A WORKING CONTEXT FOR INTERPRETATION OF TALLGRASS PRAIRIE REMNANTS

A Practicum submitted to the Faculty of Graduate Studies in partial fulfillment of the requirements for the degree of Master of Landscape Architecture.

by

James Clews Cowan

Department of Landscape Architecture
University of Manitoba
Winnipeg, Manitoba

May 1981

ABSTRACT

The practicum is a case study on tallgrass prairie vegetation which compares a computer-aided approach to interpretation with a manual approach.

Seventy-eight criteria useful in interpreting tallgrass prairie were identified for four user groups: the native people, the immigrants, ecologists, and environmental engineers. These resource-based criteria were structured to reveal an individual plant's relationship to levels within the tallgrass prairie ecosystem. A computer program (SHARRA) was written to allow a user to manipulate data stored in a file based on species at the Living Prairie Museum, Winnipeg, Canada. The program replicates operations normally undertaken manually -- listing the plant inventory, displaying a chart matching plant species against information in records, sorting information for any combinations of performance standards (the criteria) and listing complying plants, and displaying plant records a user specifies by genus.

The program was used to address problems, on the same site, which had already been solved using manually constructed charts. The time and effort for both methods were compared and from a comparison of the results it became clear that the computer-aided approach greatly extended and complemented the abilities of an interpreter. The implications of such an alternative method of managing information revealed tremendous potential for development of packages of information on ecosystems

(cassettes or discs) and/or as an extended library of programs and plant files. There were no apparent high costs involved and the system lends itself to development, in small incremental stages, by universities or government agencies. The major benefits in establishing an alternative approach are the considerable savings of time and money in preparing environmental impact assessments,and the ease of interpretation in understanding,using and managing tallgrass prairie.

ACKNOWLEDGMENTS

I am very grateful to four groups of people who contributed to this study.

- The Canadian Commonwealth Scholarship and Fellowship Committee provided me, through their financial support, with the opportunity to study in Canada. In addition, they awarded a travel grant which allowed me to visit tallgrass prairie sites in the United States and Canada.

The second group are those individuals who have influenced the direction of my studies.

- The Practicum Committee: Professor Alexander E. Rattray, Dr. John M. Stewart, and Professor Benjamin F. Harnish.
- Mr. Harold D. Moore, Director/Curator of the Buechel Memorial Lakota Museum (St. Francis, S.D.).
- Mr. Robert J. Tetlow, University of California, Berkeley.
- Mr. Mark Turnbull, of William J. Cairns and Partners, Edinburgh, Scotland.

The third group contributed directly toward the practicum's final form.

- Mr. James D. Cortens for his advice on programming.
- Mrs. Evelyn Fieldhouse for her time and effort in typing the manuscript.
- Mr. Roger Green and Professor Edward B. McLachlan for photographs of prairie species.
- Miss Kadri A. Sults for correcting and constructively commenting on many draft submissions.

- The Provincial Archives of Manitoba for photographic reproductions (pages 51, 57, 79, 84).

The final group are personal friends, in addition to those above, who provided generous moral support and encouragement.

- Alexandra Borowiecka, Hill and Liz Bylholt, Jeff and Chris Frank, Richard Frechette, Keith Koroluk, Ting Lee, Tom Llewellin, Bev Mehner, Geoff and Janice Pregnall, Alf and Zora Simon, Ingrid Thiessen, Jim and Heather Thomas, Erika Uustalu, and Sheila Van Landeghem.

TABLE OF CONTENTS

Page

LIST OF ILLUSTRATIONS

PART 1
INTRODUCTION

Sharra talked about the properties and virtues of the roots for which they dug, the leaves for which they climbed only the healthiest of trees, or equally elusive herbs that lived obscurely where other bushes had thorns to scratch...She was also acquainted with the thick bush leaves, which made a more fragrant and comfortable bedding than springier fronds...They cut the tufts from the grass for the therapeutic seeds that grew along each stem. The larger branches were laid aside and tied in bundles to be bound together for a raft...The heart of the grass plant, just above the root ball, was its most important part. This was dried and pounded into a powder that was the best medicine known for reducing fever.

> 'Sometimes I'd like to go north
> just to see all the differences,
> but then again,' and Sharra shrugged,
> 'this is where I [live]. I haven't
> seen half enough of it yet to begin
> to appreciate all its complexity.'

-- From Anne McCaffrey's
Dragondrums

1.1 The General Problem

Interpretation of information is a part of the thought process for anyone concerned with understanding, using, or managing plant species.

Most information on the attributes of plants is stored in written form for a multitude of narrowly defined working contexts -- plants as food, ornaments, medicine, building materials etc. -- so that a view of a plant's overall merits and its place in nature is obscured. Yet when it comes to interpreting man's impact on the environment this is precisely the sort of overview that is required.

The manual procedure involved in collecting and reworking significant information is time-consuming and very tedious. Plant or plant community uses are recorded, as are the essential relationships between a plant community's composition and structure, and form determinants such as the availability of soil moisture. Information provided by specialists or taken from books is collected and transferred to a hand-drawn chart (a matrix) where plant species can be matched against performance standards (criteria). An office concerned with preparing an environmental impact assessment will rework the information to: prepare a plant inventory; explore the workings of the system and overall merits of the plant species; make predictions comparing the impact of alternative proposals for a "best land use". This information is stored as the accumulated experience of individuals and in libraries of related books and charts.

With limited money and time, this manner of storing and managing information for interpretation is a very real source of concern, because every time the same working context is encountered a large part of the manual procedure often has to be repeated. It takes a great deal of time to provide quantified answers on the behaviour and merits of the plant community as a whole.

The ecosystem, a contextual framework that links all the components of the environment (Mineral/Vegetable/Animal/Man), is increasingly adopted by planners as a "resource unit" because problems encountered in interpretation usually affect all the components. Energy and information are synonymous. The vegetation of an ecosystem can be regarded as nature's store of information -- an evolved response to problems posed by environmental constraints and interacting organisms (Fig. 1.1).

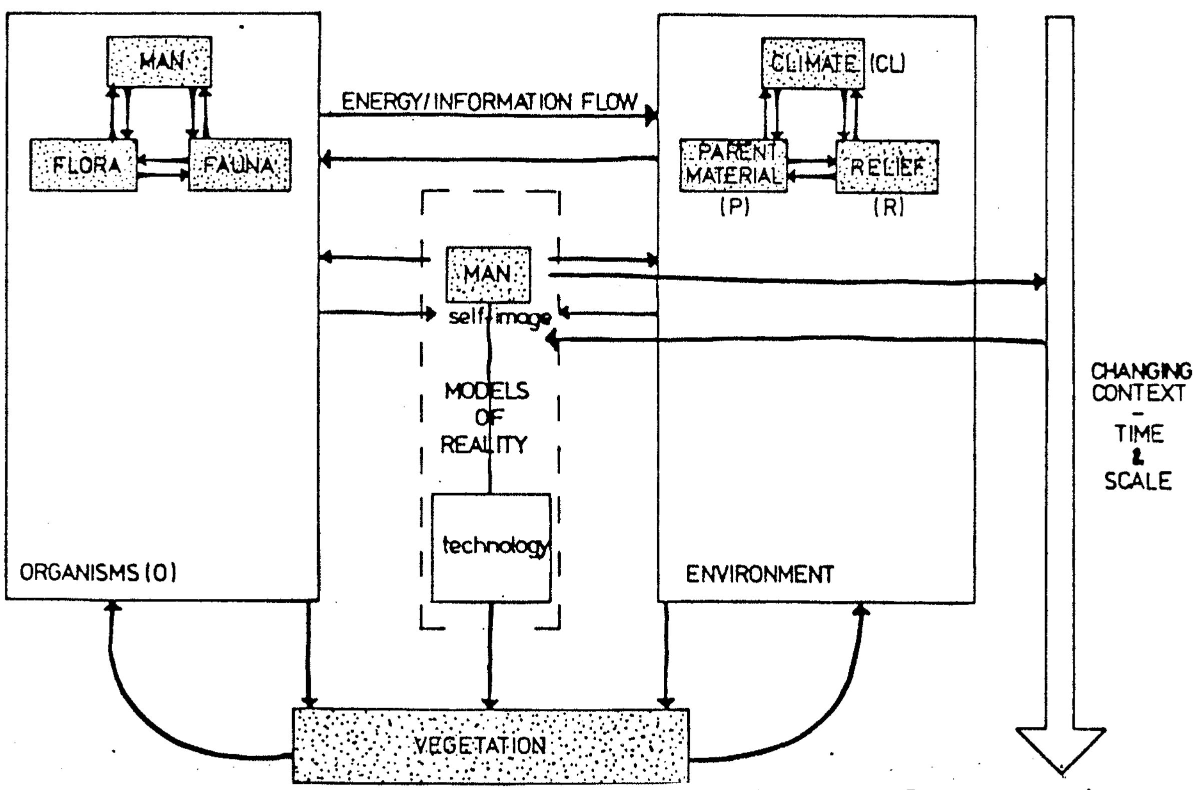


Fig. 1.1 A conceptual framework for the selection of plant species
(based on an ecological "model"— jenny's law - soil = (cl, p, r, o, t) ≡ vegetation)

The vegetation of a natural ecosystem (boreal forest, tundra, tallgrass prairie etc.) is recognisable as characteristic of the system[1] and is frequently used as an "environmental benchmark". It provides a base-line study against which the health of a disrupted ecosystem can be measured. It would be very convenient if information on plant species were stored according to nature's context, as well as within specialist classification systems. Although the ecosystem is important in regional planning, when specific questions are asked concerning plant attributes or predictable patterns of change, there are seldom specific answers immediately available. This is partly due to the complexity of natural ecosystems but is also due to the shortcomings of a traditional methodology which does not manage available information efficiently.

1.2 The Study

The premise on which this practicum was initiated is that it should be possible to combine the attributes of a computer (speed and accuracy in storing, retrieving and manipulating data) with the abilities of a person (skills of perception/ interpretation) so that the thought process leading up to the interpretation of information on plant species and communities is made more efficient and less time-consuming. The practicum takes the form of a case study on the tallgrass prairie ecosystem, using the computer as an aid to interpretation, and addresses two specific problems:

---

[1] H.Jenny, Factors of Soil Formation (New york:McGraw Hill,1941)

1) Selection of those criteria that will most frequently be of use. The majority of criteria have to be applicable to most of the plant species if the management of information is to be efficient.

2) The second problem is to replicate with the machine those operations that are normally time-consuming and inefficient when storing, selecting and sorting of information on plant material is done manually.

It is important that criteria be derived from a working context for interpretation of a definable entity such as an ecosystem. Where working context and criteria are separated, large amounts of unrelated data are processed, but the procedure gives a very small return for the computer time involved. An unfortunate and inaccurate conclusion might then be that the computer is at fault and is of limited use as an aid to interpretation. In fact, the fault would lie with a plant record which, because it is not clearly applicable to a specific problem, is certain to have an excess of redundant information and be deficient in some key specific criteria.

1.3 Study Objectives

Objectives can be summarized as follows:

a) Establish a systems context for storing information in plant records so that it has some clear meaning applicable to solving interpretative problems.

b) Compile a file on tallgrass prairie species that is large enough to be of some practical value in testing the computer-aided approach to interpretation.

c) Write an interactive program which replicates operations normally undertaken manually in storing, selecting, listing and sorting information on plants.

d) Test the applicability of a computer-aided approach to interpretation by undertaking several exercises in problem solving. The time and effort involved using the machine is compared with the manual procedure for the same problems, on the same site.

e) Draw conclusions from the comparison regarding the feasibility of such an approach and comment on future developments.

PART 2
METHODOLOGY

2.1 Context and Criteria

Perception of possible use for plant species depends on the user's context for interpretation. There is documentation on several user groups: the native people, immigrants to the region (from both Western European and late Plains Indian cultures), ecologists and environmental engineers. Interpretations relevant to these users provide four related storylines (Appendix 1), but more important, they provide justification for a choice of criteria which "mesh" to provide the required overview of multiple plant uses and relationships.

Plant species are seen to relate to four levels (Physical, Plant, Animal and Man), as part of one whole system (Fig. 2.1).

The plant record reflects criteria that are important in revealing how to identify species, when and where they are available, and what uses they have for man and wildlife. Other criteria relating to form determinants reveal why the tallgrass prairie is structured the way it is and how it responds to change. There is a total of 78 criteria in the plant record. Lists of plants complying with any one of these would be immensely useful to an interpreter, but the real significance of the record is that the given criteria are those which can most frequently be combined to explore and interpret more complex relationships, e.g. between habitat and plant community composition.

Combinations of 10 or more criteria are unlikely to

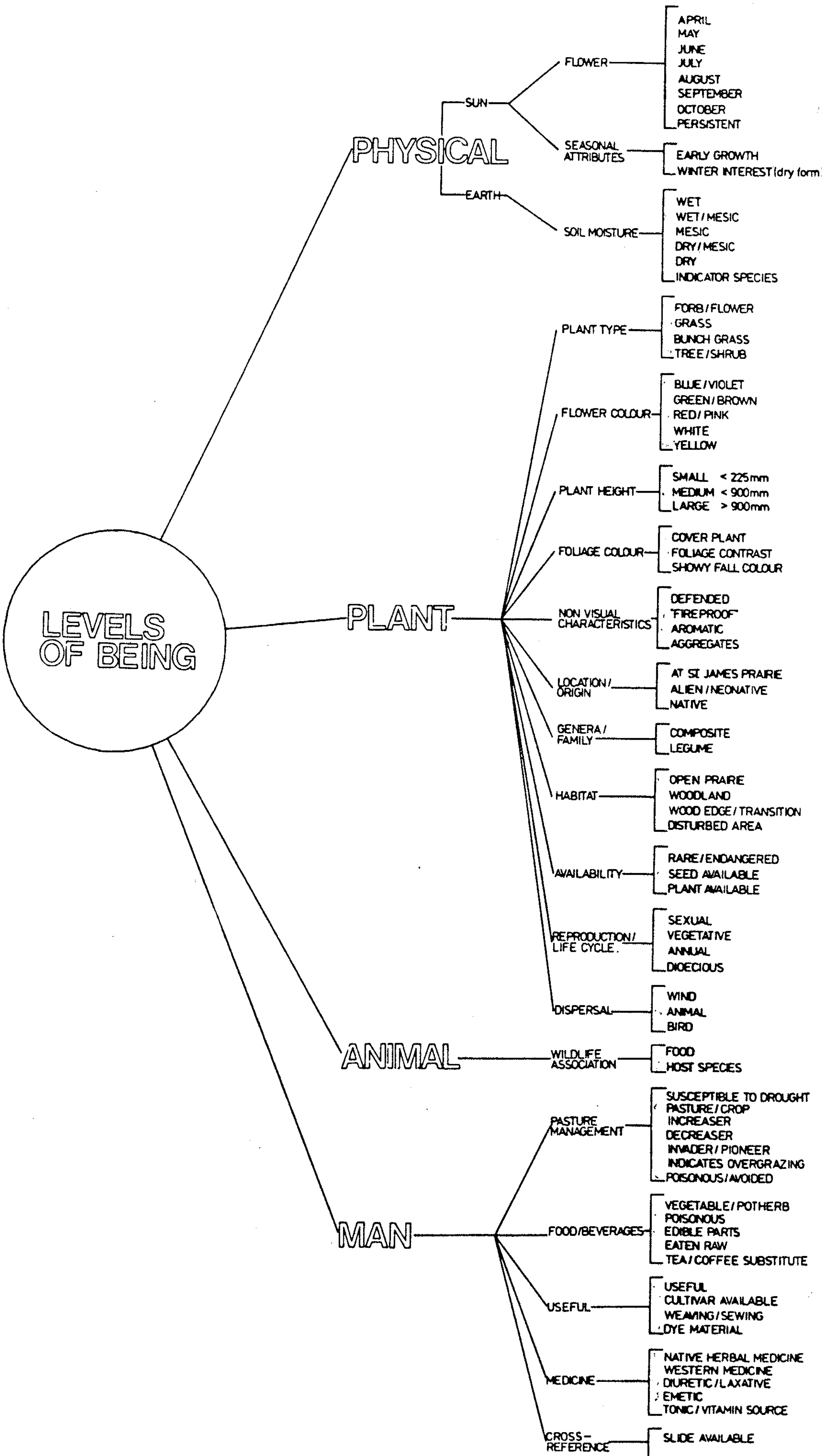


Fig. 2.1 A checklist of criteria

yield results. Only one of the performance standards relating to plant type, height, origin and family is likely to be chosen. If the user selects, for example, TREE as a performance specification, other criteria under PLANT TYPE become redundant. Were the record derived for a global context, the number of redundant criteria would be high when a specific problem is addressed. Using an ecosystem as a working context for interpretation ensures that the number of redundent criteria is kept to a minimum. The checklist offers permutations on 71 criteria, all of which have an application specific to interpreting tallgrass prairie.

2.2 The St. James Prairie: Focus for the Study

There are about 2000 species[2] spread throughout the entire range of tallgrass prairie in North America (400,000 sq. miles). The inventory of plants used for this case study is based on those which occur at the Living Prairie Museum, Winnipeg, Canada (Fig. 2.2).

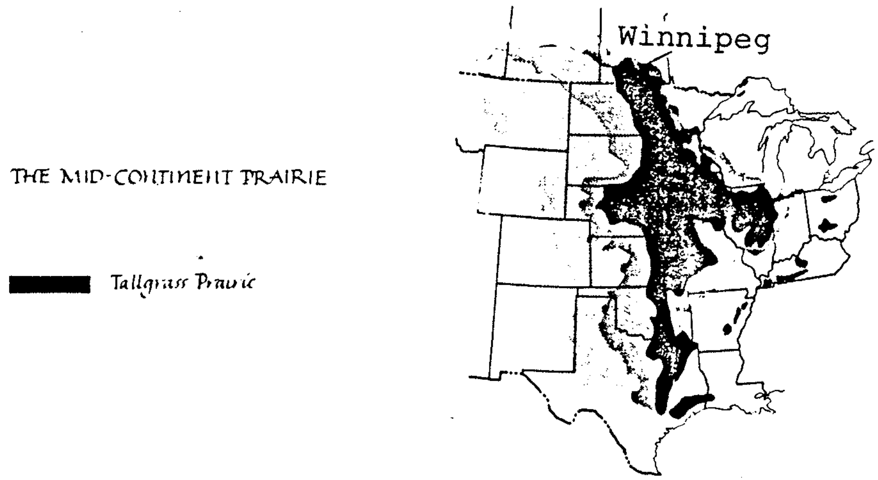


Fig. 2.2 Location of the St. James Prairie

Plant resources on the site include native woodland species (Oak/Aspen) and introduced species. Some of the introduced species occur within the tallgrass prairie, but the more obvious introductions are the alien species planted around a one-time homestead site (as windbreaks or vegetable gardens). All 169 of the species located on the site are included in the plant file, along with 17 plants associated with tallgrass prairie elsewhere in Manitoba, to give a total of 186 species. The records containing the 78 criteria are presented in Appendix 2, along with the sources of information for individual criteria. This information was compiled over a period of six months for the St. James Plant Resources (Fig. 2.3).

---

2 David F.Costello, The Prairie World (New York: Thomas Y. Crowell Co., 1975.)

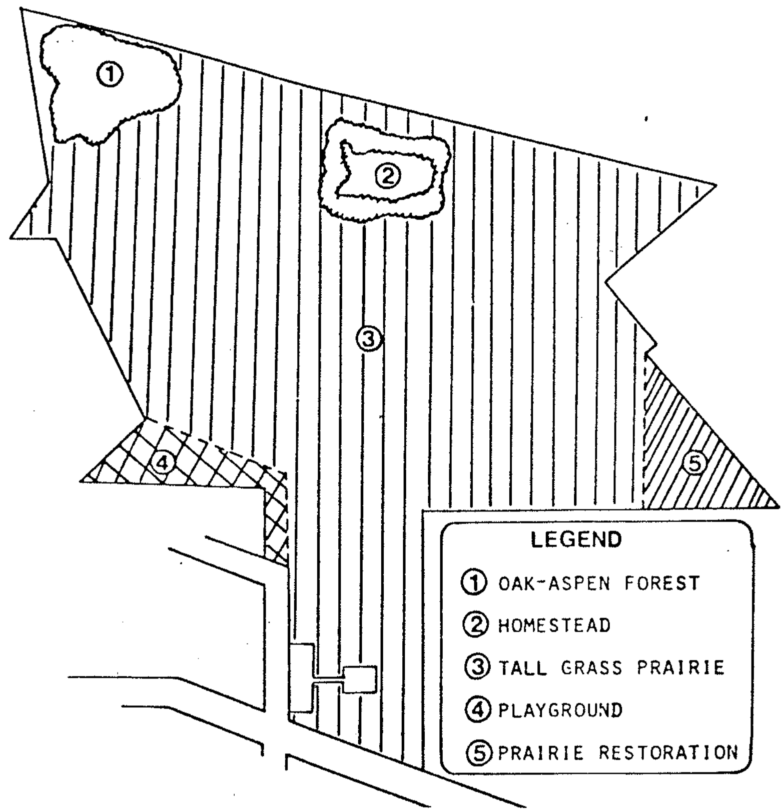


Fig. 2.3 St. James Prairie plant resources

The species of the St. James Prairie site[3] were chosen as the focus for this study because they have been subject to interpretation by students of ecology and landscape architecture in the past. By comparing the manual procedure involved in past attempts at solving interpretative problems with a computer-aided approach, it should be possible to arrive at some firm conclusions regarding the benefits of using the machine.

---

3 Department of Parks and Recreation (Winnipeg), Living Prairie Museum Plant Check List, 1980.

The site's 39.2 acres were once leased for hay but have never been ploughed.[4] In 1968 the International Biological Program recommended that the area be conserved, since it was said to represent the best example of tallgrass prairie in Manitoba. Since then an interpretative centre has been opened which is visited by about 12,000 people per year. The St. James site was chosen as a focus for the study in the hope that the final program and files may find practical application in monitoring the health of the plant resources so that the carrying capacity of the site can be determined.

2.3 Comparing Methods in Managing Information

As part of the normal coursework, students were asked to select up to 30 species and locate them on a plan for the interpretative centre. Selection of species was in response to two given problems:

1) Which species would you select for a herbal garden?
2) Which species would you use to establish tall-grass prairie on a berm which surrounds the partially underground interpretative centre?

Knowing little about the composition or structure of tallgrass prairie the initial selection of plants was made at random. As further reading identified criteria specific to prairie species it became a question of luck as to how many of the randomly chosen species matched with desirable criteria. A maximum of about 14 criteria were identified and plant lists

---

4 Norman Harburn, Living Prairie Museum Interpretation Plan (Winnipeg: City Parks Department, 1978.) p 20.

were constantly changed as it became obvious that plant species and performance standards did not match. At the end of a two-week period no one was satisfied that their plant selection was entirely appropriate. Very few of the 115 tallgrass species had been screened as to their suitability. At the end of the exercise students had a short checklist of proven criteria and a better understanding of how plant selection could be made to fit with processes in nature. The problems in managing the information were such that they could fully appreciate why many people advocate the use of native plant material but few actually use it.

Writing a program that replicates all the procedural steps undertaken manually as part of the process of selecting plant material will provide the required interpretative aid. The user starts the process of plant selection with a given checklist (78 criteria) and a comprehensive file on 186 species, so there should be a considerable amount of time saved because the initial process of information gathering is complete. The speed with which the machine reworks information should lead to further savings -- how much remains to be seen.

PART 3
SHARRA - AN INTERACTIVE COMPUTER PROGRAM

3.1 Objectives for the Program

The program is intended to replicate three operations that normally are carried out manually:

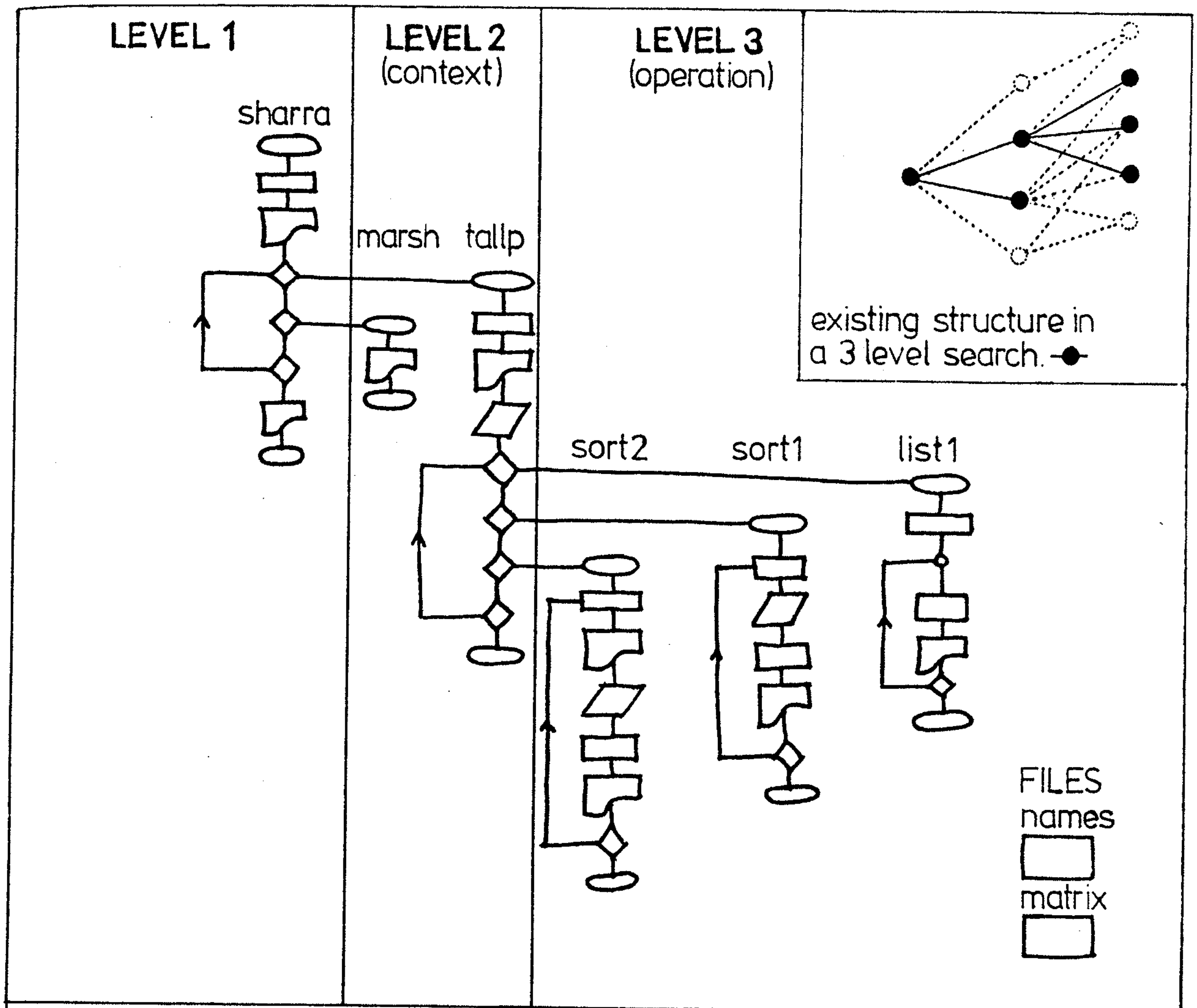
a) Provide a plant inventory -- a list of all the plant species on record (botanical and common name) -- and display plant names matched against the information on criteria that is in the file so that the user has a chart of species matched against criteria that normally would be a hand-drawn matrix.

b) Locate and display a formatted record for a plant, specified by the user according to its genus (e.g. Psoralea). This procedure is like referring to a book except that the machine does the searching.

c) Allow the user to select any combination of performance standards from a large checklist of proven criteria and have the machine match them against the stored records, list and total the plants that comply (e.g. OPEN PRAIRIE/AT ST JAMES/NATIVE HERBAL MEDICINE). This replicates the visual sorting that is made of plants in a manually constructed matrix. The sub-programs that carry out these operations appear in the appendix with the main program. They are named LIST1, SORT1 and SORT2 respectively.

3.2 The Structure of the Program

The program has three levels which are shown in the flowchart (Fig. 3.1). On Level 1 the mainline program (SHARRA) explains that the user will be working with information on ecosystems and offers two options -- tallgrass prairie (TALLP) and marshlands (MARSH). Only the case study, tallgrass prairie, is operational. The marshlands option, which returns a "no file available" message, is included to show that Level 2 can be expanded to include other working contexts, e.g. boreal forest, the city, local nursery stock, an arbortum, a herbarium, field crops, forestry -- in short, any situation where people work with information on plant material and can define criteria pertinent to the problems they encounter. Names of species and plant records are automatically read into the computer's memory only for the context chosen, otherwise they remain stored on tape. The subprogram on Level 2 (TALLP) offers three operational procedures, on Level 3, which meet the program objectives previously outlined. LIST1 produces a plant inventory and a chart that displays plant names and records. Other programs could easily be written to generate formatted charts giving flowering sequence, colour of flower, or whichever of the 78 criteria are desired. SORT1 displays a specified plant record once the user gives its genus. The genus can easily be read from the list of names (botanical and common) which the machine provides. Common names vary too much from place to place to use them for specification of a record. SORT2 matches performance specifications chosen from a displayed checklest against records, lists and counts the complying plants.



KEY

START or STOP.

This symbol indicates either the beginning or the end of an algorithm. For any particular algorithm, there will usually be one start symbol and one stop symbol.

PROCESS.

The process symbol is the one which indicates that calculations are to be performed.

DECISION.

The decision symbol is used to allow a choice as to which of two steps will be performed next.

LINE PRINTER OUTPUT.

The line printer symbol may be used when information is to be printed on a line printer. The shape of the symbol was chosen to represent a piece of paper torn off at the bottom.

INPUT/OUTPUT.

The input/output symbol may be used for any type of input or output.

