient in the(se) nutrient(s) at the rate of 1 cubic foot of manure per 100 square feet of soil. Then, skip a year, and see if the problem has been solved. If not, add 1 cubic foot of cured animal manure every other year until the plants no longer show these symptoms. Keep in mind that you are taking nutrients from another soil (the soil used to grow the crops that fed the animal) in order to feed your soil, so you will not want to add any more than the above recommended amount every other year to avoid depleting the other soil.

Application Rates for Organic Fertilizers and Composted Manures

The following application rates are designed so that you are adding annually (and no more than annually) the quantities of pure nutrients that are described in Appendix B on pages 83 to 85. **If the fertilizer you are using has a different analysis than the one shown in Appendix B, you will need to adjust the amount you apply to the amount shown in this chart.**

Cup measurements are given for some of these fertilizers in *How To Grow More Vegetables* (1995 ed.). For the small quantities noted on page 79, it may be possible to use a triple-beam balance at the local high school or community college chemistry laboratory.

Amendment	***Quantity To Add (per 100 square feet)***
Cured compost (50% soil by volume)	1.6 to 8 cubic feet
Nitrogen Fertilizers	
Alfalfa meal	16.6 pounds
Blood meal	4.2 pounds
Cottonseed meal	8.3 pounds
Fish meal	5.0 pounds
Hoof and horn meal	4.2 pounds
Linseed meal	10.0 pounds
Soybean meal	8.3 pounds
Composted chicken manure*	0.75 cubic feet
Composted dairy cow manure*	2.0 cubic feet
Composted steer manure*	1.0 cubic feet
Composted pig manure*	1.5 cubic feet
Composted sheep manure*	1.0 cubic feet
Composted horse manure*	1.5 cubic feet
Phosphorus Fertilizers	
Bone meal	0.75 pounds
Phosphate rock	0.5 pounds
Colloidal soft phosphate	0.8 pounds
Potassium Fertilizers	
Wood ashes	1.5 pounds
Crushed granite	7.5 pounds

* Composted manure is assumed to be composted in the following proportions:
Chicken manure is composted with 7 units of straw for every 1 unit of manure (no bedding) by volume and 10% by volume of soil to create an initial carbon-to-nitrogen ratio of 30 to 1. After curing, compost created by this recipe will contain about 50% soil by volume.
Cow, steer, pig or sheep manure is composted with 2.5 units of straw for every 1 unit of manure (no bedding) by volume and 10% by volume of soil to create an initial carbon-to-nitrogen ratio of 30 to 1. After curing, compost created by this recipe will contain about 50% soil by volume.
Horse manure is composted with 0.5 units of straw for every 1 unit of manure (no bedding) by volume and 10% by volume of soil to create an initial carbon-to-nitrogen ratio of 30 to 1. After curing, compost created by this recipe will contain about 50% soil by volume.

Application Rates for Organic Fertilizers and Composted Manures (cont.)

Amendment	Quantity To Add (per 100 square feet)
pH-adjusting Fertilizers	
pH Increasers	
Crushed clam and/or oyster shells	1.75 pounds
Crushed eggshells	1.75 pounds
Calcium carbonate lime (hi-cal)	1.5 pounds
Dolomitic lime	2.9 pounds
pH Decreasers	
Mined sulfur	0.4 pounds
Epsom salts	3.1 pounds
Gypsum	2.0 pounds
Potassium sulfate	2.4 pounds
Potassium magnesium sulfate	2.1 pounds
Calcium Fertilizers	
Composted animal manures	See nitrogen application rates.
Crushed clam and/or oyster shells	1.75 pounds
Wood ashes	1.5 pounds
Dolomitic lime	2.9 pounds
Calcium carbonate lime (hi-cal)	1.5 pounds
Gypsum	2.0 pounds
Crushed eggshells	1.75 pounds
Magnesium Fertilizers	
Composted animal manures	Not to exceed nitrogen application rates, though the amount of magnesium that will be added will be less than minimal.
Potassium magnesium sulfate	2.1 pounds
Epsom salts (magnesium sulfate)	3.1 pounds
Magnesium oxide	0.7 pounds
Dolomitic lime	2.9 pounds
Sulfur Fertilizers	
Composted animal manures	Not to exceed nitrogen application rates, though the amount of sulfur that will be added will be less than minimal.
Gypsum	2.0 pounds
Potassium sulfate	2.4 pounds
Mined sulfur	0.4 pounds
Potassium magnesium sulfate	2.1 pounds
Epsom salts	3.1 pounds

Application Rates for Organic Fertilizers and Composted Manures (cont.)