Fig. 3.1 A Flowchart of the programs

Choosing any one of the 78 criteria will give a plant list, but more important, any combination of criteria will give a list. Information retrieved by the other subprograms is available in books -- lists of tallgrass prairie species, edible plants, June flowering species etc. -- the computer simply retrieves information more effectively than is possible by memory. The SORT2 program gives new information in that it is an extension of our memory capabilities and our ability to synthesize information. It is immensely useful in exploring relationships. One thing the user should remember is that he/she is specifying performance criteria, e.g. by specifying NATIVE, GRASS and FORB he/she gets not a list of native grasses and forbs but a list of plants that are native and grasses and forbs.

With further refinement the operational procedures (LIST1, SORT1,SORT2) could be shared by all the "context" programs (TALLP, MARSH).

PART 4
SHARRA IN USE (APPLICATION)

4.1 Testing SHARRA as an Aid to Interpretation

SHARRA is used to address the exercises in problem solving identified earlier.

The programs were run separately on cards at the University of Manitoba's student terminal. The lineprinter at the terminal is faster than those affordable to a small office. Were the program used elsewhere, the time taken to produce lists or display records could be increased by a factor of about 300. However, this is insignificant because what it means in practice is that instead of receiving the lists in 0.5 seconds it might take up to 2.5 minutes. Expensive hardware will not make any significant difference to the overall time saved by using the program, SHARRA, as an interpretative aid.

Just how much difference does the computer make? It took about 32 hours to select species for a herbal garden when the process was carried out manually sorting information stored in books. The easiest way to show the potential benefits in using SHARRA is to address similar, if slightly more complex, problems.

QUESTION: How significant are prairie species as native herbal cures and in western medicine? Which of the species identified are available from nurseries to establish a herbal garden?

Combination of Criteria *		# of Species	% of Total
OPEN PRAIRIE/AT ST. JAMES		115	100.00
" "	/NATIVE HERBAL MEDICINE	51	44.35
" "	/WESTERN MEDICINE	14	12.17
" "	/NATIVE HERBAL MEDICINE/ WESTERN MEDICINE	10	8.17

The native people have a documented medicinal use for about 45% of the species, while western medicine has a use for only about 12%. If the interpretor takes only the species useful in both cultures and adds SEED AVAILABLE or PLANT AVAILABLE, he/she receives two alternative plant lists.

MEDICINAL PLANTS AVAILABLE AS SEED

Asclepias syriaca	Common Milkweed
Oenothera biennis	Evening Primrose
Polygala senega	Seneca Snakeroot
Solidago rigida	Stiff Goldenrod

MEDICINAL PLANTS AVAILABLE AS PLANTS

Fragaria virginiana	Wild Strawberry
Oenothera biennis	Evening Primrose
Polygala senega	Seneca Snakeroot
Rosa arkansana	Low Prairie Rose
Solidago rigida	Stiff Goldenrod

(The time taken to retrieve this information was about 1 minute, 5 seconds.)

*Criteria are from the checklist of performance standards (SORT2)
Data is from the files compiled for SHARRA (Appendix 2)
Formatted output was as for Appendix 3, example 3.

QUESTION: What choice of species would be appropriate and representative of tallgrass prairie on the berm which surrounds the partially underground interpretive center at St. James? (Assume the species would be selected from those on site.)

Grasses cover about 96% of the prairie. One way of approaching the problem is to select a grass/grasses to bind the soil and then select the forbs. The berm will range from dry to mesic soil moisture conditions and be in partial shade for a large part of the year because of the building's cast shadow.

Combination of Criteria	List of Species
OPEN PRAIRIE/BUNCH GRASS/AT ST. JAMES/NATIVE/DRY	Little Bluestem
" " " /DRY-MESIC	Junegrass Prairie Dropseed Needlegrass
" " " /MESIC	Nodding Ryegrass
OPEN PRAIRIE/FORB/AT ST. JAMES/NATIVE/DRY	24 species
" " " " /DRY-MESIC	31 species
" " " " /MESIC	27 species

Allowance is made for shade by selecting habitats with similar partial shade conditions.

Combination of Criteria	List of Species
OPEN PRAIRIE/FORB/AT ST JAMES/ NATIVE/WOOD EDGE/DRY	Three Flowered Avens Wild Bergamot
" /DRY-MESIC	Nodding Onion Wild Licorice Wild Bergamot Tall Quinquefoil
" /MESIC	Nodding Onion Spreading Dogbane Smooth Aster Wild Morning Glory Wild Licorice Wild Bergamot Heart Leaved Alexanders

N.B. Spreading Dogbane and Wild Morning Glory are documented as occurring in prairie and wood edge. Since they are more often associated with woodland, I would choose to drop them from the list. In order that the soil be improved over time, plant selection should include some nitrogen-fixing species which are also good cover.

Combination of Criteria	List of Species
OPEN PRAIRIE/LEGUME/COVER PLANT	Wild Peavine White Prairie Clover Purple Prairie Clover Indian Breadroot

The final selection of species would be of grasses (to be seeded), flowers (to be transplanted to their most fitting soil moisture location) and legumes (evenly distributed).

PLANT LIST		SLOPE CONDITION*
GRASSES		
Andropogan scoparius	Little Bluestem	
Koeleria cristata	Junegrass	
Sporobolus heterolepis	Prairie Dropseed	
Stipa spartea	Needlegrass	
Elymus canadensis	Nodding Ryegrass	
FORBS/FLOWERS		
Allium cernuum	Nodding Onion	D,D-M
Aster laevis	Smooth Aster	M
Geum triflorum	Three Flowered Avens	D
Glycyrrhiza lepidota	Wild Licorice	D-M,M
Monarda fistulosa	Wild Bergamot	D,D-M
Potentilla arguta	Tall Quinquefoil	D-M
Zizia aptera	Heart Leaved Alexanders	M
LEGUMES		
Lathyrus venosus	Wild Peavine	
Petalostemum candidum	White Prairie Clover	
Petalostemum purpureum	Purple Prairie Clover	
Psoralea esculenta	Indian Breadroot	

*D (Dry), D-M (Dry-mesic), M (Mesic)

(Total time to rework information into lists was about 2 minutes, 30 seconds.)

It took 48 working hours to arrive at a plant list for the berm at St. James without the computer-aid. While the final proposals could usually be justified it was clear that the approach had not been comprehensive. Information scrutinized in the manual processing of data,and in trying to establish the context of the site, covered only 3% of the information currently available in the file (30 species x 14 criteria as against 186 species x 78 criteria). Because considerable time was given to a careful selection of combinable criteria that are problem-related,about 16% of plants on file can be listed by the machine for as many as five performance standards. But what about some more complex interpretative problems ?

QUESTION: Is there a pattern to the flowering sequence of native prairie species, at the St. James Prairie?

Combination of Criteria				# of Species	% of Total
NATIVE/OPEN	PRAIRIE/AT	ST. JAMES		106	100.00
"	"	"	/APRIL	5	4.72
"	"	"	/MAY	27	25.47
"	"	"	/JUNE	62	58.49
"	"	"	/JULY	71	66.98
"	"	"	/AUGUST	63	59.43
"	"	"	/SEPTEMBER	31	29.25
"	"	"	/OCTOBER	12	11.32

(The total time taken to get this information was approximately 2 minutes -- about 1 min. 56 sec. to type in the criteria codes and 4 seconds for the lineprinter to supply all the lists.)

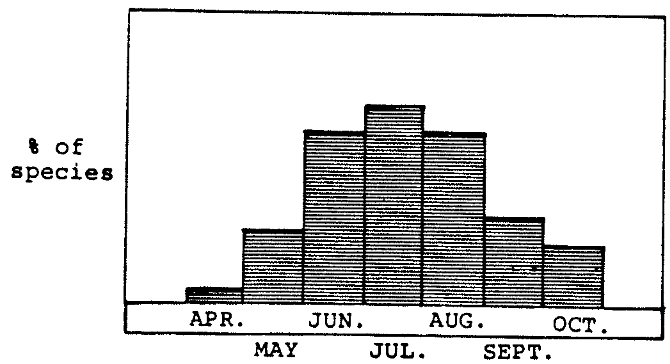


Fig. 4.1 Plant phenology (native, tallgrass species)

The pattern that emerges is almost symmetrical about the month of July and with the lists we can forecast which specific species will be in bloom for visits at different times of the year (Fig. 4.1).

QUESTION: Do the introduced alien species follow this pattern?

Combination of Criteria				# of Species	% of Total
ALIEN/OPEN	PRAIRIE/AT	ST. JAMES		9	100.00
"	"	"	/APRIL	0	0.00
"	"	"	/MAY	2	22.22
"	"	"	/JUNE	9	100.00
"	"	"	/JULY	8	88.89
"	"	"	/AUGUST	3	33.33
"	"	"	/SEPTEMBER	1	11.11
"	"	"	/OCTOBER	0	0.00

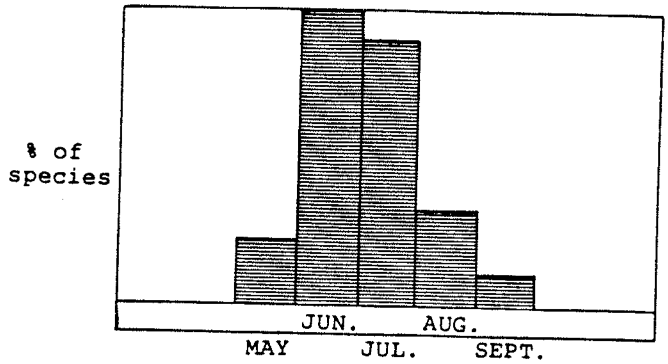


Fig. 4.2 Plant phenology (alien, tallgrass species)

Although the sample is not large, the fact that all the aliens bloom (and seed) earlier than the majority of native species may be one of the factors that gives them a competitive edge over native species. The alien species do not conform to the general pattern (Fig. 4.2).

QUESTION: Is the symmetrical pattern to plant flowering one that is visually evident, given that some species are numerous while others are rare?

Combination of Criteria	# of Species	% of Total
OPEN PRAIRIE/AT ST. JAMES/COVER	39	100.00
" " " /APRIL	1	2.56
" " " /MAY	12	30.77
" " " /JUNE	26	66.67
" " " /JULY	22	56.41
" " " /AUGUST	24	61.54
" " " /SEPTEMBER	11	28.21
" " " /OCTOBER	6	15.38

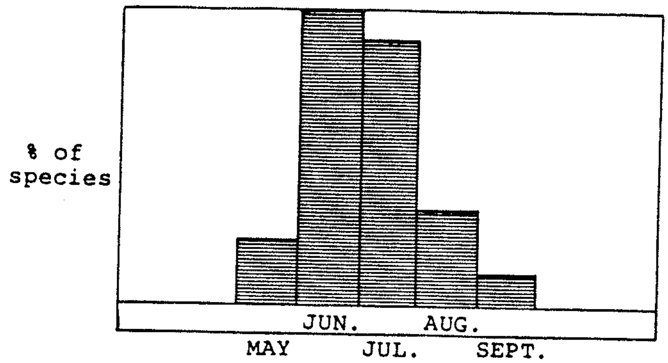


Fig. 4.2 Plant phenology (alien, tallgrass species)

Although the sample is not large, the fact that all the aliens bloom (and seed) earlier than the majority of native species may be one of the factors that gives them a competitive edge over native species. The alien species do not conform to the general pattern (Fig. 4.2).

QUESTION: Is the symmetrical pattern to plant flowering one that is visually evident, given that some species are numerous while others are rare?

Combination of Criteria				# of Species	% of Total
OPEN PRAIRIE/AT	ST. JAMES/COVER			39	100.00
"	"	"	/APRIL	1	2.56
"	"	"	/MAY	12	30.77
"	"	"	/JUNE	26	66.67
"	"	"	/JULY	22	56.41
"	"	"	/AUGUST	24	61.54
"	"	"	/SEPTEMBER	11	28.21
"	"	"	/OCTOBER	6	15.38

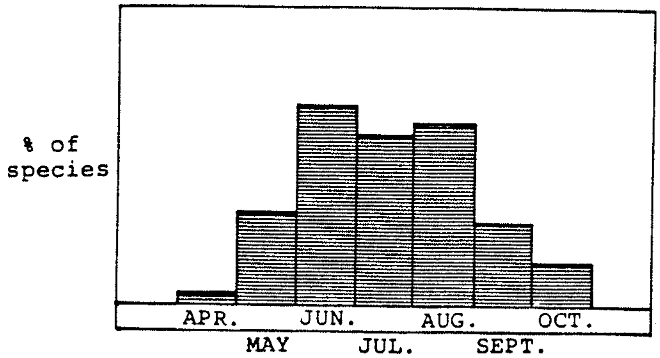


Fig. 4.3 Plant phenology (good cover, tallgrass species)

Assuming that the species that make up 75% of the prairie's cover occur in roughly the same numbers, then it would appear that casual observation would not reveal a peak in July but the observer would be aware of about the same number of species flowering in June, July and August (Fig. 4.3).

QUESTION: If the casual observer has his attention focused on groups of flowering plants, is this likely to change his interpretation of a pattern?

Combination of Criteria		# of Species	% of Total
OPEN PRAIRIE/AT ST. JAMES/ FORMS AGGREGATES		17	100.00
"	/APRIL	0	0.00
"	/MAY	3	17.65
"	/JUNE	9	52.94
"	/JULY	9	52.94
"	/AUGUST	11	64.71
"	/SEPTEMBER	8	47.06
"	/OCTOBER	3	17.65

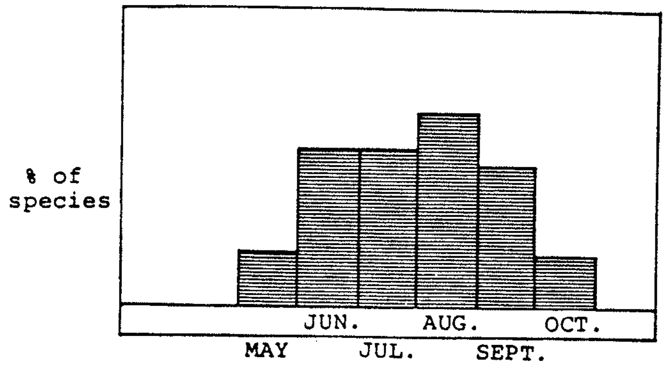


Fig. 4.4 Plant phenology (aggregates of tallgrass species)

The pattern that would be seen would be one which peaked later in the year, in August. Even if the observer does not distinguish between varieties of species (e.g. the four varieties of rose or goldenrod) and saw them as one flower, the pattern does not change. There would still be a visible peak in August (Fig. 4.4).

The time taken in collecting all the information was 8-10 minutes. The accuracy of predictions on what would be seen can be improved by more detailed information on the numbers of individual plants, but even then results would only be generally applicable, as much depends on the colour and size of the flower.

As a general interpretation the results are accurate. They show the need for quantified information on plant behaviour as opposed to visual interpretations, which are deceptive.

The need for an overview has been stressed throughout the study. When specific questions have to be addressed on the merits and working of tallgrass prairie the quantified information that SHARRA provides could be of tremendous value. The following information represents a quantitative analysis of the file for the tallgrass species which are on the St. James site.

Combination of Criteria			# of species	% of total
OPEN PRAIRIE/AT ST JAMES			115	100.00
"	"	/APRIL FLOWER	5	4.35
"	"	/MAY FLOWER	29	25.22
"	"	/JUNE FLOWER	71	61.74
"	"	/JULY FLOWER	79	68.70
"	"	/AUGUST FLOWER	66	57.39
"	"	/SEPTEMBER FLOWER	32	27.83
"	"	/OCTOBER FLOWER	12	10.43
"	"	/PERSISTENT (2 months +)	53	46.09
"	"	/EARLY GROWTH	9	7.83
"	"	/WINTER INTEREST	59	51.30
"	"	/WET (soil moisture)	18	15.65
"	"	/WET-MESIC	37	32.17
"	"	/MESIC	32	27.83
"	"	/DRY-MESIC	35	30.43
"	"	/DRY	26	22.61
"	"	/INDICATOR SPECIES (soil moisture)	22	19.13

Combination of Criteria	# of species	% of total
OPEN PRAIRIE/AT ST. JAMES/FORB or FLOWER	100	86.96
" " /GRASS	15	13.04
" " /BUNCH GRASS	6	5.22
" " /BLUE or VIOLET FLOWER	29	25.22
" " /GREEN or BROWN FLOWER	9	7.83
" " /RED or PINK FLOWER	17	14.78
" " /WHITE FLOWER	28	24.35
" " /YELLOW FLOWER	31	26.96
" " /SMALL (<9")	15	13.04
" " /MEDIUM (<36")	71	61.74
" " /LARGE (>36")	8	6.96
" " /COVER PLANT	39	33.91
" " /FOLIAGE CONTRAST	9	7.83
" " /SHOWY FALL COLOUR	8	6.96
" " /DEFENDED	3	2.61
" " /FIREPROOF	0	0.00
" " /AROMATIC	12	10.43
" " /FORMS AGGREGATES	17	14.78
" " /ALIEN	9	7.83
" " /NATIVE	106	92.17
" " /COMPOSITE	32	27.83
" " /LEGUME	15	13.04
" " /WOODLAND (as well as prairie)	3	2.61
" " /WOODEDGE	18	15.65

Combination of Criteria			# of species	% of total
OPEN PRAIRIE/AT	ST. JAMES/DISTURBED AREA		22	19.13
"	"	/RARE or ENDANGERED	6	5.22
"	"	/SEED AVAILABLE (from nurseries)	41	35.65
"	"	/PLANT AVAILABLE (from nurseries)	33	28.70
"	"	/SEXUAL REPRODUCTION	61	53.04
"	"	/VEGETATIVE REPRODUCTION	63	54.78
"	"	/ANNUAL	3	2.61
"	"	/DIOECIOUS	0	0.00
		/WIND DISPERSAL	20	17.39
"	"	/ANIMAL DISPERSAL	21	18.26
"	"	/BIRD DISPERSAL	5	4.35
"	"	/FOOD FOR WILDLIFE	54	46.96
"	"	/HOST SPECIES	5	4.35
"	"	/SUSCEPTIBLE TO DROUGHT	12	10.43
"	"	/PASTURE/CROP	32	27.83
"	"	/INCREASER	7	6.09
"	"	/DECREASER	14	12.17
"	"	/INVADER/PIONEER	12	10.43
"	"	/INDICATOR OF OVER-GRAZING	5	4.35
"	"	/POISONOUS/AVOIDED (sheep, cattle)	15	13.04
"	"	/VEGETABLE/POTHERB	14	12.17
"	"	/POISONOUS/CAUTION (to man)	12	10.43

Combination of Criteria			# of species	% of Total
OPEN PRAIRIE	/AT ST. JAMES	/EDIBLE PARTS	56	48.70
"	"	/EATEN RAW	26	22.61
"	"	/TEA/COFFEE SUBSTITUTE	31	26.96
"	"	/USEFUL	22	19.13
"	"	/CULTIVAR	25	21.74
"	"	/WEAVING/SEWING	3	2.61
"	"	/DYE MATERIAL	23	20.00
"	"	/NATIVE HERBAL MEDICINE	51	43.48
"	"	/WESTERN MEDICINE	14	12.17
"	"	/DIURETIC/LAXATIVE	9	7.83
"	"	/EMETIC	4	3.48
"	"	/TONIC/VITAMIN SOURCE	19	16.52
"	"	/SLIDE AVAILABLE (Private collection)	30	26.09

The assessment reveals that the plant community as a whole has a tremendous number of uses which are worthy of further research. It should be possible to place some economic value on these multiple uses to build a case for the conservation of prairie.

PART 5
CONCLUSIONS

5.1 The Value of SHARRA

SHARRA does not make decisions and therefore does not substitute for the skills of an interpreter. The programmed computer does what a machine does best -- those tasks that are tedious and repetitious to the human mind -- and does them quickly and efficiently. The quantitative information, on the virtues and attributes of plants, which SHARRA can provide is of great value because it reveals meaning in the landscape. When data regarding flowering sequence was quantified it revealed patterns that could not be identified in a visual interpretation of plant community behaviour.

Arguments for conservation of plant communities often hinge on a perception of their economic worth, for example as pasture. Visual and ecological criteria simply do not carry the same weight as quantified economic arguments do. The overview which SHARRA can provide on plant use facilitates an economic argument by revealing potential qualities that are not obvious. Information on the quantitative analysis, representing months of work, was reworked in 14 minutes to reveal, for example, that for tallgrass species on file

- 47% are noteworthy as food for wildlife
- 27% are tea/coffee substitutes
- 20% are dye material
- 43% have a documented use in native herbal medicine.

Couple this qualitative information with quantitative measurement of plant cover and there is a basis for a much broader interpretation of the economic worth of the plant community.

The multiplicity of uses that apply to individual species indicates that the potential overall worth of the community cannot be accurately represented in a measure of its worth as pasture.

Cause-effect relationships, in plant records, provide information useful in interpreting change. It is possible to predict the plant community's response

a) over time,

b) to different soil-moisture conditions, including drought,

c) to changes in habitat,

d) under the influence of grazing.

Choosing species for the berm at St. James was an example of anticipating the plant community's response to a changed environment so as to arrive at a fitting plant list.

SHARRA very quickly becomes a part of the background as the user discovers the ease with which information can be retrieved or reworked. The information in the files has already been structured so that it is amenable to reworking. Lists of species become the focus of the interpreter's attention. The result of this is that the user gets caught up in exploring relationships, devoting more time to the problem and less to the process of sorting information. Since the criteria offer a number of alternative routes to the solution of a problem, alternative solutions are more likely to be produced. It took only 10 seconds to get a list of herbal, prairie species that were available as plants as an alternative to those available as seed. The manual procedure for plant selection was so cumbersome that no alternatives were produced and the information which was the basis for decisions was not checked. Cross-checking information in the machine is easily done by viewing the plant/criteria chart or the individual plant record. These operations take no more than 60 seconds.

The results from a comparison of the two methodologies are quite staggering. Take the simplest of problems, the selection of a species for a herbal garden. In the manual method of collecting and sorting data, information (30 species x 2 criteria, prairie and herbal) represents about 6.5% of the relevant information now stored on file. The procedure took 32 hours. The machine checked out 100% of the species on file for a slightly more complex problem (186 species x 5 criteria) and took 65 seconds to provide all the required results. As the problems become more difficult the advantages of the machine become more apparent to the user. The manual procedure for selecting berm species required 48 hours compared with 150 seconds by machine.

The accuracy of the results depends on the accuracy of the information in the file. Because the data on file is so accessible it is <u>easy to check</u> and, if necessary, change. Over time the quality of stored data may be improved. For the present program the information on a punched card file would have to be changed, but future development could incorporate an editing program into the system. Updating of the punched cards is more likely to happen than updating of information stored in a library of books or a card-index file because use of the machine is more rewarding.

One other advantage of the machine is that by adding or dropping individual criteria, one at a time, from the selection offered in the checklist, the user can see from the lists of species which criteria most limit the selection of species. In choosing species for the berm, the lists of plants dropped from an average of 27 species to an average of 3 when WOOD EDGE was added. The user could conclude that the number of species occupying both prairie and wood edge was limited, review, and if desired revise the selection of criteria. This type of instant feedback helps develop the interpreter's feel for the problem, complementing and improving the thought process.

In summary, the advantages of using the computer are:

1) The user can devote more time to the problem and less to the mundane and tedious process of sorting information.

2) The process of collecting and analysing data is foreshortened. The existing files represent about 6 months of work which does not have to be repeated. Collecting and filing information took about half of this time. The other half went into identifying useful criteria.

3) The machine provides quantified information which is likely to improve in quality over time because of ease of checking. The file can readily be updated and corrected.

4) The machine-aided procedure complements and improves the interpreter's thought process by making it easy to cross-check information, speculate on alternatives, and develop a "feel" for the problem. It also includes a checklist of of proven criteria.

5.2 Application to Interpretation

Everyone who repeatedly faces problems in understanding, using or managing tallgrass prairie has a potential application for the existing program and its associated files. Practical applications for interpretation include:

1) Planners requiring an "environmental benchmark" for a region that has naturally recurring tallgrass prairie,

2) Organisations concerned with interpretation of eco-systems and their management, e.g. Parks Canada, who use the plant community as resource material to explain the workings of nature,

3) Landscape architects and planners concerned with retaining naturally recurring segments of a regional landscape which require a minimum of energy expended on management and which give an area its own unique identity,

4) Educational establishments, universities and high schools,

5) Various special interest groups, concerned with a single use, would undoubtedly find the program of use, but only

occasionally:

- farmers managing prairie as rangeland,
- wildlife managers conserving prairie as a means of conserving related wildlife,
- researchers into uses for plant species, e.g. as medicine.

5.3 Implications for Interpretation

The implications for interpretation are tremendously important and exciting. What the study shows, without question, is that a change in methodology can have a tremendous impact on our ability to better manage and interpret information on the environment. Future studies, following a similar approach, could expand on the plant inventory for other ecosystems or clearly definable working contexts. Imagine the benefits of having structured information that is readily accessible and easily stored, perhaps as cassettes or discs. They would be invaluable in providing quick but specific answers on the consequences of proposed development. This is especially true for the fragile environments of northern Canada. At a time when the costs of environmental impact assessments are seen as prohibitive, computer-aids provide an alternative means of addressing the general problem of interpretation. Nothing in the study suggests that the costs of developing this alternative approach would be high. Expensive hardware is not necessary. The total memory requirements of the program (45,000 bytes approximately) show that, with some modification, it could be handled by a minicomputer of modest cost, about $3,000.00 (1981). The estimated cost for 1/2 a man year, developing the program was $7,000.00. Were it developed by retailers of software, easily affordable packages of programs could be produced. The possible cost could be below $50.00 for a disc that fits with existing hardware (e.g. Apple).

An alternative to developing a series of discs or cassettes would be to build on the existing program structure. A larger institution, such as a university, could offer a range of programs and a data bank of files on a time-sharing basis. Programs would still be individually tailoured for specific ecosystems (Aspen Parkland, Coniferous Forest, Boreal Forest, Tundra etc.) or definable working contexts (Land Reclamation, Nurseries, Botanical Gardens etc.). Each program with its associated file would constitute what Edward T. Hall (1976) refers to as "high context integrative systems of thought".

5.4 Potential Development

In the future, other levels could be added to the existing structure. As well as presenting information derived from the plant resource, levels could be developed which would address interpretative problems from the point of view of wildlife. There is also considerable scope for developing more procedural programs to make more use of files; for example, a question-answer test on the merits of plant species with the computer keeping track of the user's score.

The front-end developmental work has been completed through this study and reveals tremendous potential for the future. What is needed now is the contribution of those specialists who could further refine a machine-aided approach to interpretation. A computer data expert, for example, could reduce the present memory requirements for the files considerably.

The problem of development is primarily an organisational one, since there are no obvious associated high costs involved. Because the program can be developed in small, incremental stages, it might be a task that a university or government agency would want to undertake. In a university setting departmental coursework could be usefully channelled towards development of the program system. Students of computer programming could develop operational procedures, while students frequently concerned with collecting information on plant species could define problems and working contexts and provide plant files. The benefit to students would be the stimulus they receive from being a part of a project that has very obvious applications to real life problems.

5.5 Recommendations

Recommendations are concerned with the potential opportunity for further development of the study, as discrete "packages of thought" for commercial sale or as a library resource. Potential sources of funding and/or labour should be made aware of the study's existence and potential. Feasibility studies for both alternatives might be initiated by contacting retailers of software for minicomputers, environmentally concerned organisations (e.g. The Sierra Club), and educational establishments which may be interested in development of an alternative methodology for interpretation.

5.6 General Conclusions on the Study

Two specific problems were addressed in the study. The first was that of selecting appropriate criteria for a plant file which would be of value in interpretation. The first and second study objectives relate to this problem.

By choosing an ecosystem as the context for the storage of information, the boundaries of the problem of interpretation were immediately narrowed to a recognisable and manageable entity that is of interest to a range of user groups. The plant record becomes more than an arbitrary collection of pieces of unrelated information. It is structured according to a plant's relationship with other orders and so establishes connections -- patterns in nature -- which is what the interpreter most wants to identify. By reviewing alternative outlooks, information on plant species was identified that provides a general overview which is resource-based, not derived from one cultural standpoint.

The second objective, once having established appropriate criteria, was to compile a file large enough to be of some practical value in testing a computer-aided approach to interpretation. The file on plant species (Appendix 2) is comprehensive, covering all of the Living Prairie Museum's plant resources, including tallgrass prairie. The site was the subject of past study, when a manual method of managing information was used. Selecting the site's plant inventory as a basis for the file established the basis for testing alternative methodologies. The procedure in solving the same interpretative problems for the same site could legitimately be compared.

The second specific problem of the study was to replicate manual operations and test the machine-aided procedure for managing information against the manual approach. The third, fourth and fifth study objectives relate to this problem.

The study's third objective was to write programs replicating the manual operations (Appendix 3). LIST1 provides an inventory and plant/criteria chart. SORT1 allows the user to specify a plant name (genus) and see its record displayed, and SORT2 lets the user specify any combination of performance standards, from a checklist, and receive a list of complying plants (Appendix 3).

Testing the applicability of a computer-aided approach was the fourth objective. Results, manual and machine-aided, were compared for similar problems. More complex problems on interpreting plant phenology and preparing a quantitative analysis of the tallgrass prairie community were also addressed. The comparison of results was absolutely conclusive, showing not only that the machine is significantly faster, but also that its inbuilt procedure is more comprehensive in checking available data. The interpreter's skill in identifying problems and proposing solutions was not hampered by the use of the machine.

The process behind problem solving was actually enhanced, with more time being given over to the problem and preparation of solutions, and less time being spent on mundane procedures involved in reworking information.

The fifth, and last, objective of the study was to draw some conclusions from the comparison of methods regarding the feasibility of a computer-aided approach to interpretation and to comment on future developments. The study's implications are tremendously exciting. There are no apparent reasons why the benefits of a computer-aided approach cannot be realized. Hardware costs are low and affordable, even to a small office. Software costs are also minimal. A conclusion that can be drawn from the study is that it is entirely feasible that cassettes, discs or tape libraries offering information on ecosystems can be made available in the near future. The most likely developers of such an alternative methodology are seen to be universities, government agencies, or retailers of existing computer software. The approach used in this study to establishing relevant data for files could be a model for future development of aids to interpretation of other ecosystems.

How efficient the aids are is not simply a question of how good a program is. The critical issue lies in how well the problem can be defined and the context understood, and that is not generally the contribution of a programmer. Those people presently involved in solving environmental problems can, and should, contribute their expertise towards the development of better computer aids. Computer technology cannot make us better interpreters of information, but it can enhance the thought process by making information processing much less time-consuming and tedious. A computer-aided approach to interpretation is highly feasible, highly desirable, and inevitable.

APPENDIX 1

THE EXTENT, IMAGE & USE OF TALLGRASS PRAIRIE

LIST OF ILLUSTRATIONS

Page

1.1 A Native View

Tallgrass prairie used to extend from southern Manitoba to central Texas, cover 400,000 square miles, and support 80 species of mammals, 300 species of birds and thousands of kinds of insects and other animal life.[1] It was a part of the Mid-Continental Prairie which extended from Pennsylvania and Ohio to the Rocky Mountains and from southern Canada to the Gulf of Mexico -- the most extensive natural vegetation type on the North-American Continent. This Mid-Continental Prairie had many geographic variations and flourished under different climates. Its botanical components varied from place to place as did the indigenous wildlife, but it was characterised by the dominance of grasses and their relationship to the larger mammals -- bison, pronghorn antelope, deer and elk -- which influenced the appearance of vast landscapes by their grazing effects on the vegetation.

The principal grassland types are often identified according to their dominant grasses: tallgrass prairie, mixed-grass prairie and short-grass prairie (Fig. 1.1). The tallgrass predominated where rainfall was 35" or more annually but also extended along the bottomlands of streams and rivers into drier areas such as southern Manitoba (20" rainfall annually). Big Bluestem communities (Andropogon gerardi), the dominant tallgrass, occurred in the broad lowland valleys of the Red River, the Missouri, the Platte and the Arkansas. Slough or Cordgrass (Beckmannia syzigachne), a component of tallgrass prairie, occurred in the seasonally flooded areas, fires, whereas Bluestem communities, because of their many protected rhizomes in the top 4" of topsoil, are quick to recover and so establish a competitive advantage over other species.

> The prairie, lying at the south and southwest (of Minnesota), and reaching into the Red River Valley as far north as Lake Winnipeg, was (in 1880) abundant with tallgrasses and bore a great variety of flowers, including asters (Aster spp.), goldenrods (Solidago spp.), Blazing Stars (Liatris spp.), prairie clover (Petalostemum spp.), roses (Rosa spp.), lilies (Lilium spp.), phlox (Phlox spp.) and fringed gentian (Gentiana crinita).
>
> (Costello, The Prairie World, p52)

The original extent to true or tallgrass prairie in Manitoba is shown in Figure 1.2.

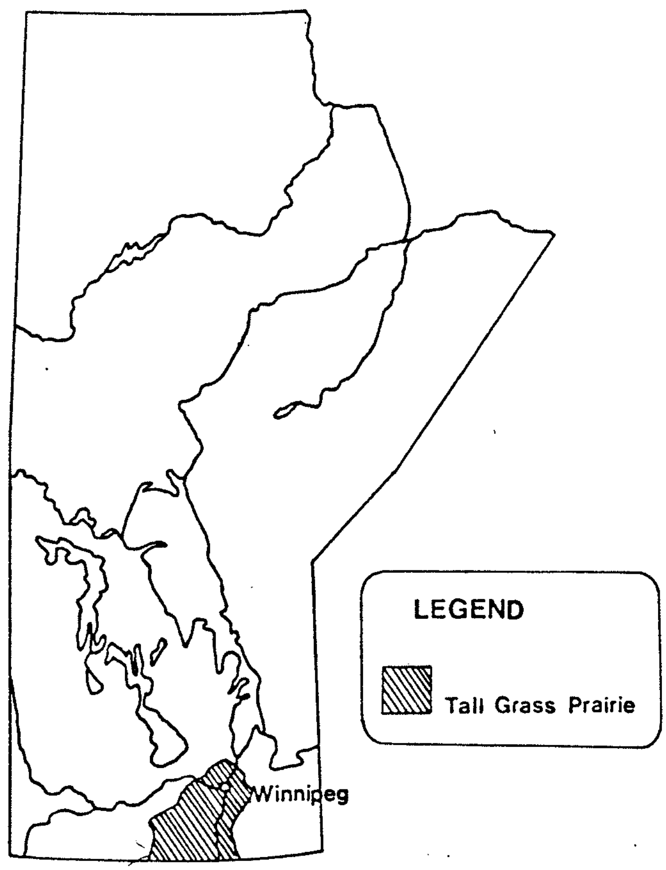


Fig. 1.2 The original extent of Manitoba's tallgrass prairie

The natural state of the prairie found by the first Europeans was influenced by the native people, who had come to the New World via the Bering land bridge about 20,000 years ago. For some 10,000 years or more they lived under various forms of simple interacting cultures which had a major role in the evolution of the tallgrass prairie community because of their use of fire in managing grassland areas and for hunting. Any scars on the land made by drought, flood, wind erosion, overgrazing by wildlife, set fires, and the extremes of heat or cold in summer and winter, made temporary wounds on the face of a vegetative system that was large enough and resilient enough to heal itself.

Archaeological diggings reveal that the majority of Indian cultures on the prairie were semi-agricultural with field crops of maize, corn and squash.[2] A Hidatsa village on the Knife River of North Dakota had, for example, a population estimated at 2500, living 20 to each earth dwelling. They grew crops in the floodplains of rivers and foraged from uncultivated plants that they classified as "vegetables," as well as trading crops for meat which the neighbouring hunting culture of the Dakota Sioux had in excess. These Indians sometimes lived lives of violence, insecurity and physical hardship but not of poverty since the bison and antelope were always available. Bison were estimated to number about 60 million, located primarily on the mixed prairie, while antelope were estimated at about 40 million.

The native people had a very general verbal model[3] with which they explained their surroundings, whether boreal forest or tallgrass prairie. Vegetation was seen as a part of a system which incorporated not just the plant life but all of their surroundings (THE FOUR ORDERS: Physical, Plant, Animal, Human). They saw life in its visible, material forms as something brief and transient and assumed that the qualities of personality that they recognised in themselves were common to all other things in the world. Every rock, plant, animal or man was regarded as an individual spirit with certain intrinsic powers or character traits. These powers, they believed, were constantly recycled to maintain a unity with and a balance within the material world. This was an idea as all-prevailing within Indian cultures as is our notion of progress.

All the parts of the system were seen as being on the one level.

> Any distinction between humans and animals -- particularly any notion that one is in some way superior to the other -- is blurred as a consequence of their belief that humans may be reincarnated in animal form.

Although they saw a cyclic exchange of powers in the world around them they regarded this as a short-term illusion, with the real world being the spirit world. They apparently did not feel the need to define the source of these powers but assumed that nature had always existed and that any source of powers was so remote and mysterious that it was better to communicate or worship through the spirits as intermediaries. Their main concern, during at least 350 years of documented forced migration, was maintenance of a balance with nature and survival as a central issue[4] (Fig. 1.3).

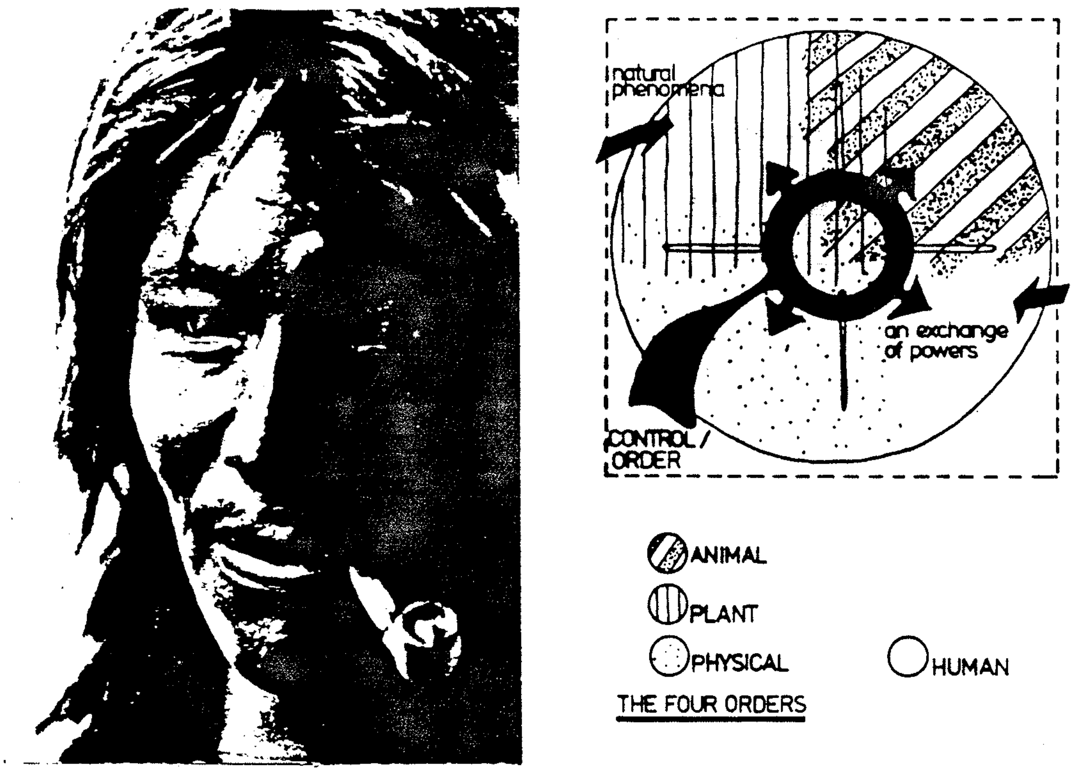


Fig. 1.3 A native view; the four orders

What information defined a working context for a Native People whose prime concern was that of survival? An Ojibwa interpretation provides some answers:

> There are FOUR ORDERS in creation. First is the PHYSICAL world; second, the PLANT world; third the ANIMAL; last the HUMAN world. All four parts are so intertwined that they make up life and our whole existence. With less than the four orders, life and being are incomplete and unintelligible. No one portion is self-sufficient or complete, rather each derives its meaning from and fulfills its function and purpose within the context of the whole creation. . . . While there is a natural predilection and instinct for conformity to the great laws of balance in the world of plants and animals, mankind is not so endowed by nature. . . . Before he can abide by the law, mankind must understand the framework of the ordinances. In this way, man will honour the order as was intended by Kitche Manitou (The Great Spirit or Mystery). (Johnston, Ojibway Heritage, p21)

In this holistic view, each of the orders was gifted with a spirit and certain powers (Fig. 1.4):

	ORDER	COMPONENTS	POWERS
THE FOUR ORDERS "A Whole Existence"	Physical	Rock/Earth Water Fire/Sun Wind	Growth/Healing Purity/Renewal Light/Heat Music/Life
	Plant	Flowers Grasses Trees Vegetables	Spirit of Life/ Growth/Healing/ Beauty/Harmony/ and Order
	Animals	Two leggeds Four leggeds Wingeds Swimmers	Character traits Curiosity, Courage, etc.
	Human "Cheejauk" Soul-spirit	Character Personality Soul Spirit Heart or Feeling A Life Principle	The ability to Dream - Conscious Thought

Fig. 1.4 Orders, spirits and powers

All of nature was personalized and had significant powers. When the "plant beings" were created they were of four categories: FLOWERS, GRASSES, TREES and VEGETABLES (both wild and cultivated edible species). The significant categories of information to the Native People were those that revealed the interaction of plant beings with the other orders as part of a holistic concept. In an 1850 history of the Ojibwa,[5] G. Copway describes the verbal traditions of his people regarding plant material:

> There is not a flower that buds, however small, that is not for some wise purpose.
>
> There is not a blade of grass, however insignificant, that the Indian does not require.
>
> Learning this, and acting in accordance with these truths, will work out your own good, and will please the Great Spirit.

(Copway, The Traditional History of the OJIBWAY NATION, p175)

What, then, were the uses associated with plants and their relationship to the four orders?

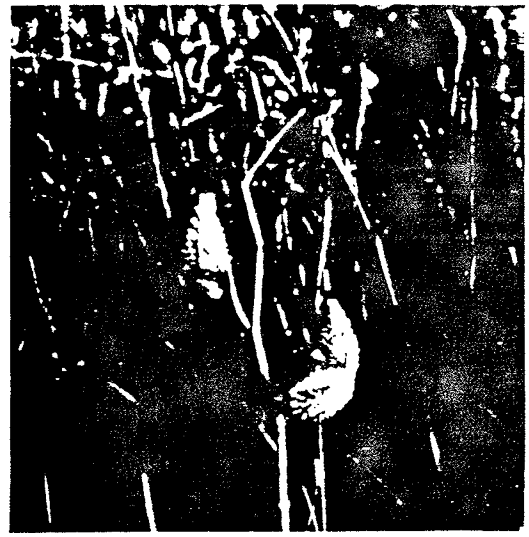
THE PLANT AND THE PHYSICAL ORDER

In the Physical Order -- the rhythms and cycles of the Sun, Stars, Earth and Moon -- the plant beings and their flowering were indicators of TIME of the year in a cyclic system. The Dakota Sioux referred to time in terms of the phases of the moon and seasonal events:

JANUARY	MOON OF FROST IN THE TEPEE
FEBRUARY	MOON OF THE DARK RED CALVES
MARCH	MOON OF THE SNOWBLIND
APRIL	MOON OF THE RED GRASS APPEARING
MAY	MOON WHEN THE PONIES SHED
JUNE	MOON OF MAKING FAT
JULY	MOON WHEN CHERRIES ARE RIPE
AUGUST	MOON WHEN CHERRIES TURN BLACK
SEPTEMBER	MOON WHEN THE PLUMS ARE SCARLET
OCTOBER	MOON OF THE CHANGING SEASON
NOVEMBER	MOON OF THE FALLING LEAVES
DECEMBER	MOON OF THE POPPING TREES

Sequences of growth, flowering and fruiting were attributed to the action of the SUN and EARTH, two of the most important components in the Physical Order. The availability of plants as "vegetables" meant that food gatherers were interested in the plant's SEASONAL ATTRIBUTES: edible flowers that were PERSISTENT (Yarrow, Achillea millefolium), i.e. in flower for more than two months of the year; EARLY GROWTH plants (Milkweed, Asclepias ovalifolia) because they often had roots that would be the first fresh vegetables of the year and were also most nutritious in early Spring; and those species that were of WINTER INTEREST (Smooth Rose, Rosa blanda as sources of dry berries.

PERSISTENT/YARROW



EARLY GROWTH/MILKWEED

WINTER INTEREST/SMOOTH ROSE

ROSE HIPS

THE PLANT WITHIN THE PLANT ORDER

Plants were seen to have VISUAL ATTRIBUTES important in their identification. "Nations" or genera were identified as sharing similar characteristics, e.g. of flower or leaf shape, but on a more general level PLANT TYPE (FLOWER, GRASS, TREE, VEGETABLE), COLOUR OF FLOWER, PLANT SIZE and FOLIAGE were important criteria for identification. Foliage contrasting with green, usually silvery/grey species, stands out from the overall framework of the grasses which visually often remain as a backcloth. A SHOWY FALL COLOUR (Trembling Aspen, *Populus tremuloides*) was interpreted in legend as a gift from the sun.

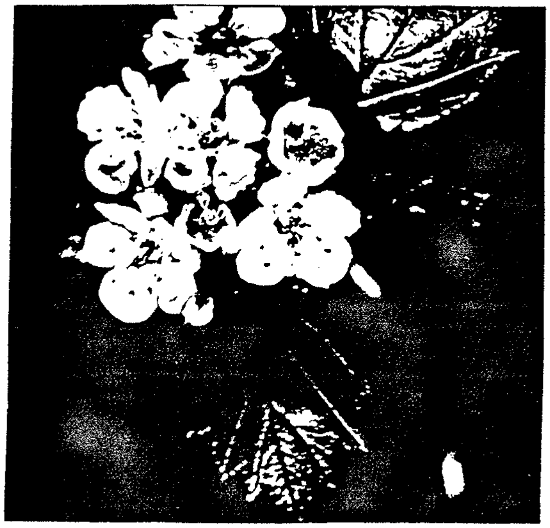
SHOWY FALL COLOUR/TREMBLING ASPEN

One of the useful NON-VISUAL CHARACTERISTICS was whether the plant was DEFENDED, i.e. possessing thorns, prickles or a skin irritant. They had many uses:[6]

In medicine (Common Nettle, *Urtica dioica*) to restore feeling to numb areas with poor circulation.

In sewing and weaving (Long-spined Hawthorn, *Crataegus succulenta*) with thorns that were used as sewing needles.

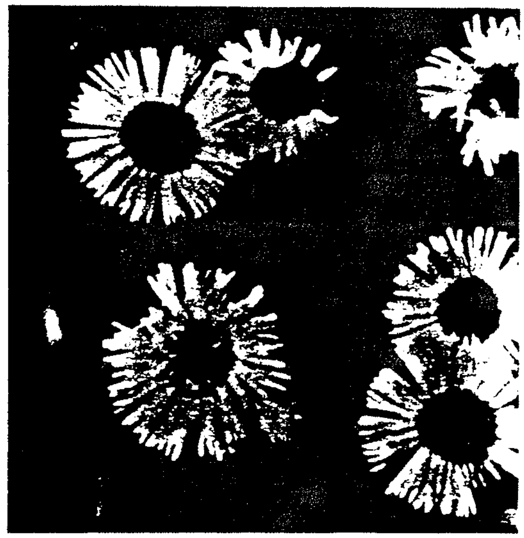
In warfare (Poison Ivy, Rhus radicans) which was thrown on fires upwind of enemy camps so that the irritant-carrying ash drifted into the camp.



DEFENDED/HAWTHORN

FIREPROOF plants (American Hazelnut, Corylus americana), i.e. those that burn only in intense burns, were important controlling edges to managed areas, such as campsites or hunting areas.

AROMATIC species, pleasant in themselves, were valued as fumigants hung in tepees or used in sweat lodges, and were used to scent clothes and/or as perfumes. Some were repellants (e.g. Daisy Fleabane, Erigeron strigosus, to repel fleas, or White Clover, Melilotus alba, to repel moths).



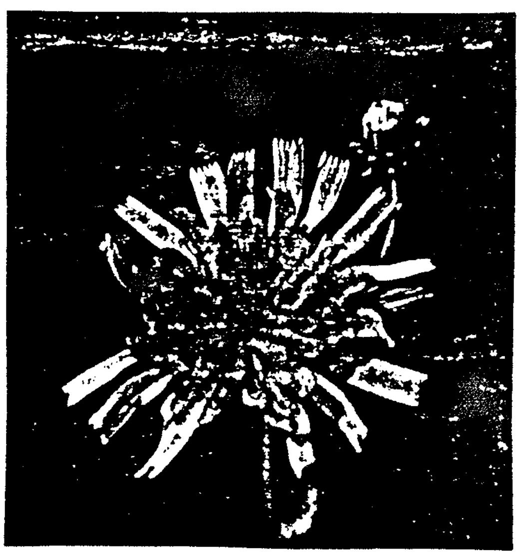
AROMATIC/DAISY FLEABANE

Each "plant being" was known to prefer a specific HABITAT and contribute towards its sense of place.

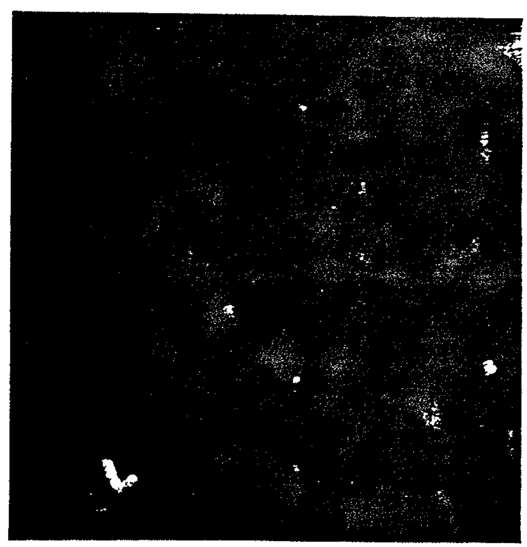
> Each valley or any other earth form--a meadow, a bay, a grove, a hill--possesses a mood which reflects the state of being of that place. Whatever the mood, happy, peaceful, turbulent, or melancholy, it is the tone of that soul-spirit. As proof, destroy or alter or remove a portion of the plant beings, and the mood and tone of that valley will not be what it was before.
>
> (Johnston, Ojibway Heritage, p43)

For the native people, the terms PRAIRIE and WOODLAND would be of limited use. The language of the Dakota Sioux, for example, was capable of being much more explicit. Their words for woodland also convey an idea as to how dense it is and how the trees are distributed.

AVAILABILITY of seed was important not only because they were eaten but also because some were sown close to camps. There is good reason to suppose that the diversity of some prairie species is a result of their having been selectively bred. Observation of plants and animals did much to explain the patterning of the prairie. The manner of DISPERSAL of seed contributed to the pattern. Caches of seed or nuts that animals buried might grow to be clumps of grasses or stands of oak trees. Three potential means of dispersal were by WIND (False Dandelion, Agoseris glauca), ANIMAL (Wild Licorice, Glycyrrhiza lepidota -- called "little jealous woman" by the Sioux because of its adhering burrs) or by BIRD (Wood Rose, Rosa woodsii, which cannot germinate naturally until it has passed through a bird's digestive tract). If there were VEGETATIVE REPRODUCTION then the repeated occurrence of the plant was predictable for future foraging.



WIND DISPERSAL/FALSE DANDELION

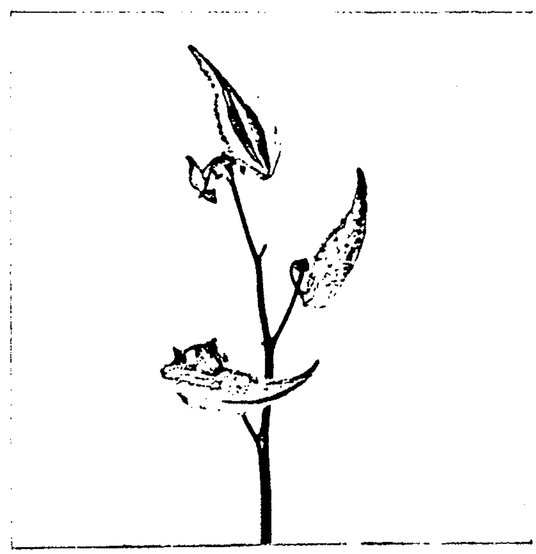


ANIMAL DISPERSAL/WILD LICORICE

THE PLANT AND THE ANIMAL ORDER

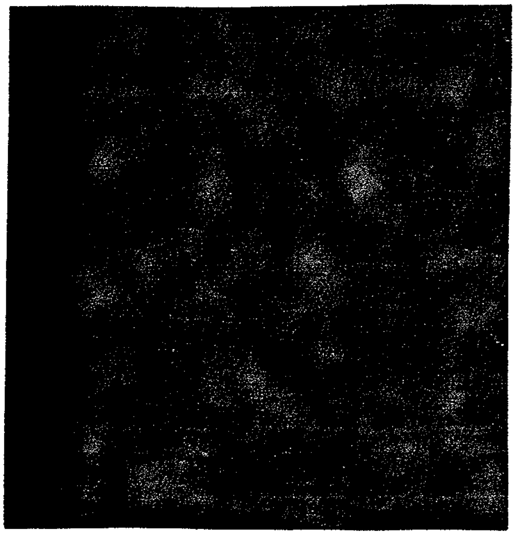
Much was learned from observation of animals. Sick animals would search out species with curative powers. One legend tells of a frog using Jewel Weed, Impatiens spp., as a cure for poison ivy. Hungry animals would reveal edible plants, though not all plants eaten by animals are edible by man. The woodpecker is supposed to have discovered the secret of maple sap as a source of nutrition.

Some species have a particular WILDLIFE ASSOCIATION with merit as FOOD (Silverweed, Potentilla anserina -- a favourite of geese) or as a HOST SPECIES (Milkweed, Asclepias syriaca -- host for the monarch butterfly).



HOST SPECIES/MILKWEED

Of particular significance was the prairie's value as PASTURE, and not just because of the grasses (Buffalo Grass, Buchloe dactyloides, as a major part of the bison's diet). Other species healed bare areas (Common Sunflower, Helianthus annus) and/or fixed nitrogen in the soil (American Vetch, Vicia americana).

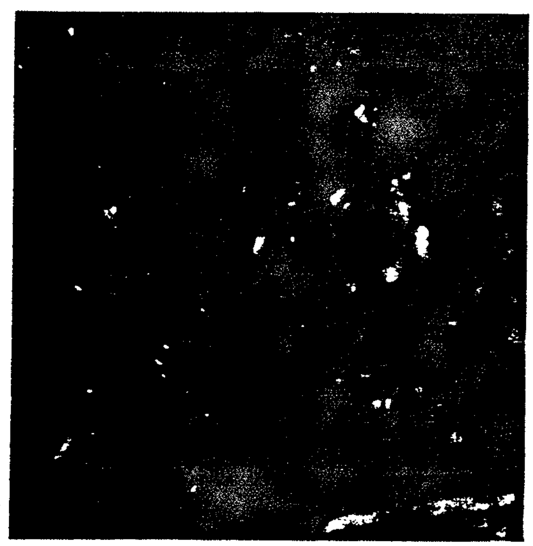


PASTURE/CROP/SUNFLOWER

PASTURE/AMERICAN VETCH

(There were plants singled out as CROPS, Helianthus annus, which yielded edible seed as well as oil used for the hair.)

Certain species were POISONOUS or AVOIDED by domesticated stock -- Locoweed (Oxytropis splendens), affecting horses and cattle, and Goldenrods (Solidago spp.), being poisonous to sheep. Observation of cattle would also show that they browse on trees and shrubs, though the native people could not know that they are a source of many vital minerals not available elsewhere.

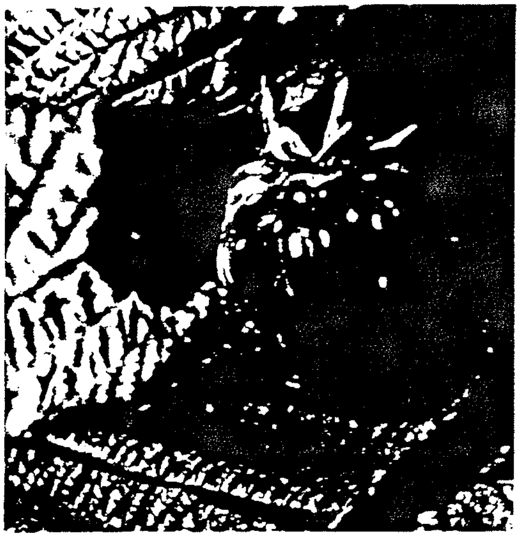


POISONOUS/AVOIDED/GOLDENRODS

THE PLANT AND THE HUMAN ORDER

It is in the Human Order that the "vital link" is clearly seen. Whereas we have many middlemen for growing, collecting, distributing and selling plant material as medicines and food, an Indian's knowledge of these attributes was first-hand. He could not fail to see the use of tallgrass prairie. Charlotte Erichsen-Brown has done a wonderful job of documenting first-hand accounts of plant uses and she reminds us of an agricultural heritage that is not often portrayed as a part of the Indians' use of prairie. She refers here to the Ojibwa who farmed in Ontario's southern forests and moved onto the prairie as hunters of bison in the mid-1700's, but the same could be said of the Mandan, Hidatsa or Arikara of North Dakota, who farmed on the prairie.[7] They had

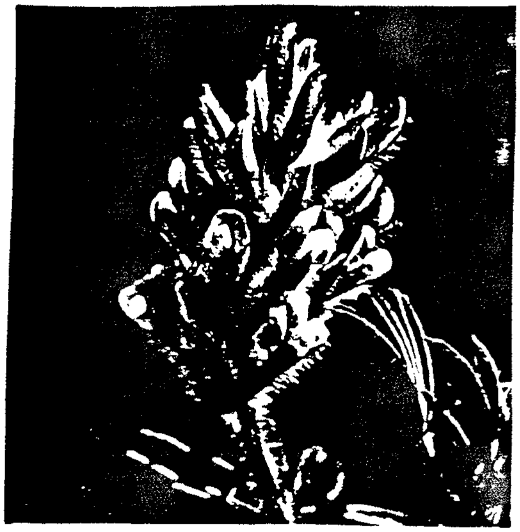
> . . . a sophisticated agriculture and a net-work of trade routes. They had brought corn to its northern limit of development by carrying north with them the seeds of frost resistant plants. They had planted the good edible nut trees near their fields for easy harvest, again bringing some of these trees to their northern limits by choosing the nuts from late budding trees for planting. They spread the native apples. . . . There is some question as to whether they knew how to graft as well. They soaked their corn seed in a decoction of plants before sowing it to protect it from slugs and birds. They sprouted their pumpkin seeds in their houses, near their fires, ready to plant out as soon as danger of frost had passed. They semi-cultivated the raspberry (Rubus spp.), two kinds of strawberry (Fragaria spp.), grapes (Vitis spp.), juneberries (Amelanchier spp.), milkweeds (Asclepias spp.) and the citron or May apple (Pyrus spp.) for its delicious yellow fruit. . . . They burned the climax forests around them to make clearings of sixty acres or more in which to plant their corn and to encourage growth of those plants they semi-cultivated for medicine, fiber and food.
>
> (Erichsen-Brown, Use of Plants, pvii)



CULTIVAR/RASPBERRY

CULTIVAR/STRAWBERRY

Plants as FOOD (Prairie Turnip, *Psoralea esculenta*) or giving a beverage were readily available from within the uncultivated plant community[8] -- plants as VEGETABLE OR POTHERB (Fireweed, *Epilobium augustifolium*), those with EDIBLE PARTS (Canada Thistle, *Cirsium arvense*), those that can be EATEN RAW (Wild Bergamot, *Monarda fistulosa*), those that are TEA/COFFEE SUBSTITUTES (Pineappleweed, Chamomile, *Matricaria matricarioides*) and, of course, some that were avoided, being POISONOUS TO MAN. (Horsetails, *Equisetum spp*., are said to be poisonous to Whites but not to Indians. Baneberry, *Actaea rubra*, is poisonous to both.) Some species are dangerous if taken in large amounts (e.g. the milkweeds), therefore they were used with caution.