Amendment	Quantity To Add (per 100 square feet)
Boron Fertilizer	
Borax	0.02 ounce
Copper Fertilizers	
Copper sulfate	0.22 ounce
Copper oxide	0.07 ounce
Iron Fertilizer	
Ferrous sulfate	0.06 ounce in 1 quart water
Manganese Fertilizer	
Manganous sulfate	0.2 ounce
Molybdenum Fertilizers	
Ammonium molybdenum	0.001 ounce
Sodium molybdenum	0.001 ounce
Zinc Fertilizer	
Zinc sulfate	0.07 ounce

Sustainable Use of Animal Manure

Let us consider for a moment the sustainable use of animal manure so that we do not inadvertently destroy one soil in our efforts to improve another.

We need to maintain four components in the soil in order to maintain its fertility: air, water, organic matter and minerals. Sufficient air and water can be added through double-digging and watering. Organic matter and minerals can be more difficult and complex to maintain. Ways to accomplish this, especially when animals and/or their manure are included in the farming system, are described below.

ORGANIC MATTER: All soils continually lose organic matter. Organic matter is essential for the health and productivity of the soil. Therefore, a farmer needs to add organic matter to the soil to keep the soil healthy and producing good crops. In temperate climates, we will want to aim for a soil organic matter content of 4 to 6% by weight, and 3% by weight in the tropics.

The highest-quality and longest-lasting organic matter that a farmer can add to the soil is compost made from 45% (by volume) fresh green plant wastes (possibly including small amounts of fresh animal manure), 45% (by volume) mature, dried plant wastes (such as straw and dry stalks) and 10% soil by volume. When crops are harvested and their fibrous roots left in the ground, excellent-quality organic matter is also added to the soil.

The primary component of organic matter is carbon. When an animal eats plant material that could be used for making compost, much of the carbon is digested and breathed out in the form of carbon dioxide. The carbon that remains in its manure is only a small fraction of what was originally available in the plants it consumed. Therefore, more organic matter and compost can be produced from plants than from the manure produced after plants are digested. In order to compensate for this and produce adequate amounts of plant material for the animal to consume and to maintain the organic matter level of the soil that produced the food for the animal, additional crops that are high in carbon (such as straw-producing crops) must be grown. These crops, once transformed into compost, can be used to maintain the organic matter levels of the soil feeding the animal and the soil producing the additional high-carbon "compost" crops.

If organic matter in the form of compost and roots is not added to the soil, the soil will eventually be unable to produce good crops for people and animals.

MINERALS: All soils must have the necessary minerals to produce good crops. When crops grow, they take minerals from the soil. When we harvest the crops, it is important that we return as many of the minerals taken from the soil as we can. For example, when a cow eats grass, the grass contains minerals that were once in the soil. The minerals enter the cow's body and leave the cow's body in the principal forms of milk, calves, urine and manure.

If we collect manure from animals fed plants grown on another farm, compost the manure and put it in our garden, there is a danger, in that we have taken minerals from one soil and given them to another. If we continually do this without returning the minerals to the soil where they originally came from, that soil will run out of minerals and eventually become barren. Therefore, in order not to deplete another soil, when we use animal manure in our garden, our garden must have produced the food for the animals which produced the manure, or we must complete the cycle by adding compost from plants grown in our garden to the soil that produced food for the animals. If these options required for sustainability seem exceedingly difficult, keep in mind that many gardens and farms are fertile and productive without the addition of any animal manures to the soil.

When we begin to grow food in a truly sustainable way, we begin to observe and respect the cycles that renew all of life's creations.

Continuing the Example (from page 61):

Improving the Conditions of the Soil

In order to remedy the conditions of poor drainage and low humus content, I prepare the soil deeply with hand tools (in order to preserve soil structure that is often damaged with mechanical cultivation) and grow carbonaceous plants like wheat, corn and rye from which I can make humus-rich compost that I can add to the soil.

In order to add calcium and phosphorus to the soil, I will choose calcium carbonate lime and colloidal soft phosphate as the fertilizers I will use. I will add 1.5 pounds of calcium carbonate lime and 0.8 pounds of colloidal soft phosphate per 100 square feet in the spring of next year. I will plant the suggested cultivated indicator crops, observe them and record my observations as I did the previous year. Those observations will then be the basis for the fertilizers I choose to add the following spring.