FOOD/PRAIRIE TURNIP

VEGETABLE/POTHERB/FIREWEED

Other uses to man are many. Under the category heading of USEFUL we should consider species that are:

- Cooking Utensils (Manitoba Maple, Acer negundo, for dishes and spoons with no wood taste)
- Weapons (Saskatoon, Amelanchier alnifolia, for arrow shafts)
- Games/toys (Grasses, folded and tied as children's dolls)
- Scents/soaps (Tall Meadowrue, Thalictrum dasycarpum, seeds carried as perfume and used in washing)
- Oils (Sunflower, Helianthus annus, for hair oil)
- Gums/glues (Milkweed, Asclepias syriaca, for chewing gum)
- Brushes (Needlegrass, Stipa spartea, grass stems in a bundle)
- Cladding for dwellings (Birch Bark, Betula papyrifera, sewn together with spruce roots and used in tepees)
- Prayer offerings (Asters, Aster laevis, burned or smoked)
- Storage utensils (Birch Bark, used for containers)
- Smoking material (Dogwood, Cornus stolonifera, for inner bark)

- Bait for wildlife (New England Aster, Aster novae-angliae, smoked in pipe to attract game)
- Absorbents (Wood Moss, Dicranum bonjeanii, is mildly anti-septic and used as diapers or to dress wounds)
- Needles/lances/hooks (Hawthorn, Crataegus succulenta, as hooks to catch birds)
- Torches (Bullrushes, Scirpus spp., after pith has been saturated with animal fat)
- Structural supports (Aspen, Populus tremuloides, for tepee poles)
- Insulation (Northern Bedstraw, Galium septentrionale, bales used in winter tepee)
- Charms (Dogbane, Apocynum androsaemifolium, root chewed to counteract evil charms)
- Cordage/fiber (Canada Thistle, Cirsium arvense, for fishing line).

Some plants also have merit because they are used in WEAVING/SEWING of baskets, mats etc. (Burdock, Arctium minus, used for fiber), or to give coloured DYES (Trembling Aspen leaves give a yellow dye).

In using plants as MEDICINE, there is great potential merit in looking at native herbal cures, which were at least comparable with herbal medicine as it was practiced in Europe at the time of contact with the native culture.[9] There are numerous accounts of documented cures and many of our modern day medicines had their origin as native remedies. Salicin contained in Aspirin was discovered in the inner bark of willow, which was chewed to cure a headache. The potential for further research in this direction is phenomenal. Frances Densmore categorized the medicinal uses to which the people of the White Earth reserve, Minnesota, put plant material,[10] (Fig. 1.5):

HEADINGS FOR MEDICINAL USE.

NERVOUS SYSTEM
- CONVULSIONS
- HEADACHE
- CRAZINESS

CIRCULATORY SYSTEM
- HEART TROUBLE
- IN THE BLOOD

RESPIRATORY SYSTEM
- COLDS
- COUGH
- LUNG TROUBLE
- HEMORRHAGE FROM LUNGS

DIGESTIVE SYSTEM
- SORE MOUTH
- TOOTHACHE
- SORE THROAT
- INDIGESTION
- PAIN IN STOMACH
- COLIC
- CRAMPS
- DYSENTRY
- PHYSIC (USE OF)
- EMETICS (USE OF)
- WORMS
- CHOLERA INFANTUM

URINARY SYSTEM
- KIDNEY TROUBLE
- STOPPAGE OF URINE
- GRAVEL

SKIN
- INFLAMATION
- BOILS
- SORES
- ERUPTIONS
- WARTS
- HAIR RESTORER

WOUNDS
- INCISED
- INTERNAL
- SNAKE BITE

FOR SNAKE REPELLENT
- BRUISES
- BURNS
- ULCERS
- FEVERS
- SCROFULA
- NOSE BLEED
- HEMORRHAGES
- WOMEN"S FRAILTY
  - MENSTRUATION
  - CHILDBIRTH
  - CONTRACEPTIVE
- SORE EYES
- CATARACT
- STY

EAR TROUBLE
RHEUMATISM
SPRAINS
BATHS
TONICS AND STIMULANTS
ENEMAS
BILIOUSNESS
DIABETES
FRACTURE
SWELLING
DISINFECTANT
HORSE TONICS

Fig. 1.5 Medicinal uses for plant material

Some prairie plant material is a part of WESTERN MEDICINE and its herbal tradition (Yarrow, Achillea millefolium). Three categories can be included in the plant record to illustrate this future potential. They are those which are DIURETIC or LAXATIVE (Seneca Snakeroot, Polygala senega), EMETIC (Nodding Trillium, Trillium cernuum), taken to induce vomiting, and those that have special merit as TONICS or VITAMIN SOURCES (Prairie Rose, Rosa arkansana, which has 15 times more vitamin C than orange juice).

There is a chance that native herbal practices were influenced by a European source, since the Vikings occupied villages on what is now Newfoundland from 1004 A.D. to 1404 A.D.

Native herbal medicine may be a branch of a continuing tradition that is known to extend back 60,000 years to Neanderthal Man.

From this review of native uses of tallgrass prairie and its closely associated oak/aspen woodlands, certain categories of information emerge as significant criteria (Fig. 1.6).

The main reason we see things differently from the native people may be because we rely heavily on the classification of things as objects, not as individual spirits.[11] Plants to us are shade tolerant, native, evergreen, crops, weeds etc. The native outlook was to see things as subjects which were essential to his well-being. Since only knowledge that could be stored in the mind could be passed on, there were practical limits to the number of mental lists that could be stored. Our literary heritage has enabled us to establish labels/classifications as a way of concentrating our energies and enquiring into the nature of the world, but it is now a less personal world -- a world of objects. This outlook is well illustrated in a study by Frances Densmore. She as an anthropologist had to collect information on the use of plants and assign it to headings such as their use as medicine, as charms, in art or as food. However, that was not the way her informants recalled the information; they brought individual species and identified their use. She states:

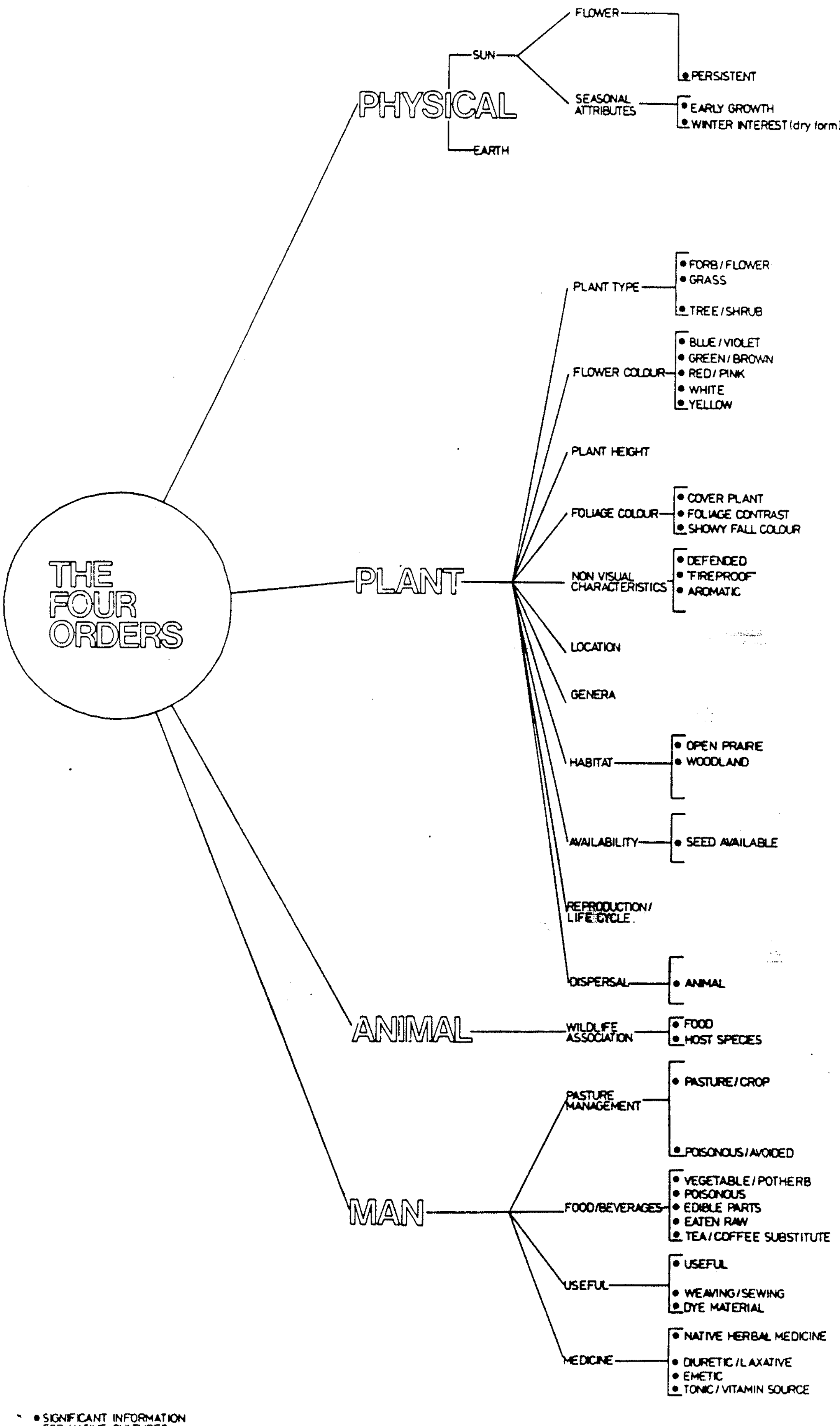
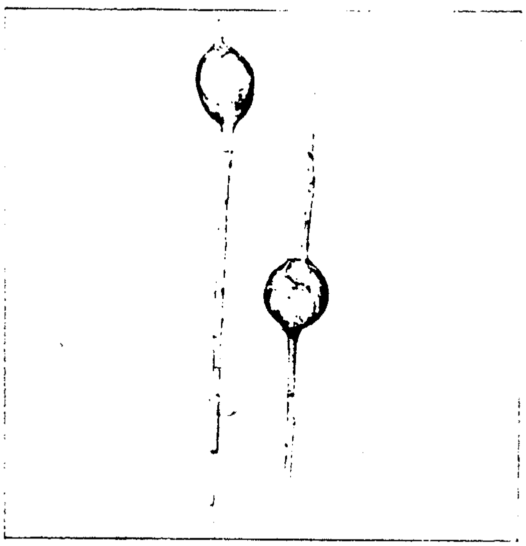


Fig. 1.6 Significant information for native cultures.

There are also some Indian names for plants that reveal relationships.[12] Goldenrods (Solidago spp.) are called by the Dakota Sioux "Lumpy Stem," which is thought to be a reference to the insect galls that frequently occur in the plant since it is a host species. The same plant illustrates how Indian tribes were attuned to the seasons by floral events. The Omaha planted their corn when the plum trees blossomed; they returned from the summer buffalo hunt to harvest their corn when the goldenrods bloomed.



GOLDENRODS - "LUMPY STEM"

Our plant names have become labels for identification. Potential usage and sometimes even identifying characteristics are made more obscure with more reliance being placed on taxonometric keys (Fig. 1.7). Folk taxonomies communicate more about plants for a general context.

Here we have our dilemma. At the moment our classification systems tend to store information on plants under headings that make sense only within narrowly defined contexts so that a holistic view of the merits of plant material is obscured. As Hall puts it:

> Where do we go for the overview? Who is putting things together? Who are the experts in the <u>high context integrative systems</u>? Who knows how to make the type of observations necessary to build integrative systems of thought that will tell us where we stand?

What we may need is a blend between western thought and that of the native people, for a working context that is derived from nature.

NATIVE NAME	A´djidamo´wano
MEANING	"Squirrel tail" (Specific appearance of the leaf.)
COMMON NAME	Yarrow
MEANING	From Old English "Gearwe," meaning "The Healing Plant." (Specific reference to its use as a herbal medicine.)
PROPER NAME	<u>Achillea millefolium</u>
MEANING	Resembling Yarrow or Milfoil and bearing a thousand leaves. (General description.)
NATIVE NAME	Mûckodé cigagá wûnj
MEANING	"Prairie skunk plant" (Specific reference to its smell.)
COMMON NAME	Wild Onion
MEANING	From Anglo-Norman "Union" meaning "Pearl, unique in size and quantity." (Specific appearance of the bulb.)
PROPER NAME	<u>Allium stellatum</u>
MEANING	Garlik-like with star-shaped flowers. (General appearance when in flower.)

Fig. 1.7 A changing context for nomenclature

REFERENCES TO RELATED READING ON

"A NATIVE VIEW"

1. David F. Costello, The Prairie World--Plants and Animals of the Grassland Sea (New York: Thomas Y. Crowell Co., 1975.

2. Peter Farb, Man's Rise to Civilization--The Cultural Accent of the Indians of North America (New York: Bantam Books Inc., 1978).

3. John G. Neihardt, Black Elk Speaks--Being the Life Story of a Holy Man of the Oglala Sioux (New York: Pocket Books, 1975).

   T. C. McLuhan, Touch the Earth--A Self-Portrait of Indian Existence (New York: Promontory Press, 1971).

   Basil Johnston, Ojibway Heritage--The Ceremonies, Rituals, Songs, Dances, Prayers and Legends of the Ojibway (Toronto: McClelland and Stewart, 1979).

   David G. Mandelbaum, The Plains Cree--An Ethnographic, Historical, and Comparative Study (Regina: Canadian Plains Research Center, 1979).

   Adolf Hungry Wolf, My Cree People--Told by Fine Day (Invermere, B.C.: Good Medicine Books, 1973.

   Edward Ahenakew (ed. Ruth M. Buck), Voices of the Plains Cree (Toronto: McClelland and Stewart, 1973).

4. Diamond Jenness, Indians of Canada (Ottawa: University of Toronto Press, 1977).

   John Price, Indians of Canada--Cultural Dynamics (Scarborough: Prentice-Hall, 1979).

5. G. Copway, The Traditional History and Characteristic Sketches of the Ojibway Nation, 1850 (Toronto: Facsimile edition by Coles Publishing Co., 1972).

6. Charlotte Erichsen-Brown, Use of Plants - for the past 500 years (Toronto: Breezy Creeks Press, 1979).

7. Dr. W. R. Leslie, "Indian Gardening," The Prairie Garden (, 1972), pp. 24-27.

8. Bernard Assiniwi, Survival in the Bush (Toronto: Copp Clark, 19).

9. Katherine Pettipas, "Ojibwa Pharmacopeoia," Manitoba Nature (Autumn, 1977), pp. 12-19.

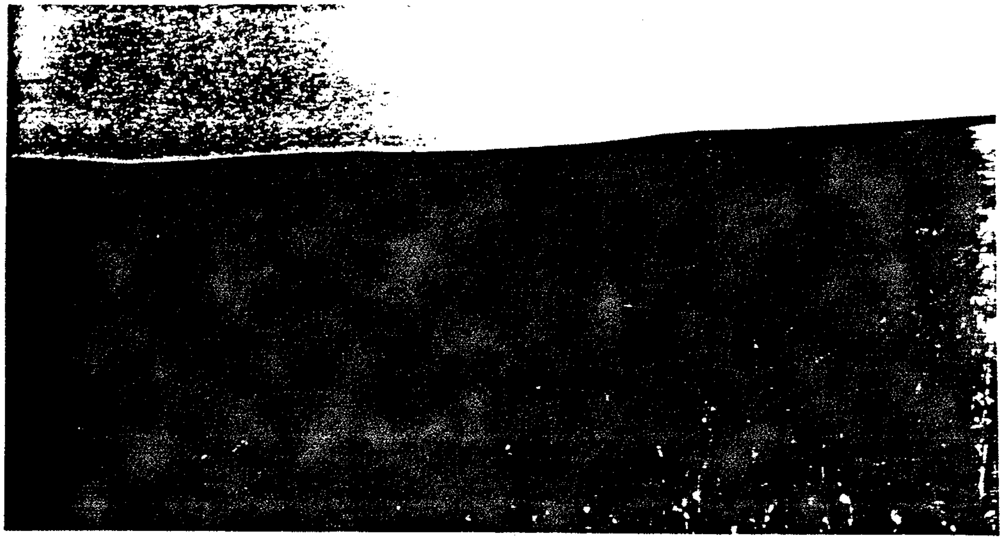
   Albert Burger, "Medicinal Plants--Food for Thought," Manitoba Nature (Spring, 1974), pp. 21-23.

10. Frances Densmore, How Indians Use Wild Plants for Food, Medicine and Crafts (New York: Dover Books, 19).

11. Edward T. Hall, Beyond Culture (New York: Anchor Press/ Doubleday, 1977).

12. Dilwyn J. Rogers, Lakota Names and Traditional Uses of Plants by Sicangu (Brule) People in the Rosebud Area, South Dakota (St. Francis, S.D.: The Rosebud Educational Society, Inc., 1980).

1.2 An Immigrant View



The Cayler Prairie Botanical Reserve, Iowa.

The story of the impact of Europeans on tallgrass prairie is largely the story of a developing technological capability at a time when short term goals of survival were paramount and/or the ramifications of its use were not immediately clear. The black soil was a store of potential energy, an untapped resource, and prairie use was seen as being either use of the vegetation for grazing or use of the soil as cropland. When the technology did not exist that would allow the sod to be easily broken, only small areas were cultivated by the pioneers as vegetable and/or herbal gardens, from which some introduced species (e.g. Asparagus, Asparagus officinalis) escaped to become another component of tallgrass prairie. The wirelike mesh of roots close to the surface and the extent of the rooting systems, which can for individual species be 35 feet deep, initially made grazing a more feasible option than growing crops. Domestic cattle replaced the large mammals, but now the land was grazed intensively and, if poorly managed, had no time to recover from overgrazing. When wire fencing was introduced (after 1874) it became economically feasible to fence off larger and larger areas, as this was much cheaper than the foregoing practice of constructing wooden fences or planting hedges of prickly plant material (e.g. the Osage orange hedges of Illinois). Range land thus conflicted with the migratory movement of the large mammals, which were seen to be competing for grazing areas. The subsequent need to move large herds of Longhorn cattle to shipping points on the rapidly developing railroads was seen as a reason to extirpate other species (e.g. prairie dogs) that competed for forage and, by burrowing, created hazards for travellers on horseback.

Needless to say, the removal of one species impacted on entire food chains so that balances within animal communities were altered. For example, the black-footed ferret's range decreased as its main source of food, the prairie dog, was reduced in numbers. The larger predators (the wolf, prairie grizzly bear, coyote, fox, red-tailed hawk etc.) were exterminated where possible. The relationship between these animals and tallgrass prairie vegetation was initially obscure. As the natural predators for relatively harmless species were removed, their numbers increased to the point where they constituted a threat, such as the 1880 infestation of locusts in the Red River Valley, Minnesota. Entire vegetative systems were reshaped.[1] The impact of deer browsing in the woodland areas increased greatly, as the wolf was removed, so that their favoured plant foods were virtually removed. Starvation among deer became the factor which maintained a balance in population. By removing the burrowing animals associated with tallgrass prairie (e.g. gophers), the means whereby the topsoil was turned over and aerated was removed. Disturbed areas where the prairie annuals survive and initiate recolonization were reduced, thereby reducing species diversity and the ability of the plant community to self-heal. Removal of wildlife also meant removal of the source of organic wastes and its means of distribution and recycling into the rich black soil. By 1830 bison herds east of the Mississippi had been destroyed and the systematic reduction of the remaining north and south Plains herds had begun. By 1900 there were 300 wild bison remaining. The Pronghorn Antelope was also nearly destroyed. In 1800 they had numbered about 30-40 million; by 1875 their numbers had decreased to 15,000.

The destruction of the prairie ecosystem and its vegetation was hastened by improvements in farming technology: the introduction of the steel plow (1837); sulky plowing (about 1877) when the plowman rode on his plough; the introduction of extensive drainage systems; the arrival of steam tractors; and, today, the application of intensive farming techniques that sometimes kill off the micro-organisms in the soil. The tallgrass prairie was almost totally destroyed before there was any serious attempt to understand what it was or how it came to be.[2]

George Catlin, the artist, recommended in 1842 that the entire plains area be set aside in southern Canada for the use of the Plains Indians in maintaining their hunting lifestyle.[3] In 1850 G. Copway, the Christian Chief of the Ojibwa, tried to convince the U.S. President that he should set aside what now approximates to the State of Iowa as a reserve (Fig. 1.8). Both proposals were seen as being wasteful of good farmland and potentially dangerous since they would bring together large numbers of dispossessed Indians. At the time the issue was how best to deal with the native people. Very few people saw the retention of tallgrass prairie as a partial solution to the problem because the predominant cultural view was that the native people had little use for the land.

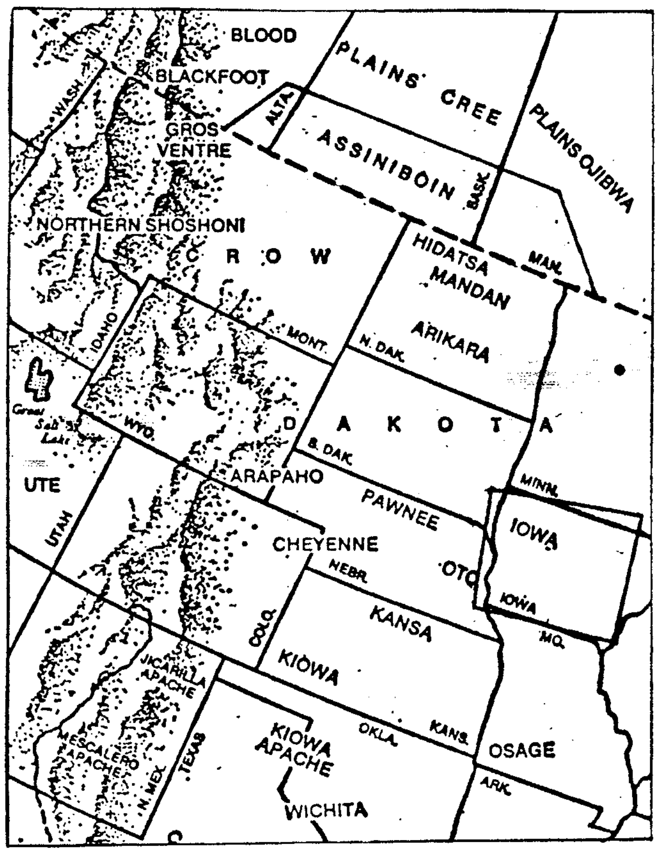


Fig. 1.8 Early proposals for reserves

Problems were dealt with as they occurred, as separate issues:

How to manage the native people?

How to manage the wildlife?

How to manage the vegetation?

How to manage the soil?

The view of the world that the immigrants had was deficient in recognising relationships.[4] There was an assumed linear hierarchy in a "Chain of Being," but relationships between the FOUR LEVELS OF BEING were poorly defined and most scientific enquiry was directed towards understanding one of the levels in isolation, e.g. the vegetation. Both a religious outlook and a scientific/evolutionary outlook promoted this view so that even the native people in the untypical late plains cultures adopted the European notion of a hierarchy of levels (Fig. 1.9).

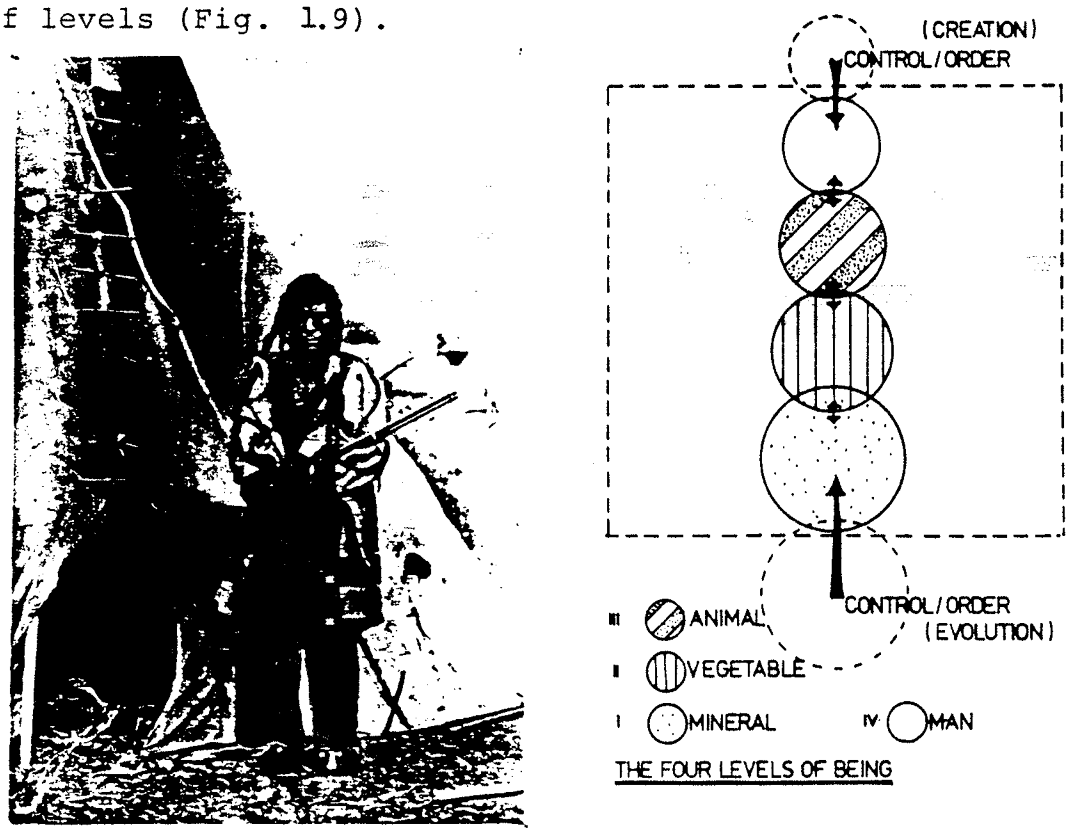


Fig. 1.9 Four levels of being

Biological records of the Prairie as the Europeans found it and recorded by early travellers (Narvarez and Cabenza de Vaca in 1528-36, De Soto in 1539-42, Coronada in 1540-42, La Verendrye and sons in 1742, and Lewis and Clark in 1804-1805) were generally poor because scientific knowledge was still in its infancy and the plants encountered were of undocumented families. The first complete accounts came from André Michaux, J. M. Peck (1834) and H. L. Ellsworth (1837). Most of the early botanists saw only the striking appearance of the prairie and ignored the Indian concept of the prairie as a supplier of food, clothing, medicine and shelter. Fortunately there were some noteworthy exceptions, e.g. Father Eugene Buechel's collection of plants as used on the Rosebud reserve (South Dakota) around 1920.

The idea of separate, self-contained levels of being promoted scientific thought of a specialist nature. Most of the criteria (flower type, leaf shape etc.) that were important to the dominant horticultural view were concerned with identification, classification and manipulation of often unfamiliar plant species. These criteria are important but because they were not derived in trying to solve a systems-related problem, they are not particularly useful for such a working context.

When survival is seen as a contest waged against nature, technological development (Science for Manipulation -- as in horticulture) is promoted as a necessary cultural extension of our powers. When survival is seen as a question of co-operation with nature, development of a symbiotic relationship, then Wisdom (Science for Understanding) is of paramount importance. The balance between the two shifts constantly. It is an ecological view that is more pertinent to understanding relationships between what the native people had defined as "the four orders."

REFERENCES TO RELATED READING ON

"AN IMMIGRANT VIEW"

1. May Theilgaard Watts, Reading the Landscape of America (New York: Collier Books, 1975), pp. 96-131.

2. Dennis Farney, "The Tallgrass Prairie: Can It Be Saved?" National Geographic (January, 1980), pp. 37-61.

3. Claude Mondor, "The Canadian Plains: The Vanishing Act," Nature Canada (June, 1976), pp. 32-39.

4. E. F. Schumacher, A Guide for the Perplexed (New York: Harper and Row, 1977).

1.3 An Ecological View

When ecologists turned their attention to the tall-grass prairie ecosystem, they established criteria relating to processes which supplement the native viewpoint. They are often the result of studying managerial problems, e.g. the consequences of drought or grazing.[1]

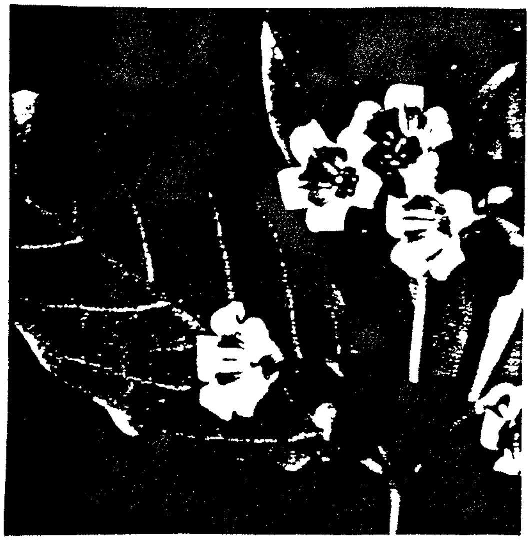
THE PLANT AND THE PHYSICAL ORDER

Flowering time can be plotted against monthly intervals that, in Manitoba, run from April to October. Examples of species that typify the sequence are:

APRIL	(Prairie Crocus, Anemone patens)
MAY	(Thimbleweed, Anemone canadensis)
JUNE	(White Prairie Clover, Petalostemum candidum)
JULY	(Clasping Leaved Dogbane, Apocynum sibiricum)
AUGUST	(Many Flowered Aster, Aster pansus)
SEPTEMBER	(Smooth Aster, Aster Laevis)
OCTOBER	(Stiff Goldenrod, Solidago rigida)

APRIL/PRAIRIE CROCUS

JUNE/WHITE PRAIRIE CLOVER

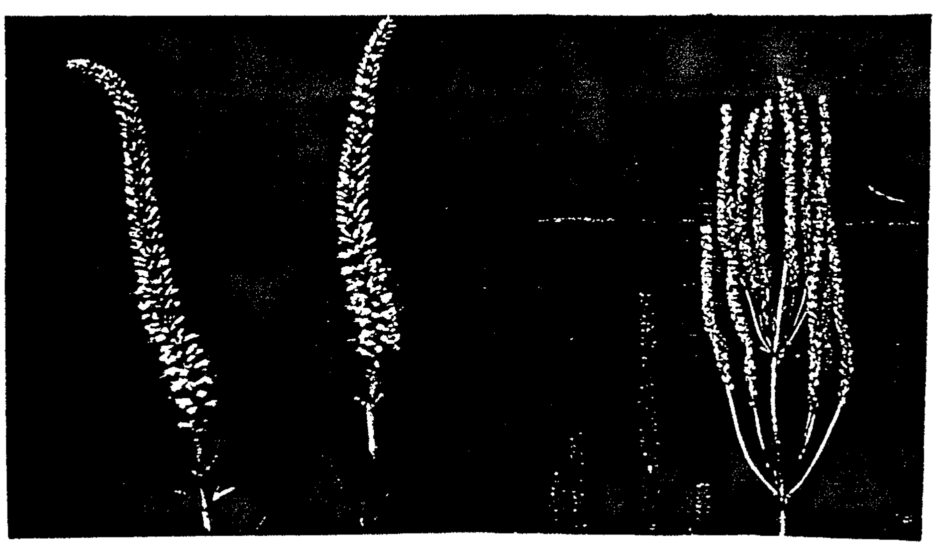


JULY/CLASPING LEAVED DOGBANE

OCTOBER/STIFF GOLDENROD

With observation of plant phenology, some relationships emerge. Flowering sequences and plant height appear to be related, with the smaller prairie species blooming early in the season and the larger species later. The changing seasons also appear to be characterized by different colours of flowers, with the single most mentioned relationship being the late predominance of yellow flowering species.

The process of lignification means that some species persist through the winter months as skeletal forms or DRY forms (Culver's Root, Veronicastrum virginicum), which are attractive in both their natural setting and as indoor arrangements.[2]



WINTER INTEREST/DRY FORM/CULVER'S ROOT

EARLY GROWTH, important to food-foragers, might also be important to the plant, giving it a competitive advantage over other species.

Probably the most important relationship is between the occurrence of plant species and the relative availability of soil moisture. Changes have been monitored in community composition over a period of seven years of drought. Mostly because of the type and depth of root systems, it is possible to anticipate which species are likely to thrive in soil conditions that range from wet to dry.[3] "Wet" implies a surplus of moisture; runoff from adjacent areas, e.g. at the bottom of gradients. "Dry" implies a net loss of moisture; runoff to other areas, e.g. at the ridges of gradients. A 4" difference in adjacent areas can change the plant material. This relationship is so pronounced for some species that they are referred to as "INDICATOR SPECIES." Some examples follow for forbs and grasses that occur at the St. James Prairie (Fig. 1.10).

Soil Moisture Regime	Indicator
	FORBS
DRY	Aster ptarmicoides
DRY/MESIC	Anemone cylindrica
MESIC	Solidago missouriensis
WET/MESIC	Fragaria virginiana
WET	Aster novae-angliae
	GRASSES
DRY	Andropogon scoparius
DRY/MESIC	Koeleria cristata
MESIC	-
WET/MESIC	Panicum leibergii
WET	-

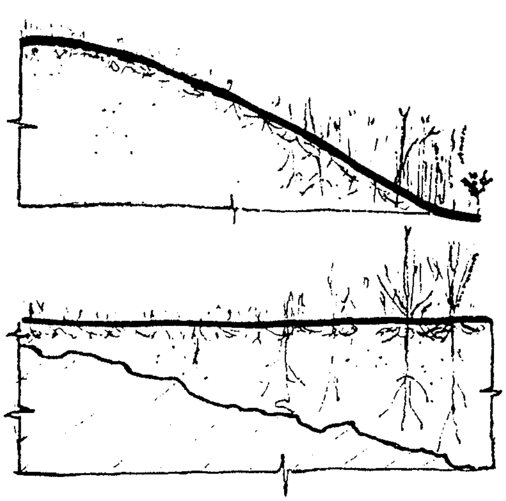
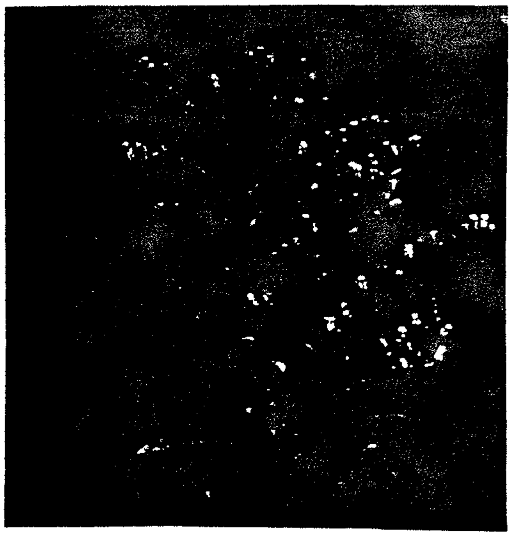


Fig. 1.10 Indicator species (soil moisture)



MESIC/LOW GOLDENROD

WET/NEW ENGLAND ASTER

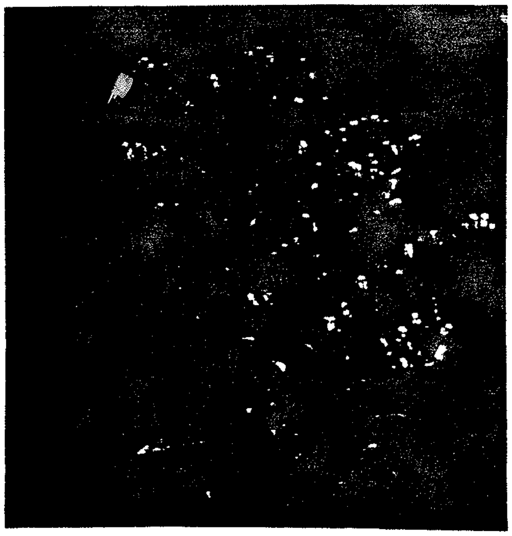
The flatness of the St. James site makes such relationships difficult to interpret, since there are not obvious gradients. More extreme slope conditions would make this relationship clearer. A pattern may well exist relating to soil moisture but having more to do with the depth to bedrock than the small gradients.

THE PLANT WITHIN THE PLANT ORDER

A useful category for PLANT TYPE is BUNCH GRASS (Little Bluestem, Andropogon scoparius), i.e. grasses having a root system adapted to dry conditions with roots near the surface that bind and stabilize the topsoil (Fig. 1.11).

SHRUBS (Wolfwillow, Silverberry, Eleagnus commutata) can be grouped with the category TREES, since our main concern is the prairie species. Where they occur represents a point of transition between true prairie and woodland.

Within the VISUAL ATTRIBUTES, HEIGHT is taken to be SMALL (< 9"), MEDIUM (< 36") and LARGE (> 36"), which was a



MESIC/LOW GOLDENROD

WET/NEW ENGLAND ASTER

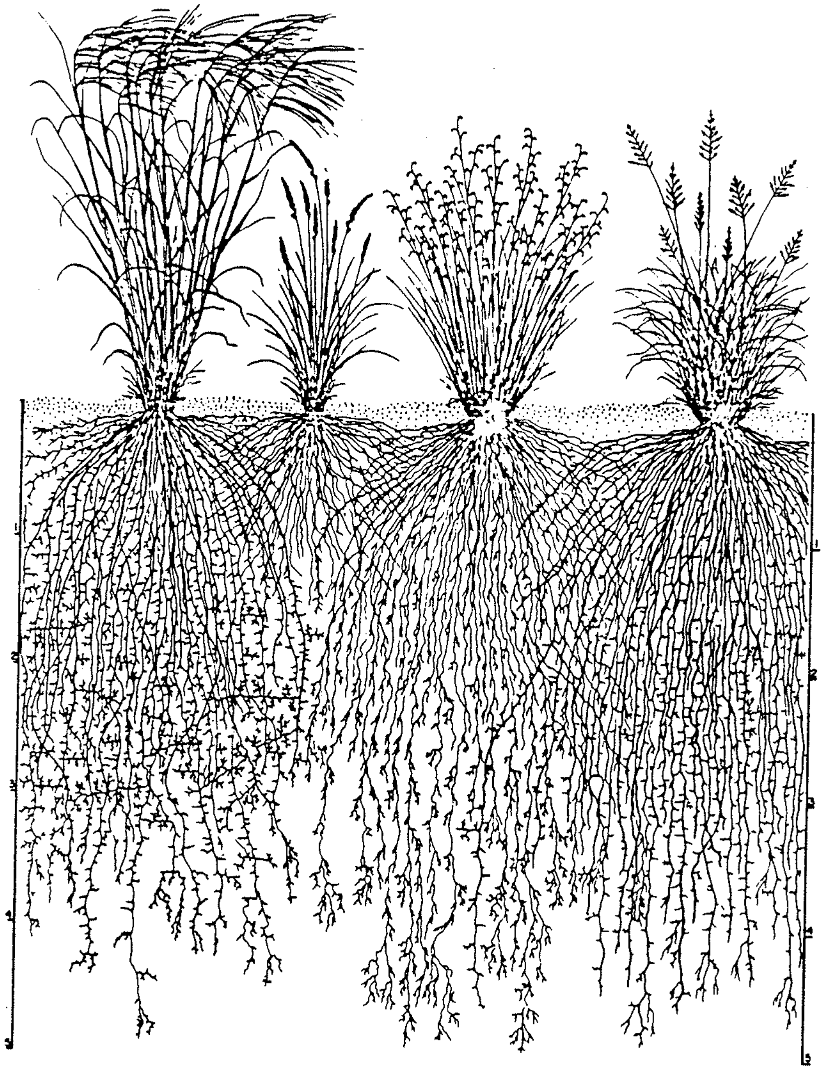
The flatness of the St. James site makes such relationships difficult to interpret, since there are not obvious gradients. More extreme slope conditions would make this relationship clearer. A pattern may well exist relating to soil moisture but having more to do with the depth to bedrock than the small gradients.

THE PLANT WITHIN THE PLANT ORDER

A useful category for PLANT TYPE is BUNCH GRASS (Little Bluestem, Andropogon scoparius), i.e. grasses having a root system adapted to dry conditions with roots near the surface that bind and stabilize the topsoil (Fig. 1.11).

SHRUBS (Wolfwillow, Silverberry, Eleagnus commutata) can be grouped with the category TREES, since our main concern is the prairie species. Where they occur represents a point of transition between true prairie and woodland.

Within the VISUAL ATTRIBUTES, HEIGHT is taken to be SMALL ($< 9"$), MEDIUM ($< 36"$) and LARGE ($> 36"$), which was a



Characteristic development of the tops and roots of four bunch grasses as they occur in several upland communities. From left to right they are needlegrass (*Stipa spartea*), Junegrass (*Koeleria cristata*), little bluestem (*Andropogon scoparius*), and prairie dropseed (*Sporobolus heterolepis*). Note that the tops are only about half as high as the roots are deep.

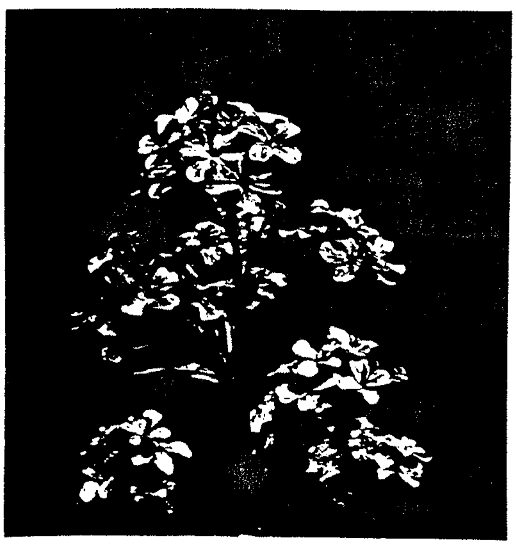
Fig. 1.11 Bunch grasses

fairly arbitrary decision, but one that may be of use in checking any relationship to flowering time.

If a plant is one of the relatively few that make up 75% of the prairie's cover, it is a COVER PLANT (Canada Everlasting, Antennaria neglecta). When it occurs in groups or "drifts" of one species it is said it AGGREGATES (Pasture Sage, Artemisia frigida).

There are estimated to be in excess of 2,000 species in tallgrass prairie, throughout its entire range. Those at St. James, 169 in total, will be the basis for the file.

Two categories that are controversial but of interest deal with the known origin of species.[4] ALIEN (Dame's Rocket, Hesperis matronalis) refers to plants "not accepted as constituents of the Manitoba flora." They are introduced. NATIVE (Silverleaf Psoralea, Psoralea argophylla) species are those believed to have had their origins partly or solely in Manitoba.



ALIEN/DAME'S ROCKET

NATIVE/SILVERLEAF PSORALEA

There is no clear understanding of what constitutes an alien or a native, with the issue becoming increasingly confused for those species that are introduced but reproduce and spread naturally. Some of these "alien weeds" may serve some useful purpose in today's tallgrass prairie though they were not present 100 years ago. NEONATIVE[5] might be a better label, although others argue that because some of the species are aggressive they are a threat and unwanted. Some disrupt the order within tallgrass prairie, occupying niches of native species and outcompeting them, so that diversity of species is reduced and the system with fewer potential responses is made less stable. It appears to be a question of time as to whether an individual species can be shown to contribute to the system. Even "native" is a term of limited use because the context for determining a plant's origins can be geographically much larger than its range within the geographic region. The situation is rather confused because most references to origins do not state the context. That a species is native to tallgrass prairie does not necessarily make it a good choice for a specific site. To maintain the genotype of a site's species it is recommended that seed come from within a three kilometer radius. Kentucky Bluegrass (Poa pratensis) is believed by some to be a native of tallgrass prairie, but not by everyone. It does not do well at St. James because it requires more moisture than is annually available (20") in the northern and transitional edges of the tallgrass prairie biome. While research into the use of plant files and computer aids is necessary, it should by now be clear that they are not a substitute for knowing local plant material as individuals.

Although the native people identified the genera of plants, it was only later that plant FAMILIES could be identified -- largely because the scale of perception was larger. Three groups emerge as being of particular importance: the GRASSES, COMPOSITES and LEGUMES. Plant cover occurs in predictable percentages for a healthy community (Fig. 1.12).

ESTIMATE OF PLANT COVER FOR TALLGRASS PRAIRIE...

Species	Big bluestem Type. 155 sq.m. % Comp.	% Freq.
Little bluestem	2.0	19
Big bluestem	78.0	100
Kentucky bluegrass	8.8	88
Needlegrass	1.9	31
Prairie dropseed	.1	1
Indian grass	1.9	37
Side-oats grama	.1	7
Small panic grasses	.3	28
Junegrass	.1	10
Nodding wild-rye	.1	12
Switchgrass	1.7	22
Sloughgrass	.4	12
Forbs	3.6	74
Total	99.0	

Fig. 1.12 Species composition and frequency

Within the general areas of "prairie" and "woodland" it is of use to identify other areas. Vegetation patterns are the material representation of the parts of a Dynamic energy system that changes constantly, in response to changes in some key factors. In the prairie community this can be competition for light between seeds and bulbs, tubers etc. when the depth of litter is critical, or later it can be competition for soil moisture in a plant community that has different depths and types of root systems. The roots are stratified so that the plant community can survive, sometimes at the expense of individuals, in a co-operative system that is more efficient in utilizing soil moisture than the sum of the parts would suggest, because of its meshing roots and stratification. In a severe drought individual species are lost but the prairie cover is maintained.

Within the associated oak/aspen woodland, flowering and leafing sequences for stratified layers (tree, shrub, herbaceous) evolved through competition for light. Species in the herbaceous layer may flower earlier in the year before being shaded out by the tree canopy. The WOOD EDGE is of interest because in competing for light at the edge, it has come to be characterised by a particular association of species. They form a dense edge, which is a windbreak that influences the microclimate within the woodland. It is generally warmer and more humid. It is more stable without the extremes of heat and cold that plants endure on the open prairie. The wood edge is also the ecotone or area of transition where changes in the relative areas of prairie and woodland can be monitored. The wood edge may be advancing or in recession. This WOOD EDGE/TRANSITION is especially important to wildlife, providing them with good cover and a diverse supply of food.

The area of most rapid transition is within the tallgrass prairie as a DISTURBED AREA. In the past this may have been a buffalo wallow, a salt lick, a burrow or a holmstead site but today it is more likely to be a worn vehicular or pedestrian trail. They may be characterised, while recovering, by a predominance of grasses, such as little bluestem, which have their growing points protected below ground level and recover quickly. The native annuals, e.g. Sunflowers, are adapted to quickly seed and recolonize such areas.

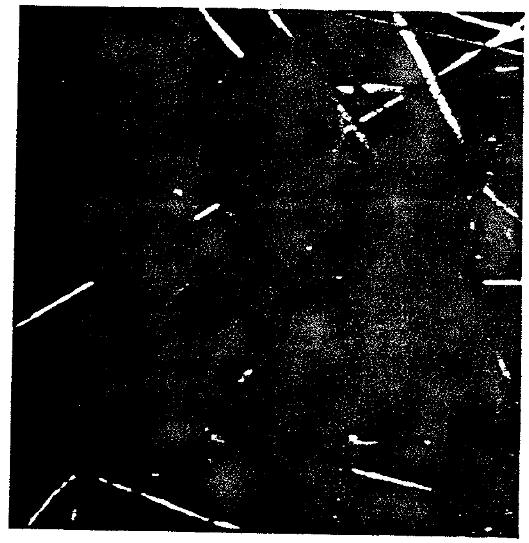
DISTURBED AREA/SUNFLOWERS

However, such areas may also be the point of entry for the more aggressive alien species (e.g. Dandelion, Taraxacum officinale) which evolved in Eurasian cultivated fields and are geared to establish extremely quickly and to persist.

Monitoring and quantification of endangered plant communities, such as tallgrass prairie, reveals that some species are now RARE (Yellow Ladyslipper, Cypripedium calceolus), or are becoming ENDANGERED (Prairie Lily, Lilium philadelphicum).

Prairie species are increasingly AVAILABLE from nurseries and seed farms. When the genotype is not an issue, e.g. home landscapes, they may be of use either AS A SEED (Wild Bergamot, Monarda fistulosa) and/or AS A PLANT (Purple Prairie Clover, Petalostemum purpureum).


RARE/YELLOW LADYSLIPPER


ENDANGERED/PRAIRY LILY

The reproductive method can be used to predict the future appearance of an area. If the preferred manner is SEXUAL the characteristics and location of offspring are diverse and unpredictable. VEGETATIVE REPRODUCTION, from rhizomes, tubers etc. is more predictable. Many species have both alternatives.

The vast majority of prairie species are perennials, some with a lifetime of about thirty years, but as we have seen, it is the ANNUAL (Pasture Sage, Artemisia frigida) that has a key role within the community as the initiator of the healing process.

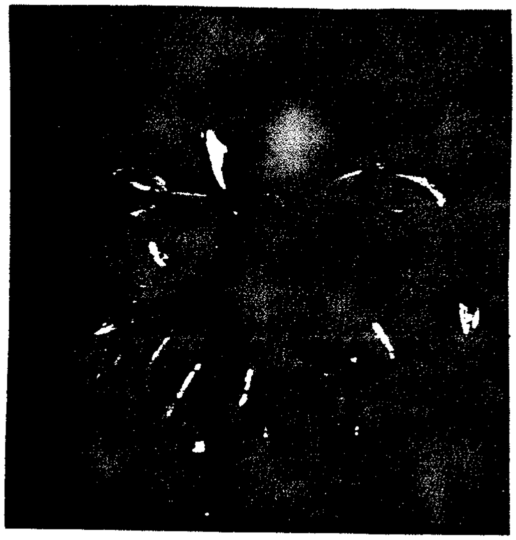
To ensure the survival of a species and its flowering it may be advisable to check whether it is DIOECIOUS (Canada Thistle, Cirsium arvense), i.e. if there are separate male and female plants.

THE PLANT AND THE ANIMAL ORDER

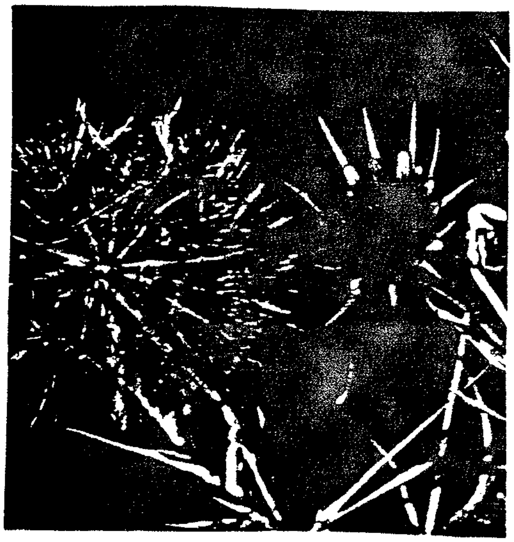
Studies on wildlife are a good source for data on a plant's value as FOOD, but they are not easy to interpret.[6] A plant may have value as a high percentage of one animal's diet or it may have value as a low percentage of the diet for a great many animals. The category as it is used in the records is intended to identify those species that are mentioned in reading material on wildlife requirements.

Although much has been done to understand changes in ecosystems under natural conditions, e.g. identification of species SUSCEPTIBLE TO DROUGHT (Tufted Vetch, Vicia cracca), some of the most useful research relates to the impact and management problems of man-the-farmer. Grazing may cause a species to proliferate if it is an "INCREASER" (Black-eyed Susan, Rudbeckia serotina), or die out if it is a "DECREASER" (Dwarf False Indigo, Amorpha nana). We have seen some that are POISONOUS to animals, but others are simply AVOIDED, perhaps because they taste bitter or are DEFENDED. One such species is Foxtail Grass (Hordeum jubatum), which causes mouth sores in cattle that, if infected, can cause death. Certain species are INDICATORS OF OVERGRAZING (Canada

Everlasting, Antennaria neglecta) where they visually dominate. They may be those left untouched or they may be the INVADER/ PIONEER species that first colonize the DISTURBED AREA.



INCREASER/BLACK EYED SUSAN

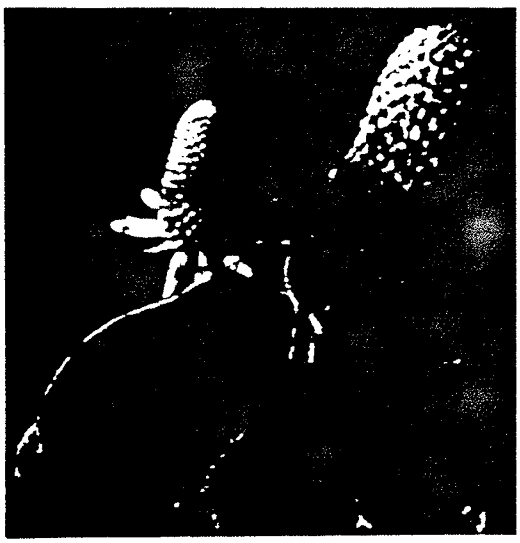


INVADER/PIONEER/YELLOW GOATSBEARD

In reading the landscape of a grazed area both Weaver and Watts suggest that cattle, like bison, may graze into a prevailing wind, so that one side of a pasture might appear more heavily grazed. Bison/cattle will also have preferred routes to and from water bodies and separate sleeping areas, less heavily grazed. It was often the pathways for large scale migration that were first used by explorers and later the settlers of the prairies.

THE PLANT AND THE HUMAN ORDER

Apart from a brief period when the immigrant Europeans as a minority group learned willingly the ways of the native people as a prerequisite for survival, the majority cultural response has been to ignore the native flora. Settlers used introduced species for windbreaks (Pea Tree, Caragana arborescens), garden vegetables (Asparagus, Asparagus officinalis) and later to decorate their surroundings. They used styles and techniques reminiscent of their native homelands. This is an alternative attitude towards the selection of plant material that has a heavy horticultural bias and still has its advocates.[7] Some species now have a CULTIVAR AVAILABLE (Long-headed Coneflower, Ratibida columnifera). Some are viable as CROPS (Jerusalem Artichoke, Helianthus tuberosus).



CULTIVAR AVAILABLE/
LONG-HEADED CONEFLOWER

CROP/JERUSALEM ARTICHOKE

Many of the native species became, in time, part of western medicine[8] (Chokecherry, Prunus virginiana -- as a cold remedy).

A combination of criteria (native and ecological) can be seen as a useful checklist and a starting point for future studies. The criteria chosen are those which arise from the context of a specific site. They represent what the vegetation has to offer as it interacts with the four orders or the interdependent levels of being. The record represents, I hope, what Edward T. Hall would regard as "a high context integrative system of thought."

There are numerous other categories which could be added to the plant record, but those given which arise from an ecological viewpoint are the minimum required to understand tallgrass prairie vegetation as something which relates to all levels of being (Fig. 1.13).

Probably one of the most important emerging lines of thought this century has been the conceptual "flip-over" that lets us look not at the orders or levels of being in the World, but at the exchange of energy between the parts, a concept expressed in Dansereau's Model of Reality as the Ecosystem[9] (Fig. 1.14).

An ecosystem merges the idea of exchanged energies (central to a native model) and levels of being (central to an immigrant model). Levels represent stores of more complex and concentrated energy but the degree of interdependency negates any idea of a hierarchical structure. That an organism is more complex does not make it more important to the health of the system. The most important component is actually the plant level because it is the only PRODUCER in the system,

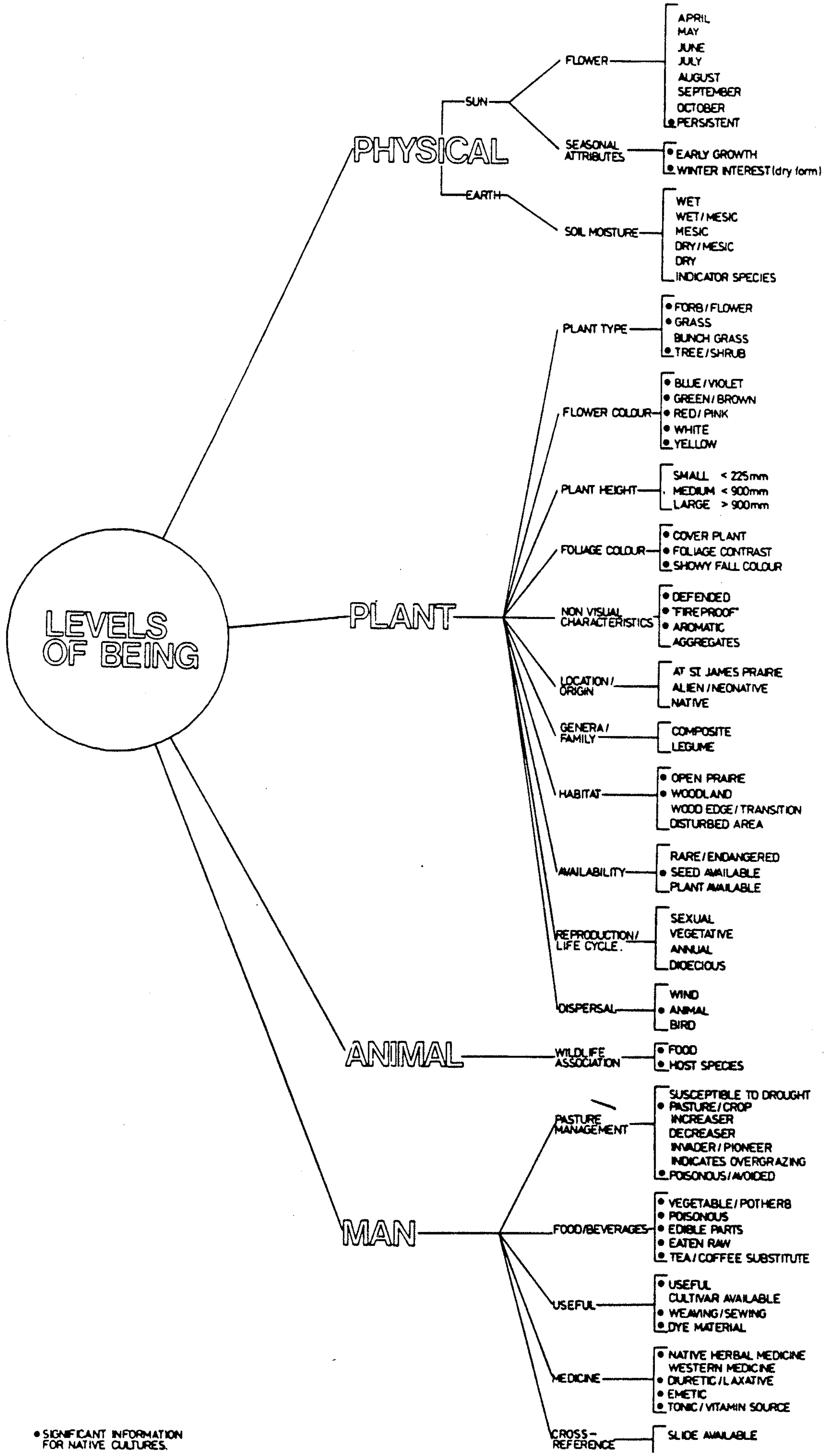
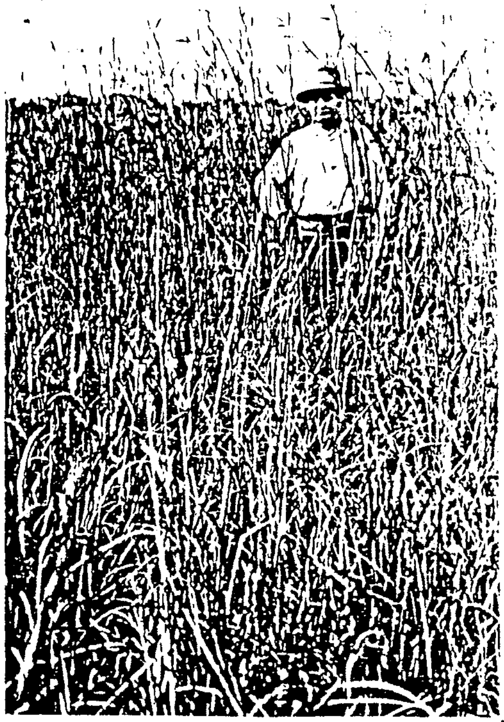


Fig. 1.13 A checklist of criteria (native and ecological)



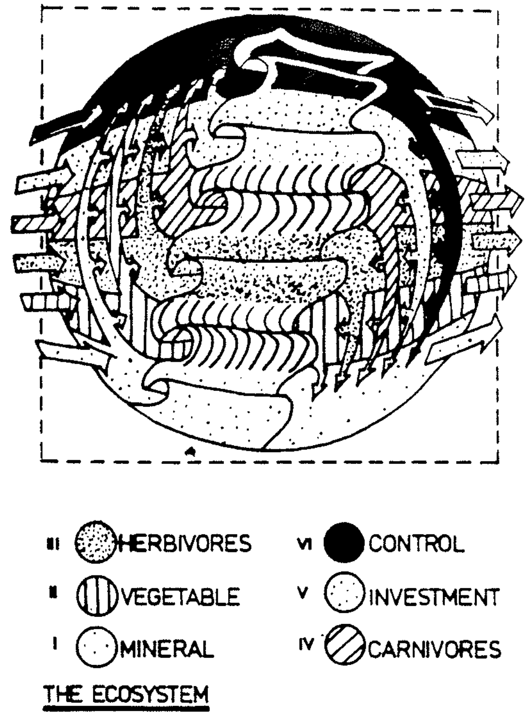


Fig. 1.14 The ecosystem

whereas all other levels are CONSUMERS. Such a model is useful for a general interpretation of a specific site but it is not going to provide us with a meaningful quantitative model because the specifics of individual organism behaviour (Worm, Rose, Bison, Man) are not accurately represented within generalised object classifications (Carnivore, Herbivore, Decomposer). Showing control or investments (stores of energy) as entities separated from mineral/animal/plant/man decomposer levels only serves to confuse or obscure relationships, since controls and energy storage originate within these levels and may bypass intermediate levels. Systems analysis shares these problems but is different in that it can address itself specifically to quantifying energy exchange and is derived from a vocabulary of symbols -- building blocks for models which can be made specific or general, depending on the nature of the problem and the quality of information available.