EXAMPLE: Summary of Wild and Cultivated Plant Indicator Observations

His	SU	Slo	PC	Mois	Drai	Text	Struc	OM	pH	Salt	Lime	Ca	N	P	K	Mg	Cu	Pb	Al	Zn	Zn	Se	B	S	Mn	Fe
OG	PS	NS		M/FI	TS	MF SF	?	HR LH	N		L	L	H	L		H									L?	

Pure Nutrients Needed:

P, Ca

Fertilizers Chosen	Amount Needed Per 100 Square Feet
calcium carbonate lime	1.5 pounds
colloidal soft phosphate	0.8 pounds

Appendix A: Comments and Suggestions

The author is continuing to research various aspects of soil analysis with plants. If you have any comments or suggestions on this booklet, if you have read any pertinent research papers on this subject that are not listed in the selected bibliography, or if you have information on the following specific topics, the author would gratefully receive them. Whenever it is possible and appropriate, please include a full citation for any information you send. Write to him at: 1243 NE 148th Street, Seattle, WA 98155. Thank you!

Specific topics about which the author would especially appreciate information:

1) Your key observations and experiences using this plant-based method of soil analysis and management.
2) Determining the precise amount of major and minor nutrients that need to be added based on one's observations of plant color, size, shape, or other characteristic.
3) Other wild indicator plants to include in the *Wild Plant Indicator Chart.*
4) Other cultivated indicator plants to include in the *Cultivated Plant Indicator Chart.*
5) Producing organic fertilizers at home or at the community level.

Appendix B: Nutrient Analysis

According to various soil scientists, if a soil is *deficient* in certain nutrients or is in need of pH adjustment, the following quantities (in pounds per 100 square feet) of pure elements or compounds can be *safely* added to the soil in the form of organic fertilizers:

Nitrogen (N)	0.5	Boron (B)	0.0001
Phosphorus (P_2O_5)	0.15	Copper (Cu)	0.003
Potassium (K_2O)	0.3	Iron (Fe)	0.0007
Calcium (Ca)	0.6	Manganese (Mn)	0.003
Magnesium (Mg)	0.4	Molybdenum (Mb)	Unknown at time of publishing
Sulfur (S)	0.4	Zinc (Zn)	0.001

These quantities refer to the *total* amount of *pure* nutrient that should be added to soils significantly deficient in that nutrient. These quantities may appear lower than those recommended to you after you have a chemical soil test. Current plant-based soil testing technology has not been sufficiently refined to determine precisely the amounts of nutrients needed, as described previously. Therefore, the above rates are recommended in order to insure that the soil does not receive an overapplication of fertilizer but instead is slowly replenished of its missing nutrients.

It may be that these amounts turn out to be too low to remedy your soil's deficiency. If, after one to two years, the deficiency symptoms continue in your plants, add the amount of nutrient indicated above a second time. If the deficiency symptom has been reduced, decrease the amount of nutrient added this second time by one half. Continue to record your observations, and increase or decrease the amount of this nutrient you add in the future, based on your observations, knowledge of soil nutrients and crop needs, and/or your intuition.

Estimated Analysis of Cured Compost and Various Organic Fertilizers

Cured Compost

Cured compost (0.5 pound of nitrogen per 6 cubic feet) -- 3.3 cubic feet of cured compost contains 0.5 pound of nitrogen, assuming the compost pile was built with an initial carbon-to-nitrogen ratio of 30 to 1, was properly managed and retained all of its nitrogen. However, under non-optimal conditions or simply with a lack of experience, much of the nitrogen can be lost, and a loss of 40-50% is common. Therefore, a loss of 45% of the nitrogen is assumed, and 6 cubic feet, instead of only 3.3 cubic feet, are needed to add 0.5 pound of pure nitrogen to the soil.

Nitrogen Fertilizers

Alfalfa meal (3% N, 0.7% P, 2.25% K)
Blood meal (12% N, 1.3% P, 0.7% K)
Cottonseed meal (6% N, 2% P, 2% K)
Fish meal (10% N, 6% P, 0% K)
Linseed meal (5%N, 2% P, 2% K)
Soybean meal (6% N, 1.4% P, 2% K)
Chicken manure, fresh (1.5% N, 1.0% P, 0.5% K)
Chicken manure, dry (4.5% N, 3.5% P, 2.0% K)
Dairy cow manure (0.56% N, 0.23% P, 0.6% K)
Horse manure (0.69% N, 0.24% P, 0.72% K)
Pig manure, fresh (0.5% N, 0.32% P, 0.46% K)
Sheep manure (1.4% N, 0.48% P, 1.2% K)
Steer manure (0.7% N, 0.55% P, 0.72% K)