REFERENCES TO RELATED READING ON

"AN ECOLOGICAL VIEW"

1. J. E. Weaver, Prairie Plants and Their Environment--A Fifty-Year Study in the Midwest (Lincoln: University of Nebraska Press, 1968).

2. Jane Embertson, Pods--Wildflowers and Weeds in Their Final Beauty (New York: Charles Scribner's Sons, 1979).

3. Wehr Nature Center, A Prairie Propagation Handbook (Whitnell Park, 5879 S. 92 St., Hales Corners, Wis. 53130).

4. Gerald A. Mulligan, Common Weeds of Canada (Toronto: McClelland and Stewart/Dept. of Agriculture and Publishing Centre, Supply and Services, Canada, 1978).

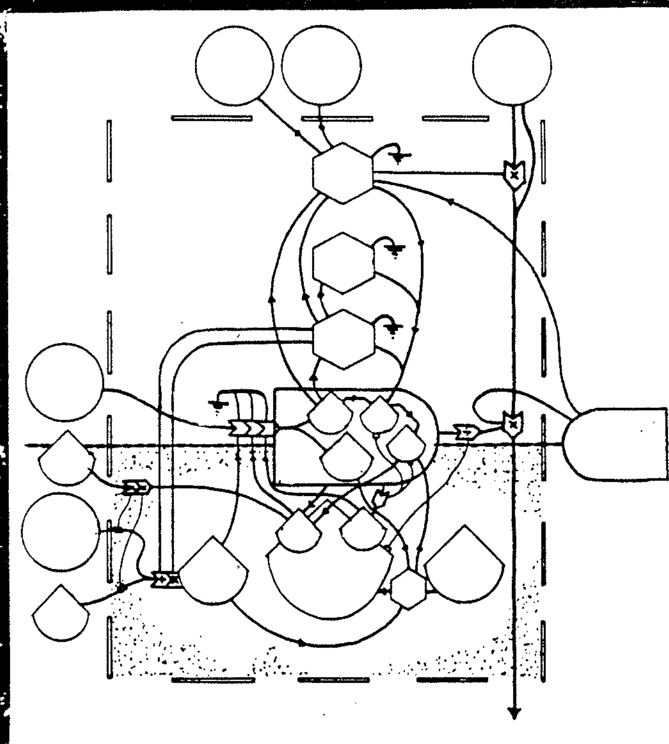
5. , "A Case for the Neonatives," Landscape Architecture (October, 1975), pp.

6. Alexander Martin, Herbert Zim, Arnold Nelson, American Wildlife and Plants--A Guide to Wildlife Food Habits (New York: Dover Publications, Inc., 1961).

7. H. F. Harp, The Prairie Gardener (Edmonton: Hurtig Publishers, 1970).

8. Stephen Jackson and Linda Prine, Wild Plants of Central North America for Food and Medicine (Winnipeg: Peguis Publishers Ltd., 1978).

9. Pierre Dansereau, Inscape and Landscape (CBC Learning Systems, 1973).



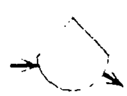
1.4 A Systems View

The purpose of this section is to produce a quantified general model of tallgrass prairie, as an energy system, so that relationships between the parts of a healthy ecosystem can be appreciated. The model shows the importance of process-orientated thinking in the management of native plant communities by showing how key "forcing factors" influence the physical appearance and composition of the plant community. The general model is then compared to the system which exists at the St. James Prairie, Winnipeg and to its area of maintained lawn, so that the energy expended by man on management/ maintenance can be compared.

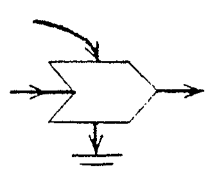
Symbols. The symbols used are those adopted by Odum (1976).[1]

Energy source from outside accompanied by causal forces.

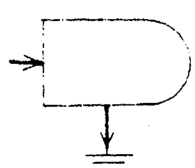
Heat sink, the draining out of degraded energy after its use in work.



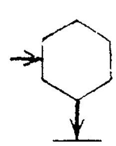
Energy storage tank delivers energy flow to pathways.



Energy interaction, where two kinds of energy are required to produce high-quality energy flow.



Producer unit converts and concentrates solar energy; it is self-maintaining. Details may be shown inside.



Consumer unit uses high-quality energy and is self-maintaining. Details may be shown inside.

A General Model

Energy flow units are Kcal.$m^{-2}.yr^{-1}$,with assumptions based,where possible,on data from studies on the ungrazed Osage tallgrass prairie,Oklahoma (growing season 272 days, annual precipitation 78.5 cm). Unless otherwise stated ,all references in brackets are from IBP19 -- Grasslands,Systems Analysis and Man[2].

From Sunlight to Plant Biomass........

Solar radiation available to the plant community is 1.49×10^6 Kcal.$m^{-2}.yr^{-1}$. This is converted by photosynthesis into total plant biomass (Pt) at an efficiency of 0.44% (Sims and Singh, 1971). For other tallgrass sites the efficiency was 1.2%, with 55% (Dalman and Kucera, 1965) of the total 6584.6 Kcal.$m^{-2}.yr^{-1}$,ie. 3621.53 Kcal.$m^{-2}.yr^{-1}$ for belowground biomass (Pb).

Stores of Plant Biomass........

Biomass aboveground and live (Ba) has 110 g(dry wt).m^{-2} of Carbon. Biomass belowground, live and dead (Bb) 78 g(dry wt).m^{-2}. of Carbon and Biomass of Litter (Bl) 325 g(dry wt).m^{-2} of Carbon. This in terms of stores of energy is:

Ba as 880 Kcal.$m^{-2}.yr^{-1}$,

Bb as 624 Kcal.$m^{-2}.yr^{-1}$,

and Bl as 2600 Kcal.$m^{-2}.yr^{-1}$.

(Carbon is about half the plant's dry weight and 1 g dry weight of plant material gives 4 Kcal of energy, when burned in a bomb calorimeter.)

Standing Dead accumulates at 339 g.$m^{-2}.yr^{-1}$ giving a flow of 1356 Kcal.$m^{-2}.yr^{-1}$, while the rate of accumulation of litter is 292.33 $g.m^{-2}.yr^{-1}$, the equivalent of 1169 $Kcal.m^{-2}.yr^{-1}$.

For the PRODUCER SYSTEM (Fig. 1.15) we have the following stores of energy and exchanges of energy:

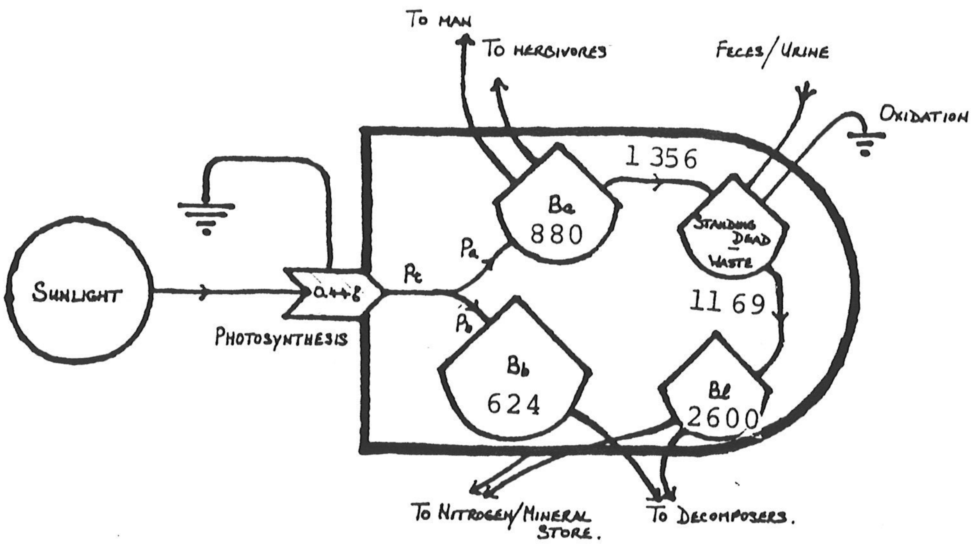


Fig. 1.15 The producer system

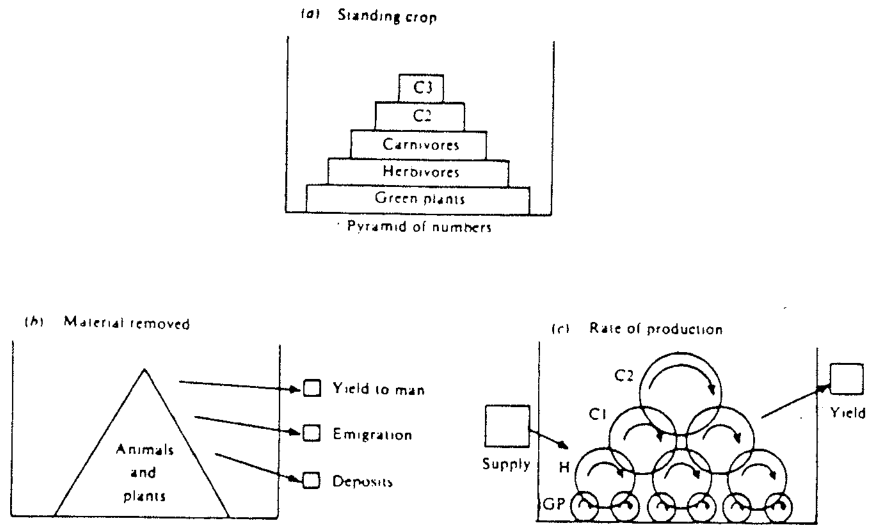
Two Food Chains........

The producer system supports two simplified food chains, above and below ground --

a) the herbivore,carnivore,man chain

and b) the decomposer,microbacteria chain.

These CONSUMER SYSTEMS are self-maintaining and perpetuate a balance within the overall system by controlling flows of energy and recycling minerals and nutrients. The overall pattern is seen as a balance of numbers between trophic levels that represent storage of energy in increasingly complex forms (Elton's Pyramid) and/or a balance in turnover rate, with work done by many small organisms with short lifetimes supporting fewer organisms with longer lifetimes (Fig. 1.16).



Concepts of productivity expressed in the form of pyramids. GP, green plants; H, herbivores; C1, primary carnivores; C2, secondary carnivores; C3, tertiary carnivores. (After Clarke, 1954.)

Fig. 1.16 Trophic structure

Although the trophic structure is modelled as being pyramidical the pattern breaks down with increasing yields being taken by man and closer scrutiny reveals natural fluctuations over time, particularly above ground. The system is dynamic and constantly shifts in response to external factors such as changes in the seasons and internal factors such as fluctuations in population numbers for organisms (Fig. 1.17).

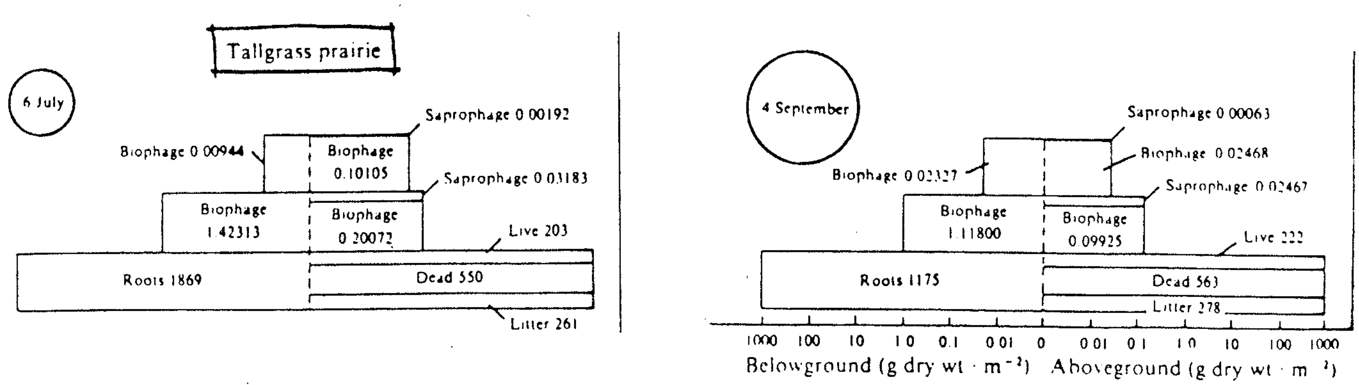
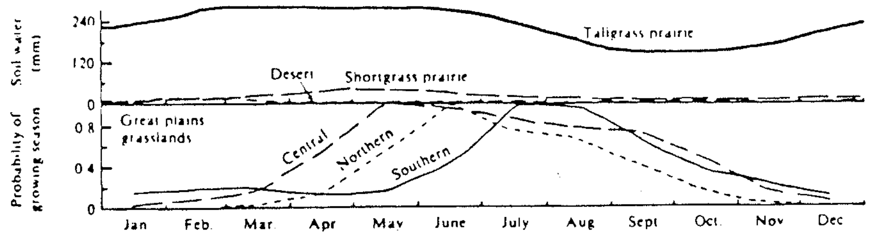


Fig. 1.17 Trophic level fluctuations

Plant biomass production rates are related to forcing factors such as the seasonal distribution of rainfall (Fig. 1.18).



Examples of the annual cycle of key abiotic driving variables in North American grasslands based on data from US/IBP grassland biome study sites and nearby locations.

Fig. 1.18 Rainfall and plant production

The situation is made more complex by delaying loops and storages within the system. A large number of variables influence the soil's ability to store and release ground water, e.g. the influence of plant uptake, soil porosity, the rate of evaporation and the contribution of surface runoff from or to adjacent areas. What is clear is that while the flows of energy may be harder to quantify, a system with more options regarding the routes that energy might take is more stable.[3]

From Plant Biomass to Soil Community.......

The rate of conversion of parent material to soil is governed by the rate at which the decomposers can rework supplies of root biomass, litter and waste products (feces and urine). Availability of soil moisture is also a factor. Turnover in root biomass (0-50 cm) was measured as 0.36 $g.m^{-2}.day^{-1}$ for the Osage prairie (I.B.P. report 19, pp. 156-157) and as 25% per year for tallgrass prairie in general (Dalman and Kucera, 1965). This gives a rate of decomposition (Pc) of between 156 and 525.6 $Kcal.m^{-2}.yr^{-1}$.

The total depth of topsoil is assumed to be 120 cm (4 feet) and the time since last glaciation about 10,000 years, which gives an accumulation rate for topsoil of 0.12 $mm.yr^{-1}$. There is some data for the uptake of Nitrogen and Minerals and an approximate order of importance:

1 Nitrogen (partly from the Legumes)
2 Carbon (turnover rate of 1.6 yrs.)
3 Phosphorous
4 Sulphur
5 Potassium
6 Calcium/Magnesium (in litter)
7 Silicon
8 Iron/Aluminum

An estimate of Nitrogen (N) and Mineral (M) uptake by biomass aboveground is 28 $g.m^{-2}.yr^{-1}$ and for biomass belowground is 65 $g.m^{-2}.yr^{-1}$, giving a total of 93 $g.m^{-2}.yr^{-1}$ (I.B.P. report 19, p. 726). The amount of water uptake is undetermined. What is known is that the efficiency of water use (Available water/Total plant biomass) is highest for grasslands with intermediate rainfall. Tallgrass prairie does not use available water as efficiently as mixed-grass prairie (Fig. 1.19).

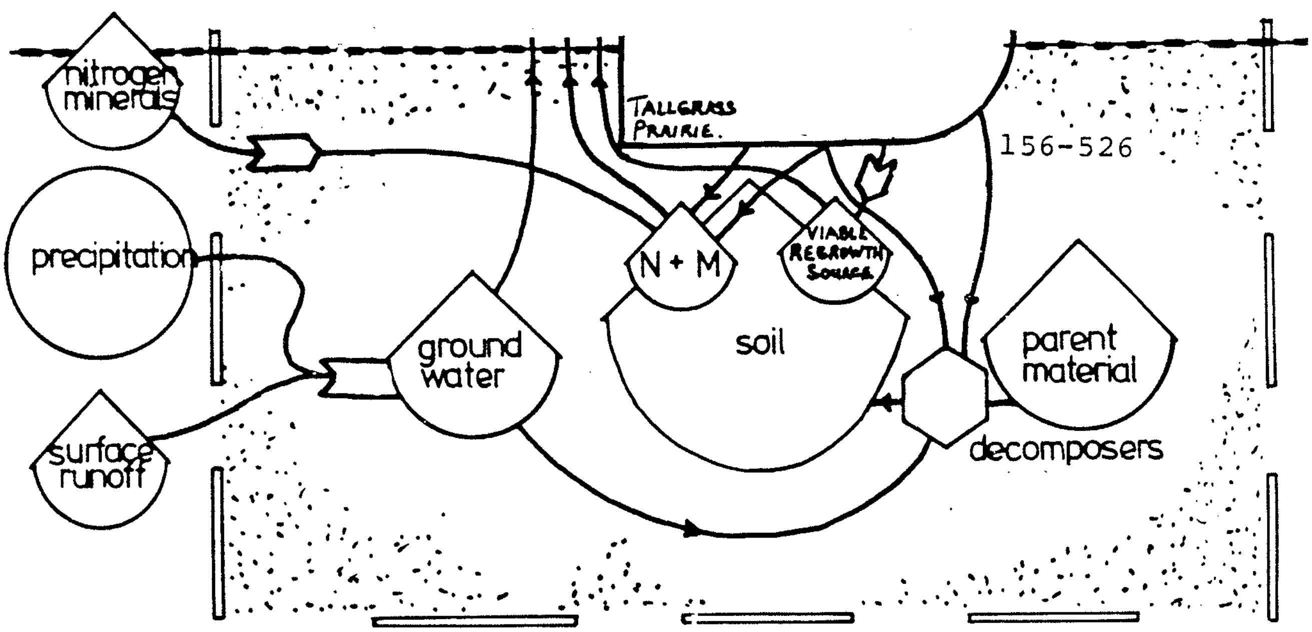


Fig. 1.19 The belowground food chain

While most plant species exhibit a preference for certain soil moisture conditions, some Indicator species have a very close relationship. Management of the water regime can shape the appearance of the prairie according to predictable patterns. (Fig. 1.20).

WET/INDICATOR

Aster novae-angliae	New England Aster
Thalictrum dasycarpum	Tall Meadowrue
Veronicastrum virginicum	Culver's Root

WET-MESIC/INDICATOR

Fragaria virginiana	Wild Strawberry
Galium septentrionale	Northern Bedstraw
Heuchera richardsonii	Alumroot
Lathyrus venosus intonsus	Wild Peavine
Panicum leibergii	Panicgrass
Rudbeckia serotina	Black Eyed Susan

MESIC/INDICATOR

Aster laevis	Smooth Aster
Convolvulus sepium	Wild Morning Glory, Devil's Guts
Solidago missouriensis	Low Goldenrod
Viola pedatifida	Birdfoot Violet

DRY-MESIC/INDICATOR

Anemone cylindrica	Thimbleweed
Koeleria cristata	Junegrass
Petalostemum candidum	White Prairie Clover
Physalis virginiana	Virginia Groundcherry
Potentilla arguta	Tall Quinquefoil
Sporobolus heterolepis	Prairie Dropseed
Stipa spartea	Needlegrass, Porcupinegrass
Viola pedatifida	Birdfoot Violet

DRY/INDICATOR

Andropogon scoparius	Little Bluestem
Aster ptarmicoides	Upland White Aster
Bouteloua curtipendula	Side Oats Grama
Petalostemum purpureum	Purple Prairie Clover

Fig. 1.20 Indicator species for soil moisture

From Plant Biomass to Man........

The Osage prairie has no large herbivores. Studies completed relate to small herbivore systems. In general there is a correlation between the total biomass of phytophagous animals feeding on grassland vegetation and its biomass (Ellis and French, 1973; Zlotin, 1975). Species diversity depends also on the number of plant species present (about 200) and the composition of plant cover -- 95.4% Grasses, 3.6% Forbs (Weaver, North American Prairie, 1954).

On ungrazed prairie there is a great diversity of animal species in the small herbivore system (grasshoppers, voles, mice etc.). They have a measured dry weight of 42.3 mg.m^{-2} (I.B.P. report 19, p. 205), 0.17 Kcal.m^{-2}. Invertebrate predators occur at 17.3 mg(dry wt).m^{-2}, 0.07 Kcal.m^{-2}, and are 21.9% of the total invertebrate population (I.B.P. report 19, p. 542). Herbivorous invertebrates total 0.32 Kcal.m^{-2} (Fig. 1.21).

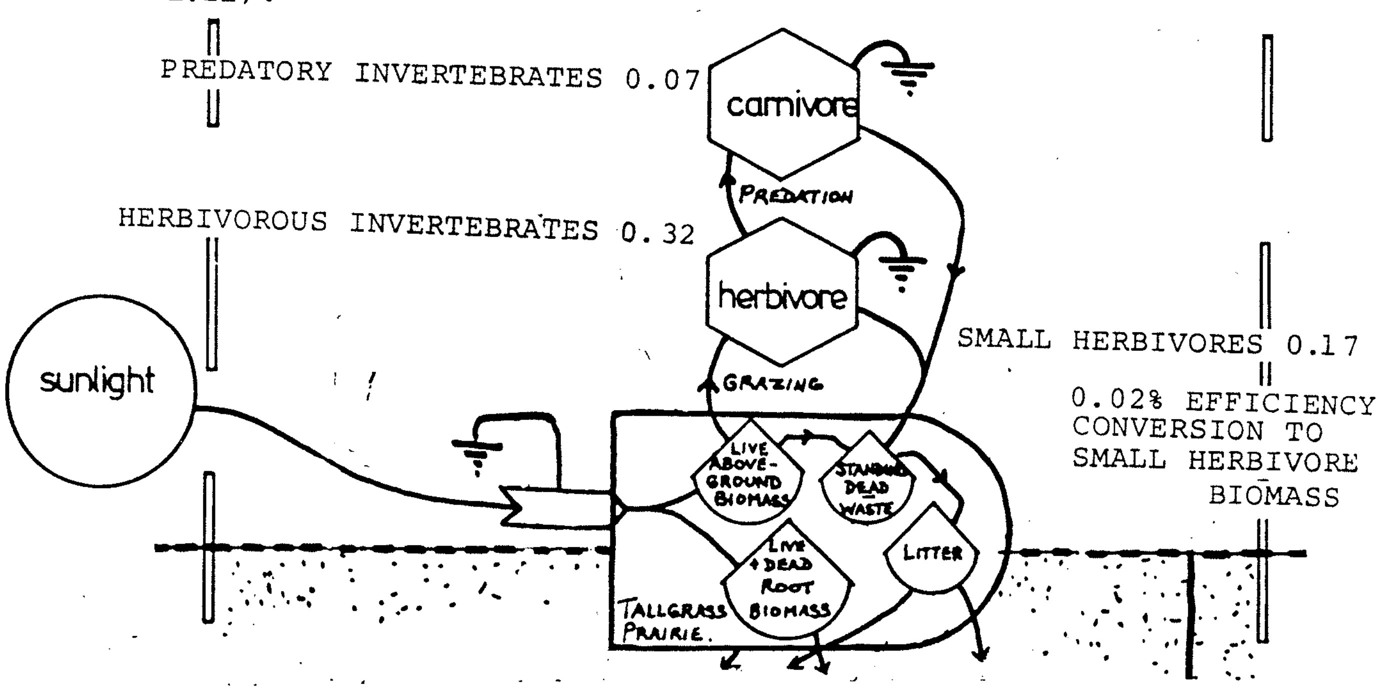


Fig. 1.21 Biomass for small herbivores and invertebrates

Moderate grazing would increase Pa by approximately 50% (Pearson, 1965; Rawes and Welch, 1966; Andrzejewska, 1974; Wielgoleski, 1975). Were there large herbivores an estimate of average grazing would be 13-20% of Pa (Petrusewiez and Grodinski, 1975) with a maximum exploitation rate of 30-45% (Wegent and Evans, 1967). Assuming 13% Pa becomes 4444.5 Kcal.m^{-2}.yr and 577.8 Kcal.m^{-2} would go to the large grazers. Production rate for litter and standing dead would be increased to 3866.7 Kcal.m^{-2}.yr from the 2525 Kcal.m^{-2}.yr on ungrazed prairie. The system is made more efficient in investing in the soil because of the moderate grazing of free ranging herbivores. Assessing the impact of grazing on the make-up of the plant community is difficult. With no limits to the range of large grazers, bison appear to take species in approximately the same percentages as they occur as cover for the prairie. If the range is limited more intense grazing promotes the dominance of grasses and the dying out of forbs. If the range is ungrazed then the percentage of forbs/flowers in the community increases.

Assuming a 10% efficiency for the conversion of plant energy to storage in large herbivore biomass since animals are generally 5-20% efficient (Southwick, Ecology and Quality of our Environment, p. 208) gives a production rate (Ph) of 57.8 Kcal.m^{-2}.yr^{-1} for large herbivores. Large predators (Prairie wolf, grizzly, coyote etc.) would have a production rate (Pp) of 5.8 Kcal.m^{-2}.yr^{-1} (Fig. 1.22).

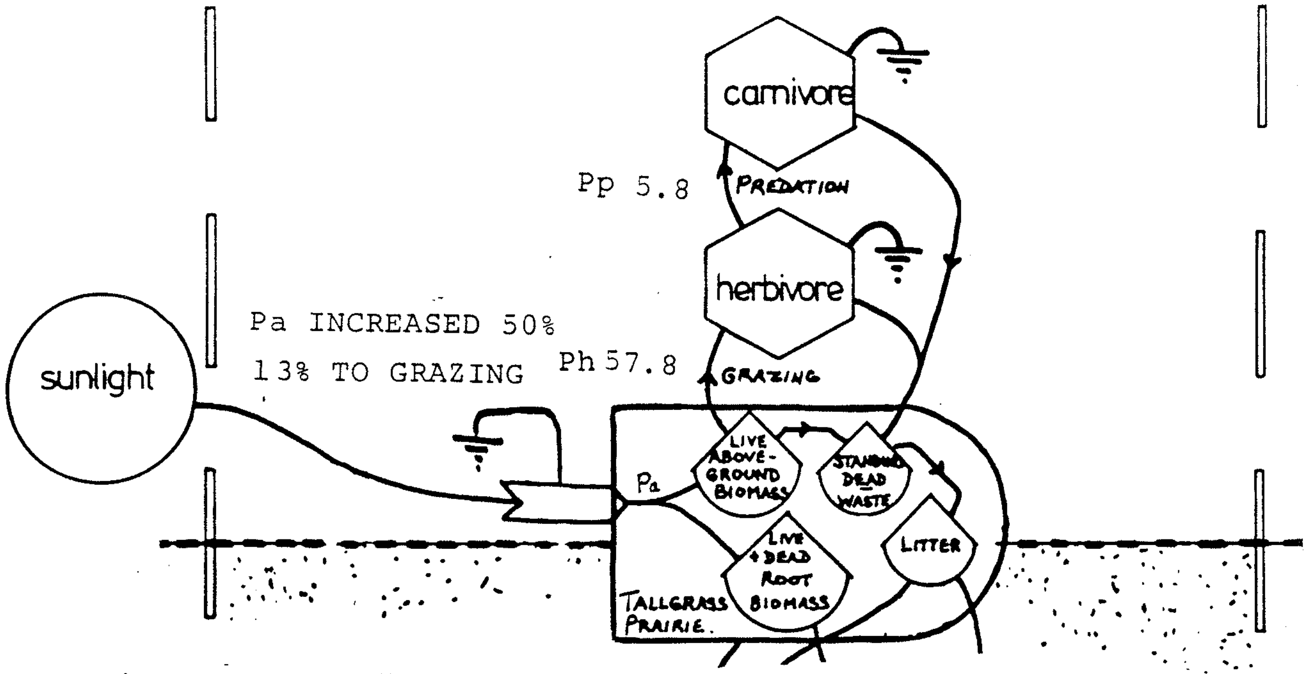


Fig. 1.22 The aboveground food chain

The several species of large herbivores associated with tall-grass prairie were able to co-exist because they were not competing for the same plant resources (Fig. 1.23).

Summary of average dietary botanical composition for all seasons for large herbivores

Species	Number	Grass	Forb	Shrub
Cattle	121	72 ± 25	15 ± 16	13 ± 21
Sheep	105	50 ± 23	30 ± 25	20 ± 21
Goats	13	29 ± 19	12 ± 11	59 ± 18
Burros	3	8 ± 3	39 ± 26	55 ± 26
Horses	8	69 ± 23	15 ± 16	16 ± 10
* Bison	12	91 ± 10	5 ± 4	4 ± 8
* Pronghorn	82	15 ± 21	42 ± 28	43 ± 32
Mule deer + black-tailed deer	83	13 ± 17	28 ± 26	59 ± 30
* White-tailed deer	42	10 ± 11	30 ± 23	60 ± 27
* Elk	22	69 ± 26	14 ± 19	17 ± 22
Red deer	5	40 ± 29	21 ± 22	39 ± 35

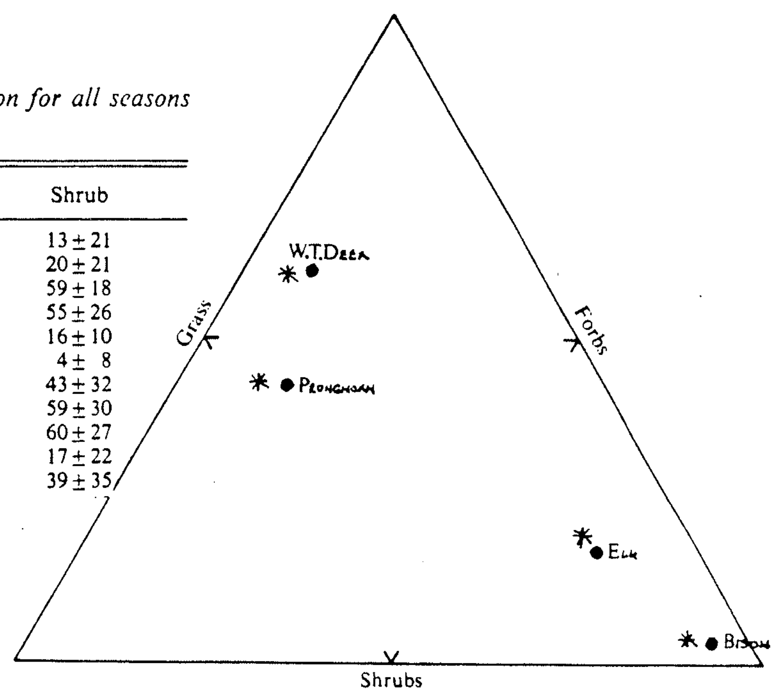


Fig. 1.23 Large herbivores and food resources

Man's role in the system was minimal. He required 2500 Kcal.day^{-1} to survive (Odum, 1976) which he acquired by hunting and by foraging from many vegetative systems. The controls for managing the system are mostly built-in and are the consequence of an evolved symbiotic relationship between the parts of the system. One exception is the occurrence of fire. It may be that the natural frequency of fires as they occur from lightning strikes does not account for the number of fires necessary to keep an area as tallgrass prairie. The native people may have had a key role in establishing tall-grass prairie[4] since they used fire for hunting and to manage the prairie with light burns about every 1-4 years. How often one specific area has to be burned over is difficult to say. What fire does is remove the build-up of standing dead and litter, which with increasing depth makes the germination of seeds increasingly difficult. Fire sets back the process of succession while at the same time releasing stores of minerals and nutrients to the soil. The soil protects the regrowth source of most prairie species (perennials) while destroying shrubs/trees which grow yearly from points of growth above-ground. Prairie was increasing because it can regenerate after fire, while the associated woodlands were receding.

Another control is the effect of burrowing animals in aerating the soil at the same time as the large grazers were compacting the soil. Both actions change the amount of storage space for soil moisture which in turn impacts on the entire system.

The model that emerges of tallgrass prairie shows clearly that no part of the system exists in isolation. There are stores of energy in different forms, but a hierarchy, if it exists, is only in terms of the quality/concentration of stored energy. The vital links that emerge, routes for energy transfer, are as important as the parts. Understanding the role of the forcing factors and working with information on plant preferences enables us to manage the system in accordance with anticipated responses, and our significant criteria are largely to do with measured responses to change in the forcing factors. Different habitats correspond to different amounts of AVAILABLE SUNLIGHT (OPEN PRAIRIE, WOOD EDGE/TRANSITION, WOODLAND) to AVAILABLE WATER (DRY, DRY-MESIC, MESIC, WET-MESIC, WET and SUSCEPTIBLE TO DROUGHT) and to FIRE (FIREPROOF). We also see man's place in the scheme of things and so are better able to interpret his vital link with nature.

Knowing the pattern to energy transfer reveals that the natural system not only required minimal energy expenditure by man, but incorporated other components (the grazers) to do the work of management, which, in turn, were sources of energy sustaining man. With the model (Fig. 1.24) we can now explore grazing as an alternative,natural form of management for this plant community.

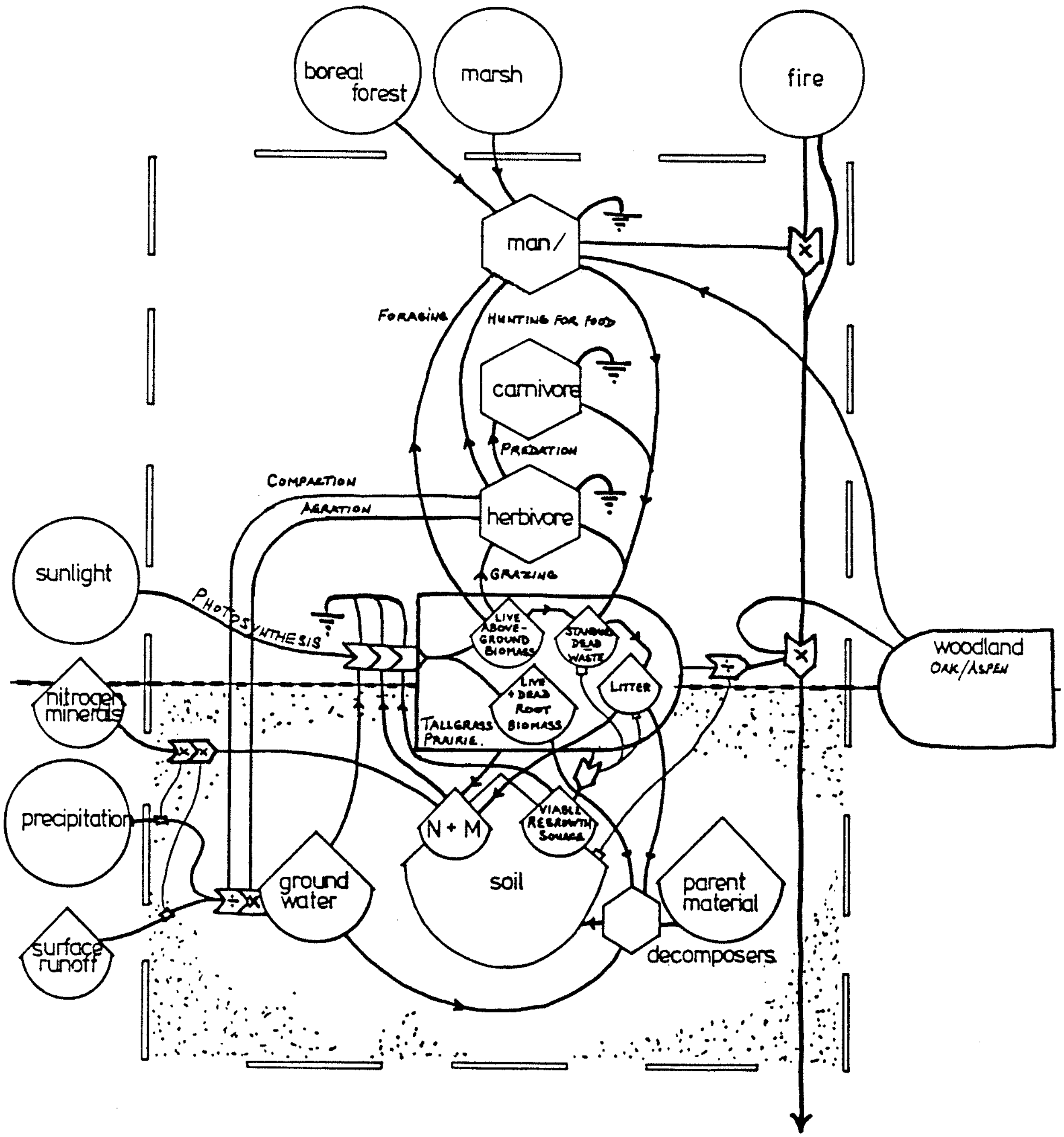
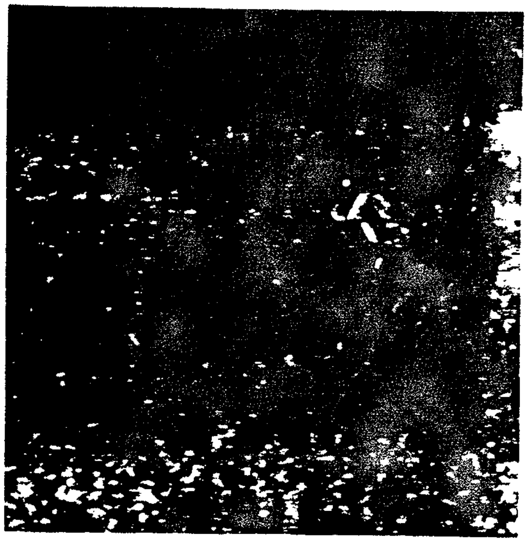


Fig. 1.24 A systems model for tallgrass prairie

Energy expended on management of the St. James Prairie

THE ST JAMES PRAIRIE

Energy expended by man is still minimal though it now includes substituting planned burns for natural fires and maintaining areas of lawn. The open prairie has about 1/10th of its area burned over every year but the advancing woodland remains unburned and continues to encroach on the prairie. The energy expended on maintenance of lawns and mown pathways is spent on making a mono-culture of grass grow (fertilizer, watering etc.) and on keeping it from growing (mowing)!

A very approximate estimate of the energy expended on 20 m^2 of lawn in one year is 2500 Kcal for labour, 10,000 Kcal for fuel and 2,500 Kcal for fertilizers and pesticides (Fallarones Inst., The Integral Urban House, p. 428). When this is added to the energy represented by the removed grass clippings (85,000 Kcal) the total energy budget is 5,500 $Kcal.m^{-2}.yr^{-1}$ (approximately $0.69 $m^{-2}.yr^{-1}$). This is not excessive in terms of managing lawn where it is needed ($138.00 per year for St. James). Where it is not needed it represents an incredible waste of money/energy. Tallgrass prairie as an alternative requires a minimum of management -- the wages of two firemen (assume \$20,000 yr^{-1}) for one day every two years, burning an area of about 15,958 square meters -- about \$54.79 yr^{-1} total or <u>\$0.0034 $m^{-2}.yr^{-1}$</u>. This assumes that for 1981 one dollar is the equivalent of 8000 Kcal (Total energy consumption in Canada/GNP). There are situations where fire management of tallgrass prairie is not a feasible option but can this be so for all the maintained grasslands in parks, roadsides and hydro-rights-of-way? Fire, used to manage the open prairie at St. James, does not appear to be effective in reducing the numbers of woodland shrubs that are invading the area, possibly because there is not enough time between fires to let combustible material build up to the point that a burn will be intense enough to kill the shrubs. The loss of the herbivores has reduced the rate at which combustible material is produced, but the rate of burning is based on the frequency of past fires on grazed prairie. Perhaps it is possible to reintroduce grazing. Using the model (Fig. 1.25) we can test whether this is possible in theory even though it is not practical for the site as it exists. Energy quantity decreases as it moves through the system but its concentration and quality increases.

SUNLIGHT (3700 Kcal $m^{-2}.day^{-1}$ in in Manitoba)	1350500.00 $Kcal.m^{-2}.yr^{-1}$
Photosynthesis (0.44% efficient)	
TOTAL PLANT BIOMASS	5942.20 $Kcal.m^{-2}.yr^{-1}$
45% ABOVEGROUND	2673.99 $Kcal.m^{-2}.yr^{-1}$
BOOSTED 50% BY GRAZING	4010.99 $Kcal.m^{-2}.yr^{-1}$
13% TAKEN BY LARGE HERBIVORES	521.43 $Kcal.m^{-2}.yr^{-1}$
CONVERTED TO ENERGY STORED AS ANIMAL BIOMASS (10% efficiency)	52.14 $Kcal.m^{-2}.yr^{-1}$
ANIMAL BIOMASS (assuming 1g of animal biomass is the equivalent of 5 Kcal of stored energy)	10.43 $g.m^{-2}.yr^{-1}$
ANIMAL BIOMASS ON WHOLE SITE (total area of 39.5 acres, 159,580 square meters)	1664.42 $g.m^{-2}.yr^{-1}$

This is the equivalent of three mature bison (500 Kg each).

Fig. 1.25 A theoretical test for grazing

While the model indicates that grazing is theoretically possible it is well to remember that the assumptions behind the model were derived for a larger scale of perception and that the applicability of the model is reduced in trying to work at such a small scale. Its use is primarily as an interpretive aid. It does not show that grazing is feasible, but given conditions as they are believed to have existed, three bison possibly could be sustained by the amount of edible material produced in the site (<u>though not necessarily as a confined pasture</u>). It may well be that they would be sustained by the total production of aboveground plant biomass but that they would naturally graze over a much wider range.

Other changes to the system include the interception of surface water runoff from surrounding areas so that available ground water is reduced. Compaction of the mown pathways by visitors may also interrupt the flow of available ground water. The aboveground food chain is not evident as an interpretive resource except in terms of the small herbivores, e.g. grasshoppers and leafhoppers.

What exists now is only the relics of a once healthy ecosystem (Fig. 1.26).

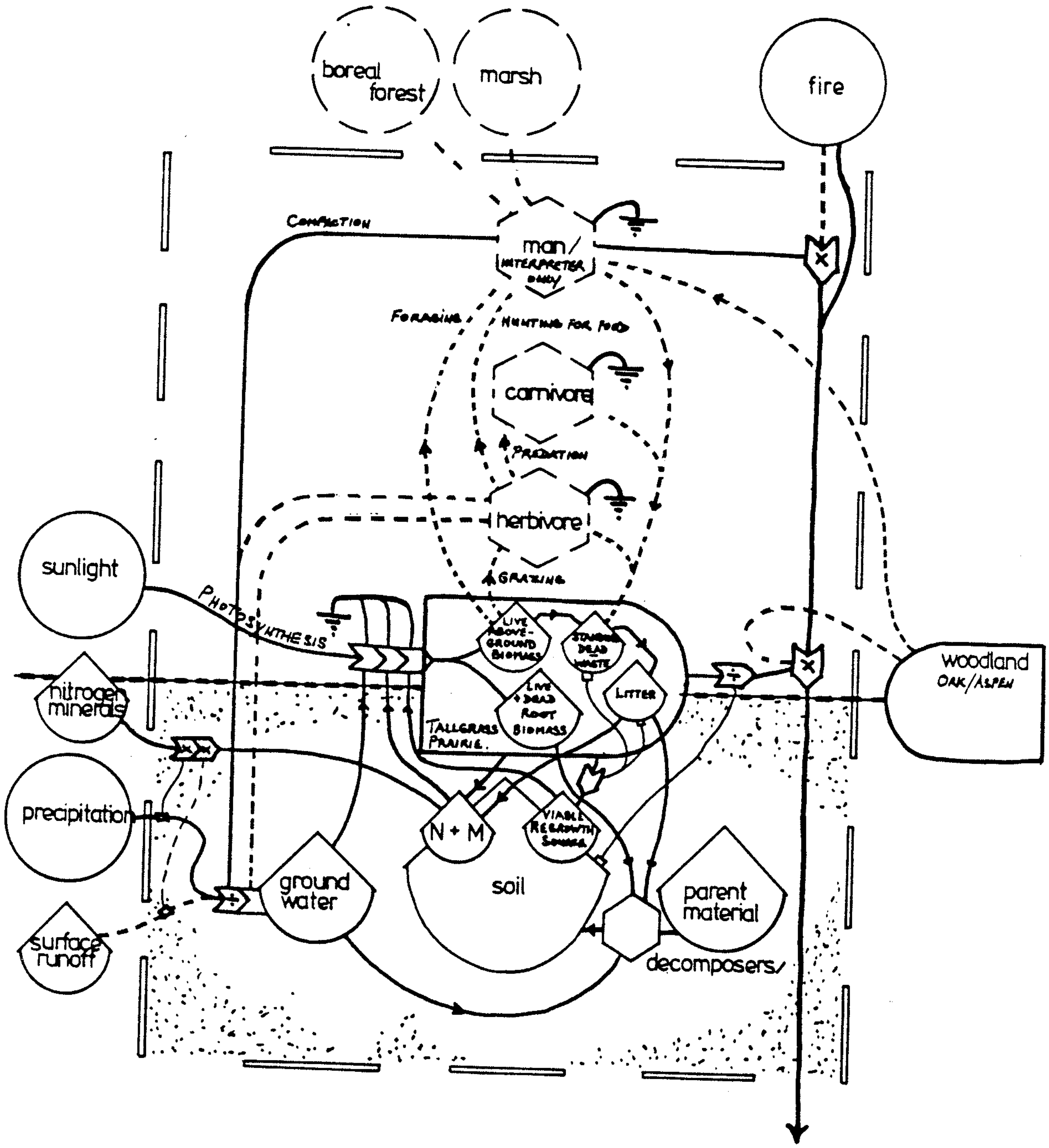


Fig. 1.26 The relics of the St. James Prairie ecosystem

REFERENCES TO RELATED READING ON

"A SYSTEMS VIEW"

1. Odum and Odum, Energy Basis for Man and Nature (New York: McGraw-Hill Book Co., 1976).

2. A. I. Breymeyer and G. M. Van Dyne (eds.), IBP19--Grasslands, Systems Analysis and Man (London: Cambridge University Press, 1980).

3. Ramón Margalef, Perspectives in Ecological Theory (Chicago: University of Chicago Press, 1968).

4. Henry T. Lewis, "Indian Fires of Spring--Hunters and gatherers of the Canadian boreal forest shaped their habitat with fire," Natural History (January, 1980), pp. 76-80.

1.5 Summary

In looking at tallgrass prairie what emerges is a line of thought that represents a developing systems context, from very general cultural models to more site-specific ones that are derived from a specialized working-context (Fig. 1.27).

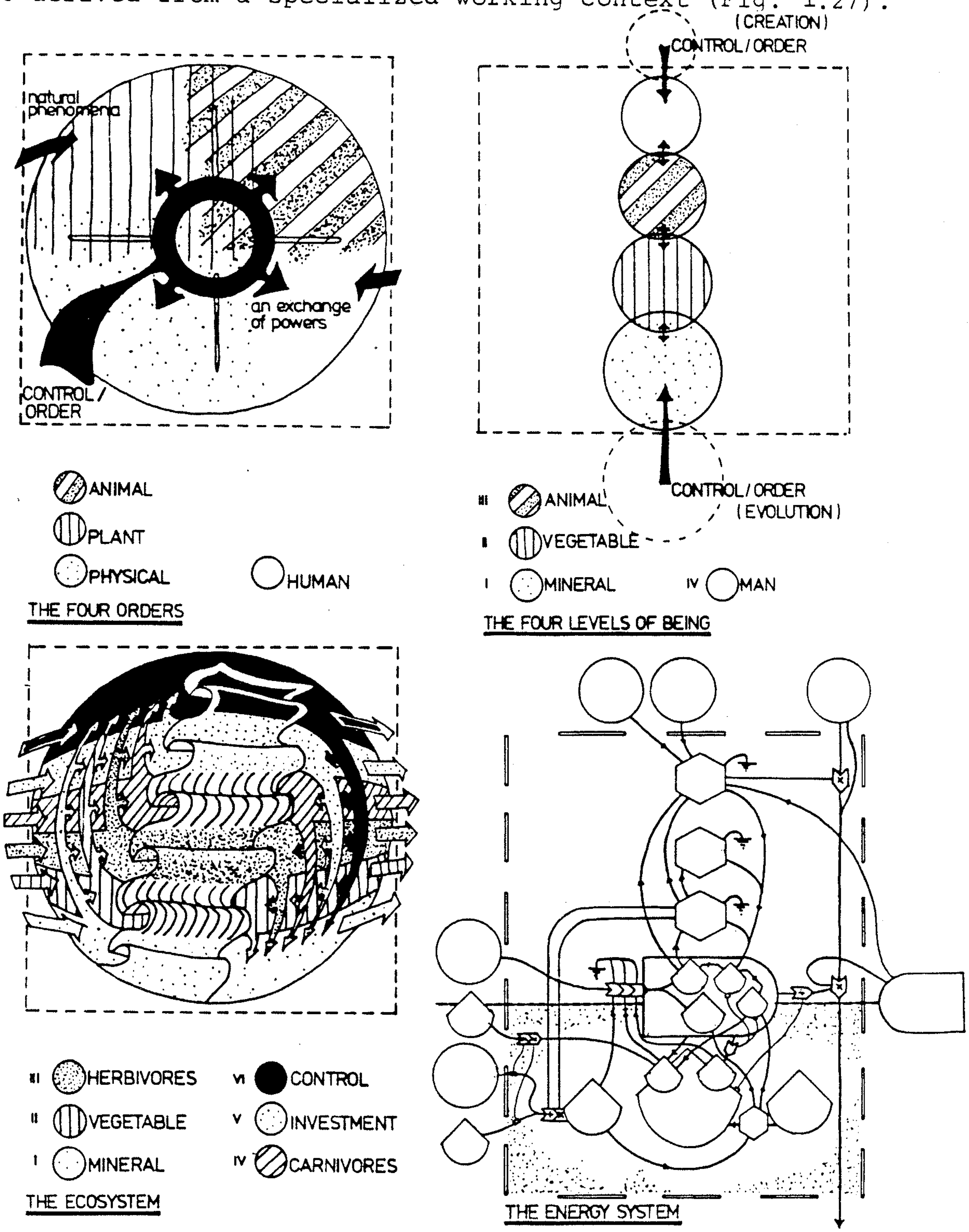


Fig. 1.27 A developing systems context

The native view identified the uniqueness of all beings and their role as a part of one whole system. An explanation of the exchange of powers/energies was central to their beliefs. The immigrant view lost sight of relationships but quantified information on the parts of the system. The ecological view combined the parts and the energy exchange but had no concise way of representing controls or investments of energy. But a systems view has developed a symbolic vocabulary that allows us to relate parts and processes -- and furthermore to quantify the processes.

One of our goals as designers/interpreters should be to explore and explain, not solely plant material, but the context of ecosystems as the tools of our trade -- to educate, to promote wisdom not technology as an end in itself. Understanding and participation, for the client/public, in the design process is just as important in achieving this end as is the example of an ecologically sound design solution. The solution will not be generally acceptable until the rationale behind it is clear.

This does not mean advocating the indiscriminate use of native plant material. Plant selection depends on what ends are to be achieved, the definition of a problem, but mostly an understanding of context and a measure of solutions against alternative solutions, including those of nature. Tallgrass prairie is not "natural" in the sense that one of the key factors in its evolution was man-made fire. Understanding our context requires an increased understanding of fields of study such as ecology and energetics.

> Ecology is the one science that possesses the ability to recapture the experience of PERSONALITY in nature. And it comes into its own as a profession at exactly the same time that an intense awareness of PERSONHOOD (an individual's right to self-discovery) enters our political life. We have begun to liberate the Earth from her false identity -- the mechanistic-reductionistic image which has made nature into an unfeeling manipulation -- just as we begin to fight our way free of the false identities which have made human beings the objects of social power. (Roszak, Person/Plant, p. 58)

Is this not a call for a Model of Reality similar to that advocated by the native people and ecologists alike, with personality in nature and recognition of the uniqueness of the individual spirit in all levels of being? Is it accidental that such thought should emerge as we prepare to return to a steady-state economy, without the luxury of excess energy from fossil fuels? Is this an example of cultural pre-adaptation? Could it be that our thought originates in the larger system of things? Lovelock and Epton, environmental scientists, have developed in their GAIA (Mother Earth) HYPOTHESIS just such a proposition.