Phosphorus Fertilizers

Bone meal (3% N, 20% P, 0% K)
Phosphate rock (0% N, 33% P, 0% K)
Colloidal soft phosphate (0% N, 18% P, 0% K)

Potassium Fertilizers

Wood ashes (0% N, 0% P, 5.5% K)
Crushed granite (0% N, 0% P, 4.5% K)

Calcium Fertilizers

Poultry-cage layer manure (2% Ca)
Other manures (0.3% Ca)
Legume hay (1.4% Ca)
Clam and/or oyster shells (34% Ca)
Wood ashes (35% Ca)
Dolomitic lime (21% Ca)
Calcium carbonate lime (hi-cal) (39% Ca)
Gypsum (23% Ca)
Crushed eggshells (34% Ca)
Colloidal soft phosphate (21% Ca)
Phosphate rock (33% Ca)

Estimated Analysis of Cured Compost and Various Organic Fertilizers (cont.)

Magnesium Fertilizers

Poultry-cage layer manure (0.3% Mg)
Other manures (0.14% Mg)
Hay (0.15% Mg)
Straw (0.1% Mg)
Potassium magnesium sulfate (10% Mg)
Epsom salts (10% Mg)
Magnesium oxide (55% Mg)
Dolomitic lime (13% Mg)

Sulfur Fertilizers

Cow manure (0.05% S)
Horse manure (0.06% S)
Pig manure (0.08% S)
Sheep manure (0.08% S)
Poultry-cage layer manure (0.2% S)
Hay (0.2% S)
Straw (0.15% S)
Gypsum (19% S)
Potassium sulfate (17% S)
Mined sulfur (100% S)
Potassium magnesium sulfate (19% S)
Epsom salts (13% S)

Boron Fertilizer

Borax (10.6% B)

Copper Fertilizers

Copper sulfate (25% Cu)
Copper oxide (75% Cu)

Iron Fertilizer

Ferrous sulfate (19% Fe)

Manganese Fertilizer

Manganous sulfate (27% Mn)

Molybdenum Fertilizers

Ammonium molybdenum (percentages unknown at time of publishing)
Sodium molybdenum (percentages unknown at time of publishing)

Zinc Fertilizer

Zinc sulfate (29% Zn)

Appendix C: Additional Resources

Wild plant identification books:

* Keator, Glenn, Ph.D. *Sierra Flower Finder*. Nature Study Guild.
* Lyons, Kathleen, and Cureo-Lazaneo, Mary Beth. *Plants of the Coast Redwood Region*. Los Altos, CA: Looking Press, 1988. 197 pp.

Muenscher, Walter Conrad. *Weeds*. 2nd ed. Ithaca, NY: Cornell University Press, 1980. 586 pp.

* Niehaus, Theodore F., and Ripper, Charles L. *Pacific States Wildflowers*. Peterson Field Guide. Houghton Mifflin Co.

Polar, Jim, and MacKinnon, Andy. *Plants of the Pacific Northwest Coast*. Redmond, WA: Lone Pine Publishing, 1994. 527 pp.

Spencer, Edwin. *Just Weeds*. Charles Scribner's Sons.

*Various authors. *Weeds of the West*. Newark, CA: The Western Society of Weed Science, 1992. 630 pp.

* = primarily for the West Coast of the United States

Books that may help you learn from plants using your other senses:

Note: These books are recommended by the author, but he has little experience using the alternative methods of learning from plants and/or analyzing soil described or implied in these books.

Brown, Tom, Jr. *Awakening Spirit*. New York, NY: Berkley Books, 1995.
This will take reading between the lines and creative extension of the techniques in order for them to pertain to soil analysis.

Brown, Tom, Jr. *Tom Brown's Field Guide to Wild Edible and Medicinal Plants*. New York, NY: Berkley Books, 1984.
This will introduce you to interesting indigenous uses of plants and alternative ways of relating to plants.

Findhorn Community, The. *The Findhorn Garden*. New York, NY: Harper & Row, 1975. 180 pp.

Wright, Michaelle Small. *Garden Workbook: A Complete Guide to Gardening with Nature Intelligences*. 2nd ed. Jeffersonton, VA: Perelandra, Ltd., 1993. 328 pp.

Wright, Michaelle Small. *Garden Workbook II: Co-Creative Energy Processes for Gardening, Agriculture and Life*. Jeffersonton, VA: Perelandra, Ltd., 1990. 200 pp.

Wright, Michaelle Small. *Behaving as if the God in All Things Mattered*. Jeffersonton, VA: Perelandra, Ltd., 1987. 213 pp.

Appendix D: Sources of Organic Soil Amendments

	DE	GC	OE	PV	SD	SP	SS	WO	NOTES
Alfalfa Meal	✓					✓			Try your local feed store.
Bone Meal	✓	✓	✓	✓		✓	✓	✓	Caution: Some bonemeal may transmit Mad Cow disease.
Borax				✓	✓	✓			Be sure to adjust for **10%** boron application.
Copper Sulfate				✓	✓				
Cottonseed Meal	Not org.	"Food grade"	*	"Pesti-cide-free"		**	Not org.	Not org.	Non-organic cottonseed meal can be harmful to microbes and should not be used. * "Certifiable for org prod in OH" ** "Clean"
Crab Meal Fines								✓	Reported effective against symphylans. Check nutrient composition to determine application rate.
Fish Meal	✓	✓		✓		✓	✓	✓	
Gypsum		✓	✓	✓	✓	✓	✓	✓	(Calcium Sulfate)
Hoof & Horn Meal							✓		
Ferrous Sulfate				✓*	✓*				*Iron Sulfate.
Kelp Meal	✓	✓	✓	✓		✓	✓	✓	
Lime, Dolomitic			✓	✓			✓		
Lime, Hi-Cal			✓				✓	✓*	* Agricultural lime (97% Calc. Carb.)
Magnesium Sulfate				✓					
Manganous Sulfate					✓*				*Manganese sulfate
Oystershell	✓			✓		✓	✓		
Phosphate Rock		✓				✓	✓	✓	
Phosphate, Soft Rock	✓		✓	✓			✓		Also called colloidal soft phosphate.
Potassium Sulfate			✓	✓	✓		✓		
Sulfur, Mined		✓*	✓*			✓*			By-product sulfur not desirable. * Elemental sulfur.
Zinc Sulfate				✓	✓				

See over for names and addresses of suppliers.

Appendix D: Sources of Organic Soil Amendments *(cont.)*

SUPPLIERS

Be sure to write for amounts, prices, and shipping costs.

DE = Down to Earth Distributors, P.O. Box 1419, Eugene OR 97440. Phone: (800) 234-5932.
Wholesale only. Ask your local nursery to contact them.

GC = Garden City Seeds, 778 Highway 93 North, Hamilton MT 59840.
Phone: (406) 961-4837; Fax: (406) 961-4877.

OE = Ohio Earth Food, Inc., 5488 Swamp Street, N.E., Hartville OH 44632.
Phone: (330) 877-9356; Fax: (330) 877-4237.

PV = Peaceful Valley Farm Supply, P.O. Box 2209, Grass Valley CA 95945.
Phone: (916) 272-4769.

SD = Sandalwood Distributing, 39648 Old Spring Road, Murrieta CA 92563.
Phone: (909) 677-7510.
*** Sells small quantities.

SP = Snow Pond Farm Supply, RR2, Box 1009, Belgrade ME 04917. Phone: (800) 768-9998.
For updated catalog: www.mint.net/snowpond

SS = Sparetime Supply, 208 E. San Francisco St., Willits CA 95490. Phone: (707) 459-6791.

WO = Walt's Organic Fertilizer Co., P.O. Box 31580, Seattle WA 98103-1580.
Phone: (206) 783-6685; Fax: (206) 547-6205.

ADDITIONAL SOURCES OF ORGANIC AMENDMENTS

North Country Organics, Depot Street, Bradford VT 05033.
Phone: (802) 222-4277; Fax: (802) 222-9661.
"All natural land care supplies."
Contact them for a list of the wholesale distributors they supply.

Select Bibliography

Bear, Firman E., et al. *Hunger Signs in Crops.* Washington, D. C.: The American Society of Agronomy and The National Fertilizer Association, 1949. 390 pp.

Campbell, Elmer. "Wild Legumes and Soil Fertility." *Ecology* VIII, no. 4 (October 1927), pp. 480-483.

Clements, Frederic. *Plant Indicators: The Relation of Plant Communities to Process and Practice.* Carnegie Publication #290. Stanford, CA: Carnegie Institute of Washington, 1920. 388 pp. (Available from Aida Wells, Carnegie Institute of Washington, Department of Plant Biology, 290 Panama St., Stanford, CA 94305 for $80.00.)

Dale, Hugh M. "Weed Complexes on Abandoned Pastures as Indicators of Site Characteristics." *Canadian Journal of Botany* 44 (1966), pp. 11-17.

Dale, Hugh M.; Harrison, P. J.; and Thomson, G. W. "Weeds as Indicators of Physical Site Characteristics in Abandoned Pastures." *Canadian Journal of Botany* 43 (1965), pp. 1319-1327.

Gershuny, Grace, and Smillie, Joseph. *The Soul of Soil.* 2nd ed. St. Johnsbury, VT: Gaia Services, 1986, p. 108.

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Kearney, T. H.; Briggs, L. J.; Shantz, H. L.; McLane, J. W.; and Piemeisel, R. L. "Indicator Significance of Vegetation in Tooele Valley, Utah." *Journal of Agricultural Research* 1, no. 5 (February 16, 1914), pp. 365-417.

Kelley, Arthur Pierson. "Plant Indicators of Soil Types." *Soil Science* 13, no. 6 (June 17, 1922), pp. 411-423.

Korstian, Clarence F. "Native Vegetation as a Criterion of Site." *The Plant World* 22, no. 9 (September 1919), pp. 253-261.

Lazenby, William R. "The Absence of Certain Native Plants in Soils Containing a Large Percentage of Lime." pp. 63-65. (Rest of citation not available.)

Livingston, Burton Edward. "The Relation of Soils to Natural Vegetation in Roscommon and Crawford Counties, Michigan." *Board of Geological Survey, Annual Report for 1903*, pp. 9-30.

Morgan, M. Francis. "Land Cover Studies as a Basis for a More Accurate Interpretation of the Soil Survey." *Journal of the American Society of Agronomy*, pp. 452-458. (Rest of citation not available.)

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Shantz, Homer Leroy. *Natural Vegetation as an Indicator of the Capabilities of Land for Crop Production in the Great Plains Area.* Washington, D.C.: U.S. Department of Agriculture, March 16, 1911. 100 pp.

Singh, B. N., and Chalam, G. V. "A Quantitative Analysis of the Weed Flora on Arable Land." *Journal of Ecology* 25, pp. 213-221.

Soil Fertility. Agrodok-series Nr. 2, pp. 12-13. (Available from: Agromisa, P.O. Box 41, 6700 AA Wageningen, The Netherlands.)

Truog, Emil. "Soil Acidity: I. Its Relation to the Growth of Plants." *Soil Science* V, no. 3 (February 15, 1918), pp. 169-195.

Wallace, T. *The Diagnosis of Mineral Deficiencies in Plants by Visual Symptoms: A Colour Atlas and Guide.* London: Her Majesty's Stationery Office, 1961.

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About the Author

Soon after graduating college and working as a microbiologist, John Beeby discovered his love of plants. After being introduced to the idea of plants as indicators of their soil and climate, John began collecting and compiling the information from all the works that he could find on the subject. With plant identification books in hand, he found that a walk, even down a city block, became a mystery adventure of deciphering clues and unearthing deeper understandings of the soil and plant life that perseveres there. This knowledge later gave birth to a deeper connection to and understanding of all plants and their ability to describe, among other things, the agricultural potential of wild and cultivated land.

From 1992 to 1996, John was with Ecology Action, learning and eventually helping others learn how to grow food with Biointensive Sustainable Mini-Farming. He also completed a book on human waste recycling called *Future Fertility: Transforming Human Waste into Human Wealth*, which was published by Ecology Action.

He is currently involved in the creation of a non-profit organization which combines Biointensive agriculture with small-scale, affordable housing into a complete yet flexible unit called a microhomestead. The non-profit organization, MicroHomestead Design, will conduct ongoing research, educate others and, through two innovative methods, make it more financially possible for others to live sustainably, both in the country and in the city. He, the three other people currently on the staff of MicroHomestead Design, and two others are in the process of creating a community that will model the goals of globally affordable housing and food self-reliance facilitated by MicroHomestead Design. A working example of a truly sustainable way of life and the means to helping others with their own sustainable ways of living are his passionate pursuits.

Please feel free to contact him with questions, thoughts and/or suggestions on this booklet, MicroHomestead Design and the microhomestead community, or anything else, at: 1243 NE 148th Street, Seattle, WA 98155.