> It appeared to us that the Earth's biosphere was able to control at least the temperature of the Earth's surface and the composition of the atmosphere...This led us to the formulation of the proposition that living matter, the air, the oceans, the land surfaces were parts of a giant system which was able to control temperature, the composition of the air and sea, the pH of the soil and so on, so as to be optimum for SURVIVAL OF THE BIOSPHERE. The system seemed to exhibit the behaviour of a single organism...One of the laws of system control is that, if a system is to maintain stability (balance), it must possess adequate variety of response...What is to be feared is that man-the-farmer and man-the-engineer are reducing the

> total variety of response open to GAIA...Natural distribution of plants and animals is being changed, ecological systems destroyed, and whole species altered or deleted. (Roszak, Person/Plant, p. 39)

The saving of tallgrass prairie is of global concern, and hopefully some of the criteria significant to its survival -- and man's survival -- are represented in the plant record. The question is: Can we convince the public that damage has been done, and do we have time enough to reduce the extent of the damage? (Fig. 1.28)

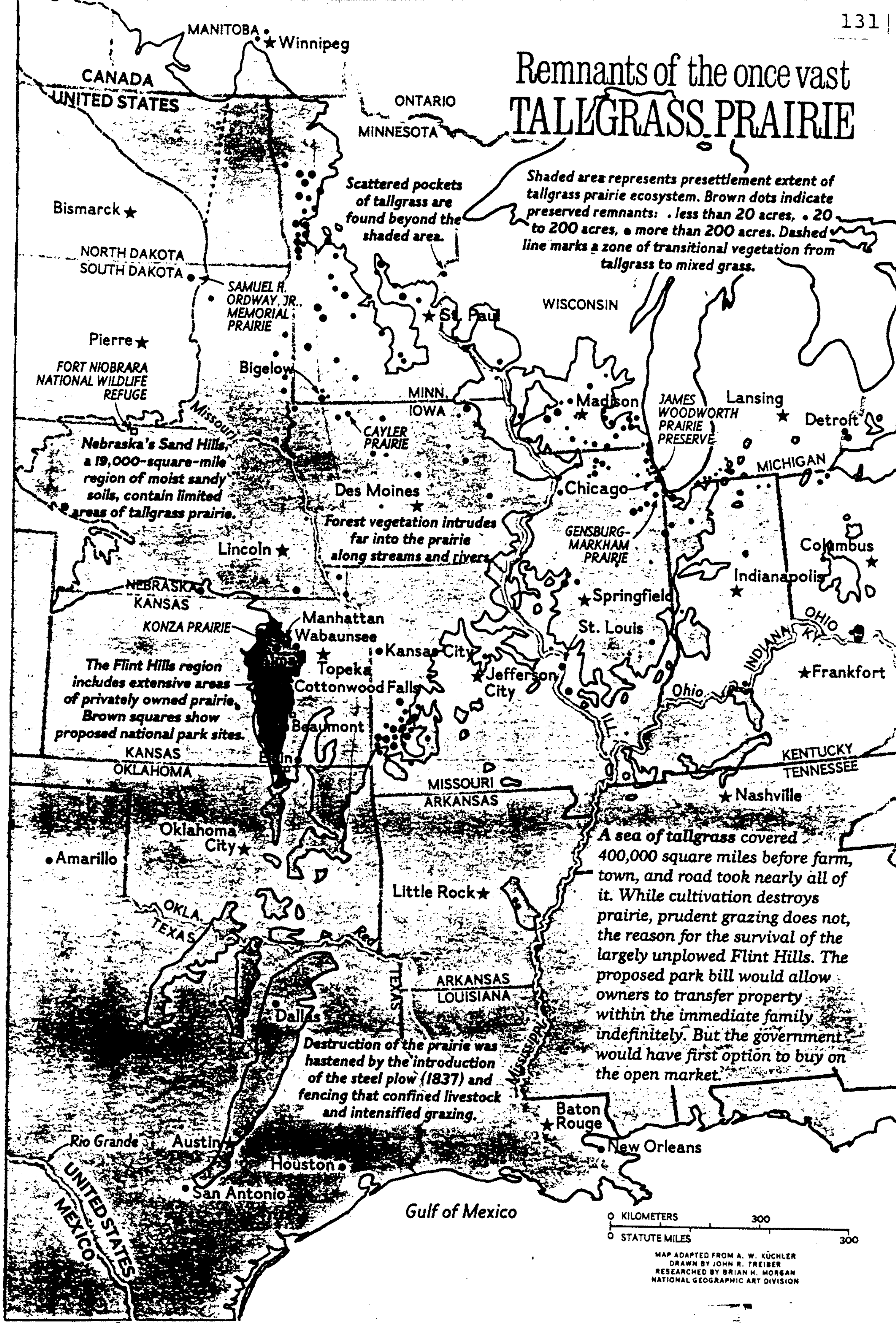


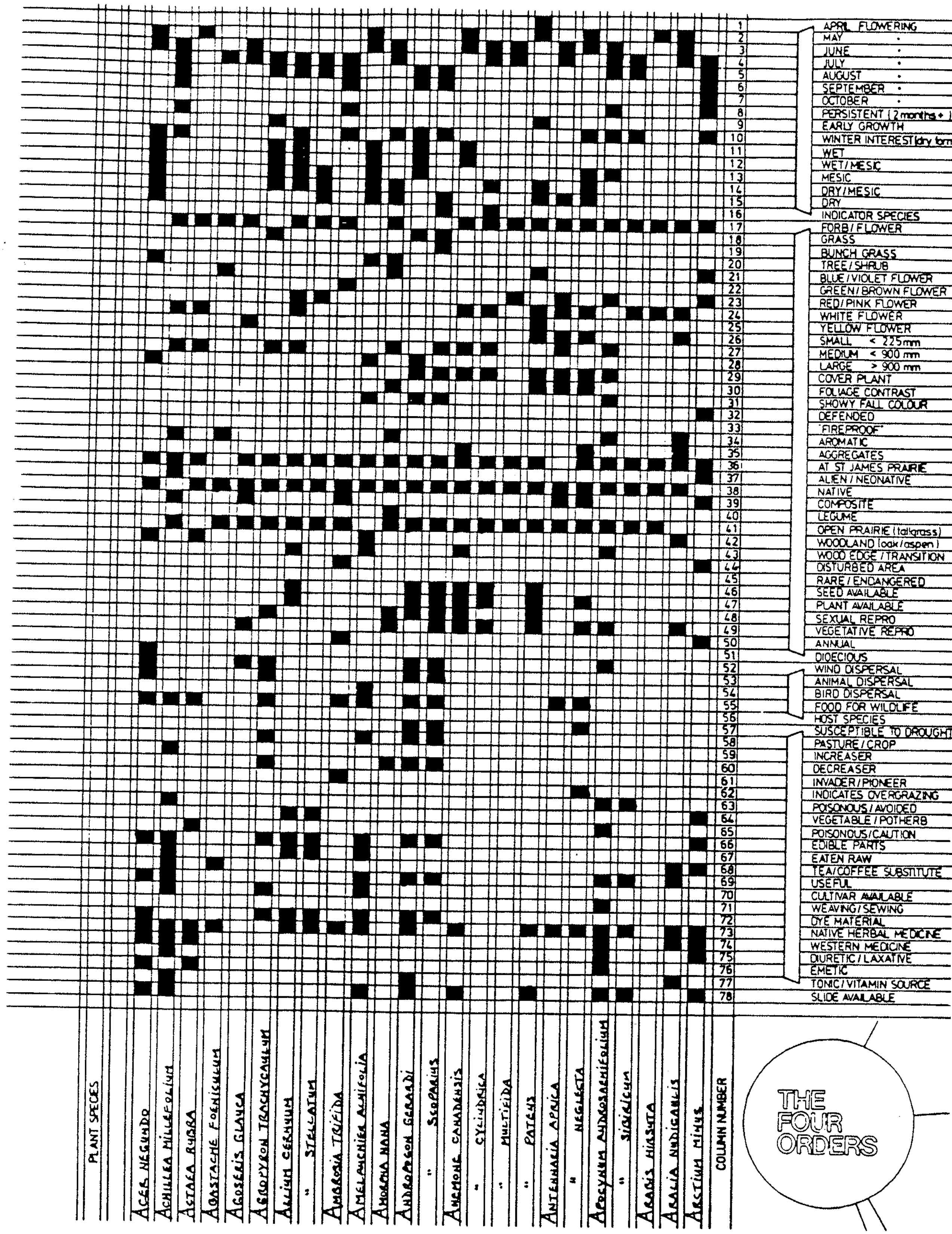
Fig. 1.28 The once vast tallgrass prairie
(extracted from National Geographic, January 1980).

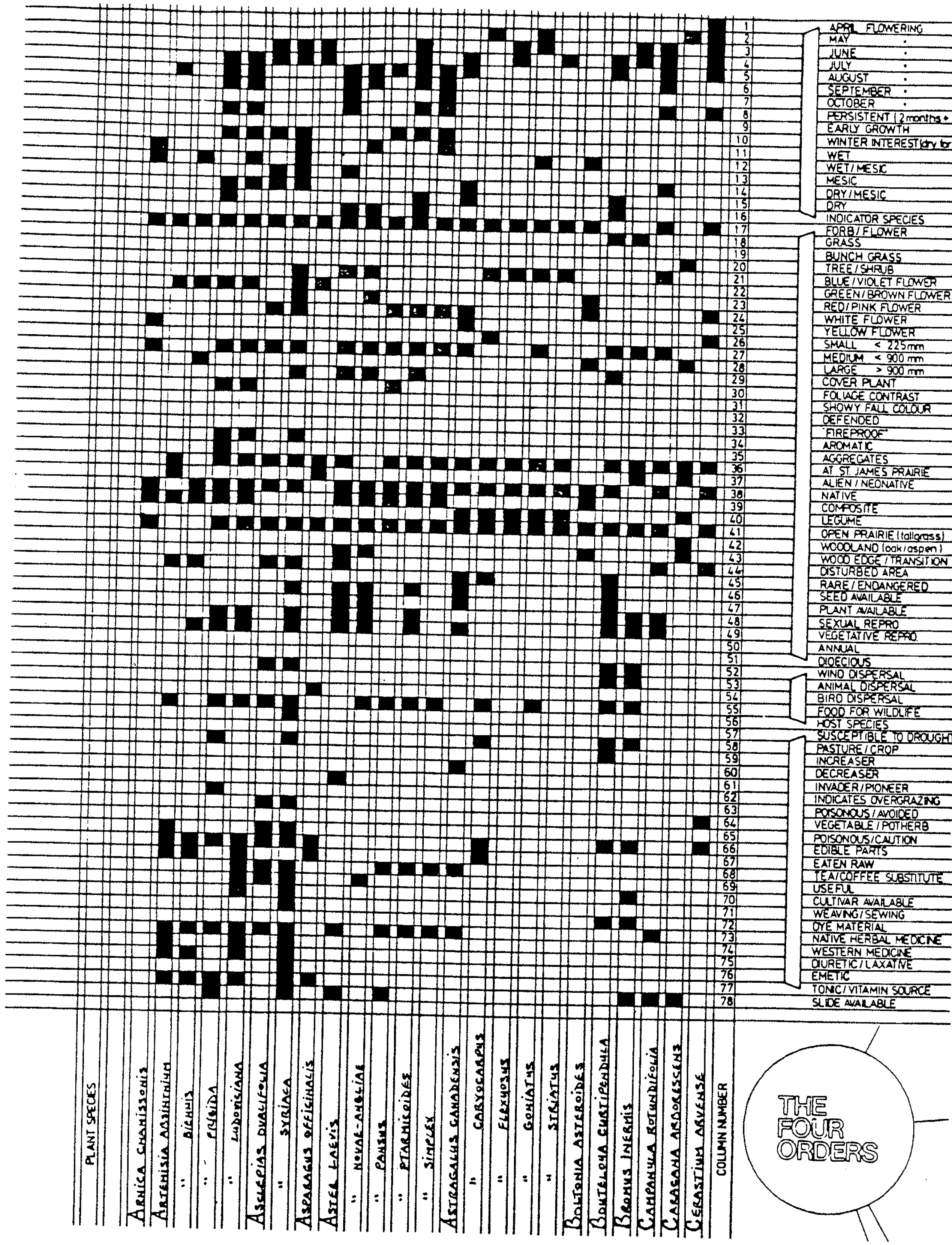
APPENDIX 2

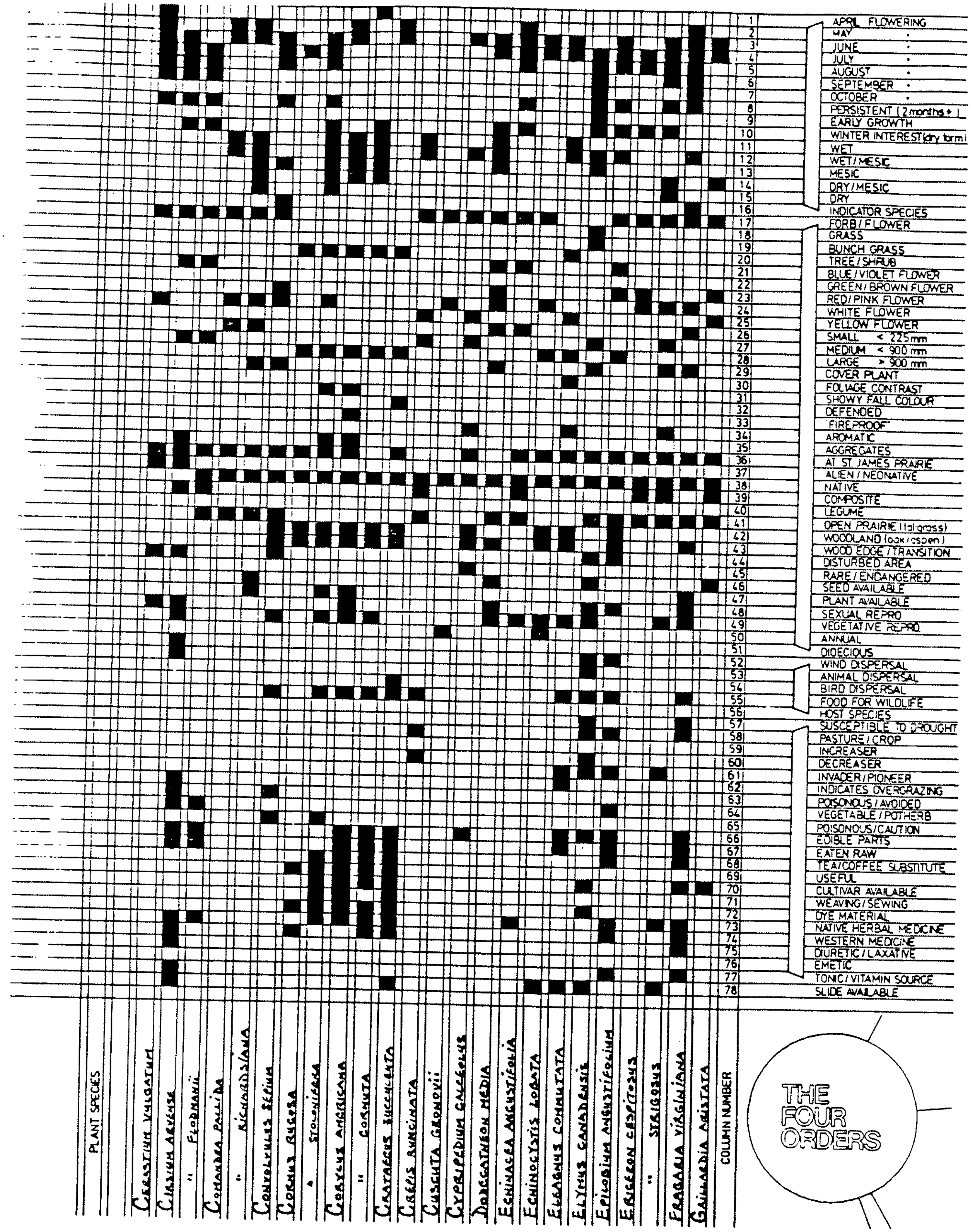
A FILE ON TALLGRASS PRAIRIE SPECIES

2.1 The File

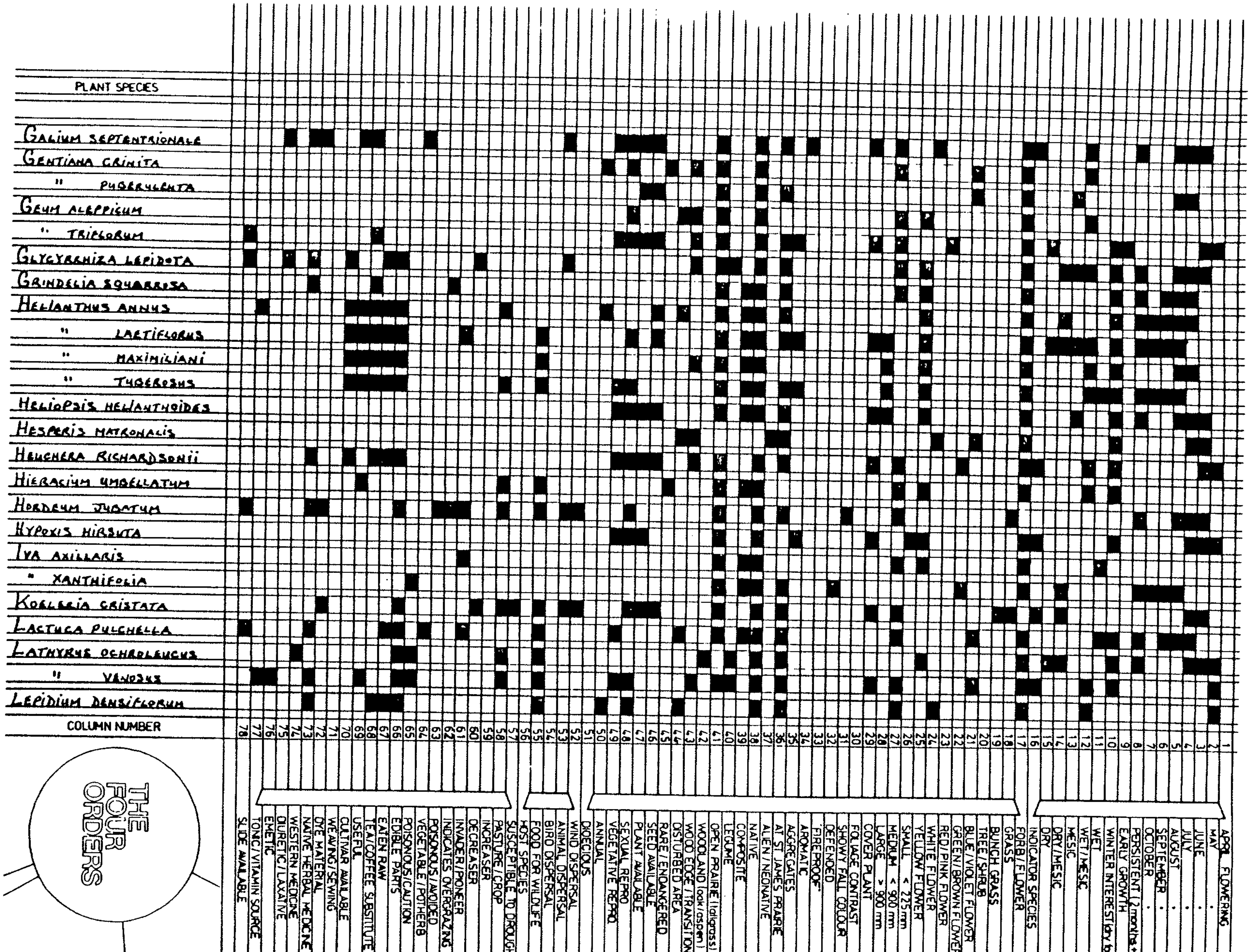
Plants in the file are those that occur at the St. James Prairie. Native woodland species and introduced species for a one-time holmstead site are included, along with species that characterise the true or tallgrass prairie. Added to this list of 169 species are 17 plants associated with tallgrass prairie elsewhere in Manitoba, to give a total of 186 species. The records are presented in alphabetical order according to a plant's botanical name. Sources of information for individual criteria are listed in the appendix.

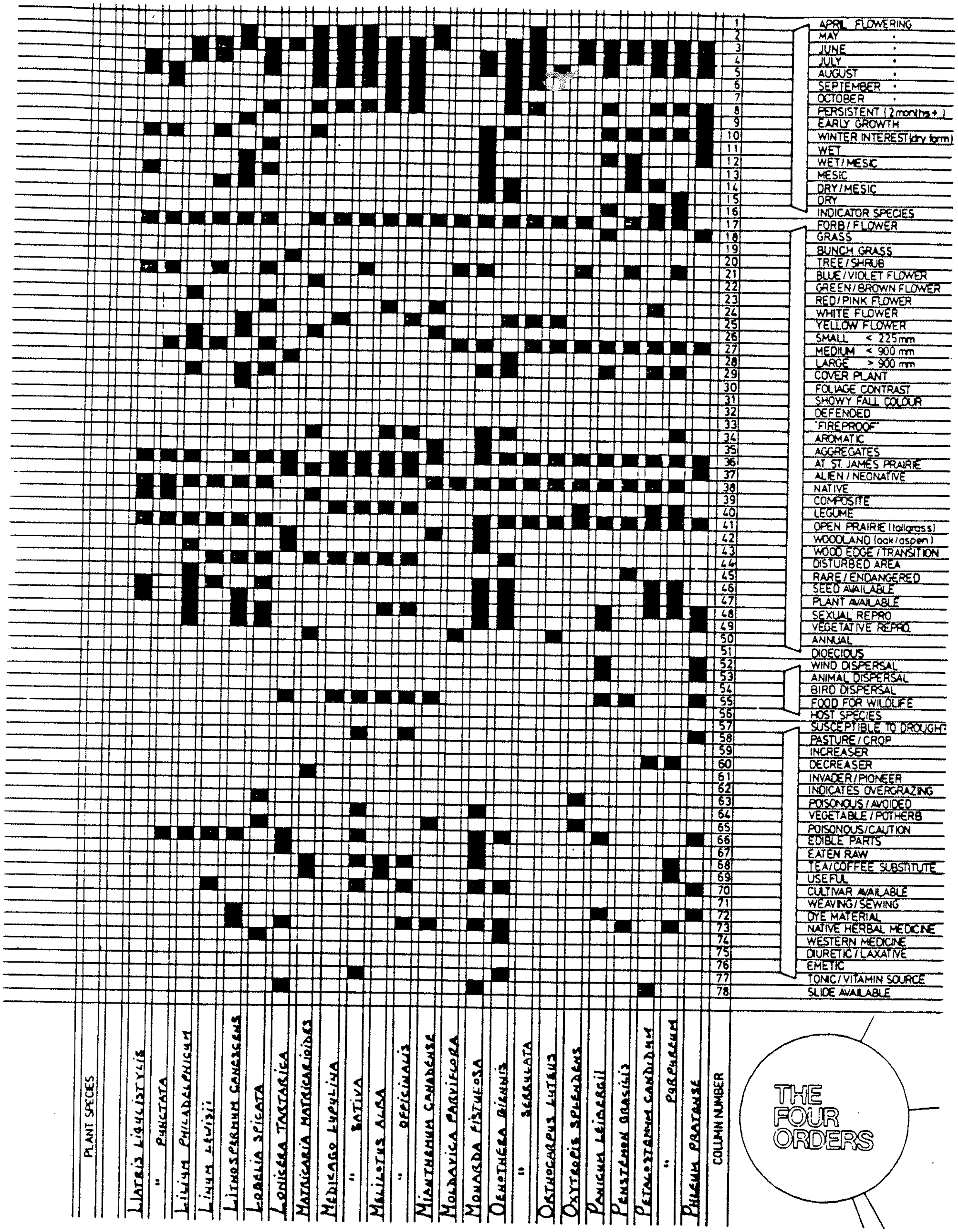

1 APRIL FLOWERING
2 MAY "
3 JUNE "
4 JULY "
5 AUGUST "
6 SEPTEMBER "
7 OCTOBER "
8 PERSISTENT (2 months +)
9 EARLY GROWTH
10 WINTER INTEREST (dry form)
11 WET
12 WET/MESIC
13 MESIC
14 DRY/MESIC
15 DRY
16 INDICATOR SPECIES
17 FORB/FLOWER
18 GRASS
19 BUNCH GRASS
20 TREE/SHRUB
21 BLUE/VIOLET FLOWER
22 GREEN/BROWN FLOWER
23 RED/PINK FLOWER
24 WHITE FLOWER
25 YELLOW FLOWER
26 SMALL < 225mm
27 MEDIUM < 900 mm
28 LARGE > 900 mm
29 COVER PLANT
30 FOLIAGE CONTRAST
31 SHOWY FALL COLOUR
32 DEFENDED
33 "FIREPROOF"
34 AROMATIC
35 AGGREGATES
36 AT ST JAMES PRAIRIE
37 ALIEN / NEONATIVE
38 NATIVE
39 COMPOSITE
40 LEGUME
41 OPEN PRAIRIE (tallgrass)
42 WOODLAND (oak/aspen)
43 WOOD EDGE / TRANSITION
44 DISTURBED AREA
45 RARE / ENDANGERED
46 SEED AVAILABLE
47 PLANT AVAILABLE
48 SEXUAL REPRO
49 VEGETATIVE REPRO
50 ANNUAL
51 DIOECIOUS
52 WIND DISPERSAL
53 ANIMAL DISPERSAL
54 BIRD DISPERSAL
55 FOOD FOR WILDLIFE
56 HOST SPECIES
57 SUSCEPTIBLE TO DROUGHT
58 PASTURE / CROP
59 INCREASER
60 DECREASER
61 INVADER / PIONEER
62 INDICATES OVERGRAZING
63 POISONOUS / AVOIDED
64 VEGETABLE / POTHERB
65 POISONOUS / CAUTION
66 EDIBLE PARTS
67 EATEN RAW
68 TEA/COFFEE SUBSTITUTE
69 USEFUL
70 CULTIVAR AVAILABLE
71 WEAVING/SEWING
72 DYE MATERIAL
73 NATIVE HERBAL MEDICINE
74 WESTERN MEDICINE
75 DIURETIC / LAXATIVE
76 EMETIC
77 TONIC / VITAMIN SOURCE
78 SLIDE AVAILABLE
PLANT SPECIES
Acer negundo
Achillea millefolium
Actaea rubra
Agastache foeniculum
Agoseris glauca
Agropyron trachycaulum
Allium cernuum
" stellatum
Ambrosia trifida
Amelanchier alnifolia
Amorpha nana
Andropogon gerardi
" scoparius
Anemone canadensis
" cylindrica
" multifida
" patens
Antennaria aprica
" neglecta
Apocynum androsaemifolium
" sibiricum
Arabis hirsuta
Aralia nudicaulis
Arctium minus
COLUMN NUMBER
THE FOUR ORDERS

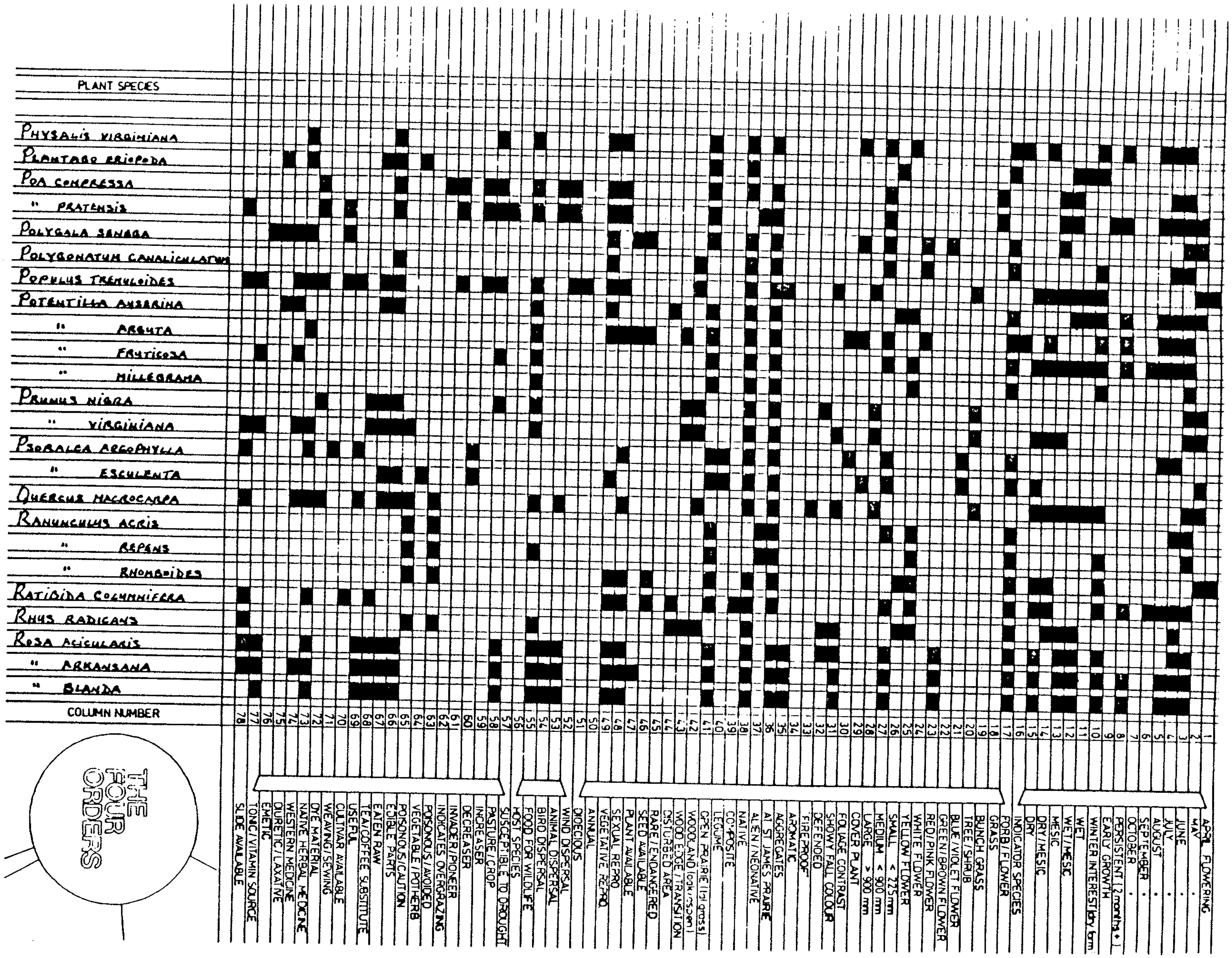

1 APRIL FLOWERING
2 MAY "
3 JUNE "
4 JULY "
5 AUGUST "
6 SEPTEMBER "
7 OCTOBER "
8 PERSISTENT (2 months +)
9 EARLY GROWTH
10 WINTER INTEREST (dry form)
11 WET
12 WET/MESIC
13 MESIC
14 DRY/MESIC
15 DRY
16 INDICATOR SPECIES
17 FORB/FLOWER
18 GRASS
19 BUNCH GRASS
20 TREE/SHRUB
21 BLUE/VIOLET FLOWER
22 GREEN/BROWN FLOWER
23 RED/PINK FLOWER
24 WHITE FLOWER
25 YELLOW FLOWER
26 SMALL < 225mm
27 MEDIUM < 900 mm
28 LARGE > 900 mm
29 COVER PLANT
30 FOLIAGE CONTRAST
31 SHOWY FALL COLOUR
32 DEFENDED
33 "FIREPROOF"
34 AROMATIC
35 AGGREGATES
36 AT ST. JAMES PRAIRIE
37 ALIEN / NEONATIVE
38 NATIVE
39 COMPOSITE
40 LEGUME
41 OPEN PRAIRIE (tallgrass)
42 WOODLAND (oak/aspen)
43 WOOD EDGE / TRANSITION
44 DISTURBED AREA
45 RARE / ENDANGERED
46 SEED AVAILABLE
47 PLANT AVAILABLE
48 SEXUAL REPRO
49 VEGETATIVE REPRO.
50 ANNUAL
51 DIOECIOUS
52 WIND DISPERSAL
53 ANIMAL DISPERSAL
54 BIRD DISPERSAL
55 FOOD FOR WILDLIFE
56 HOST SPECIES
57 SUSCEPTIBLE TO DROUGHT
58 PASTURE / CROP
59 INCREASER
60 DECREASER
61 INVADER / PIONEER
62 INDICATES OVERGRAZING
63 POISONOUS / AVOIDED
64 VEGETABLE / POTHERB
65 POISONOUS / CAUTION
66 EDIBLE PARTS
67 EATEN RAW
68 TEA/COFFEE SUBSTITUTE
69 USEFUL
70 CULTIVAR AVAILABLE
71 WEAVING / SEWING
72 DYE MATERIAL
73 NATIVE HERBAL MEDICINE
74 WESTERN MEDICINE
75 DIURETIC / LAXATIVE
76 EMETIC
77 TONIC / VITAMIN SOURCE
78 SLIDE AVAILABLE
PLANT SPECIES
ARNICA CHAMISSONIS
ARTEMISIA ABSINTHIUM
" BIENNIS
" FRIGIDA
" LUDOVICIANA
ASCLEPIAS OVALIFOLIA
" SYRIACA
ASPARAGUS OFFICINALIS
ASTER LAEVIS
" NOVAE-ANGLIAE
" PANSUS
" PTARMICOIDES
" SIMPLEX
ASTRAGALUS CANADENSIS
" CARYOCARPUS
" FLEXUOSUS
" GONIATUS
" STRIATUS
BOLTONIA ASTEROIDES
BOUTELOUA CURTIPENDULA
BROMUS INERMIS
CAMPANULA ROTUNDIFOLIA
CARAGANA ARBORESCENS
CERASTIUM ARVENSE
COLUMN NUMBER
THE FOUR ORDERS

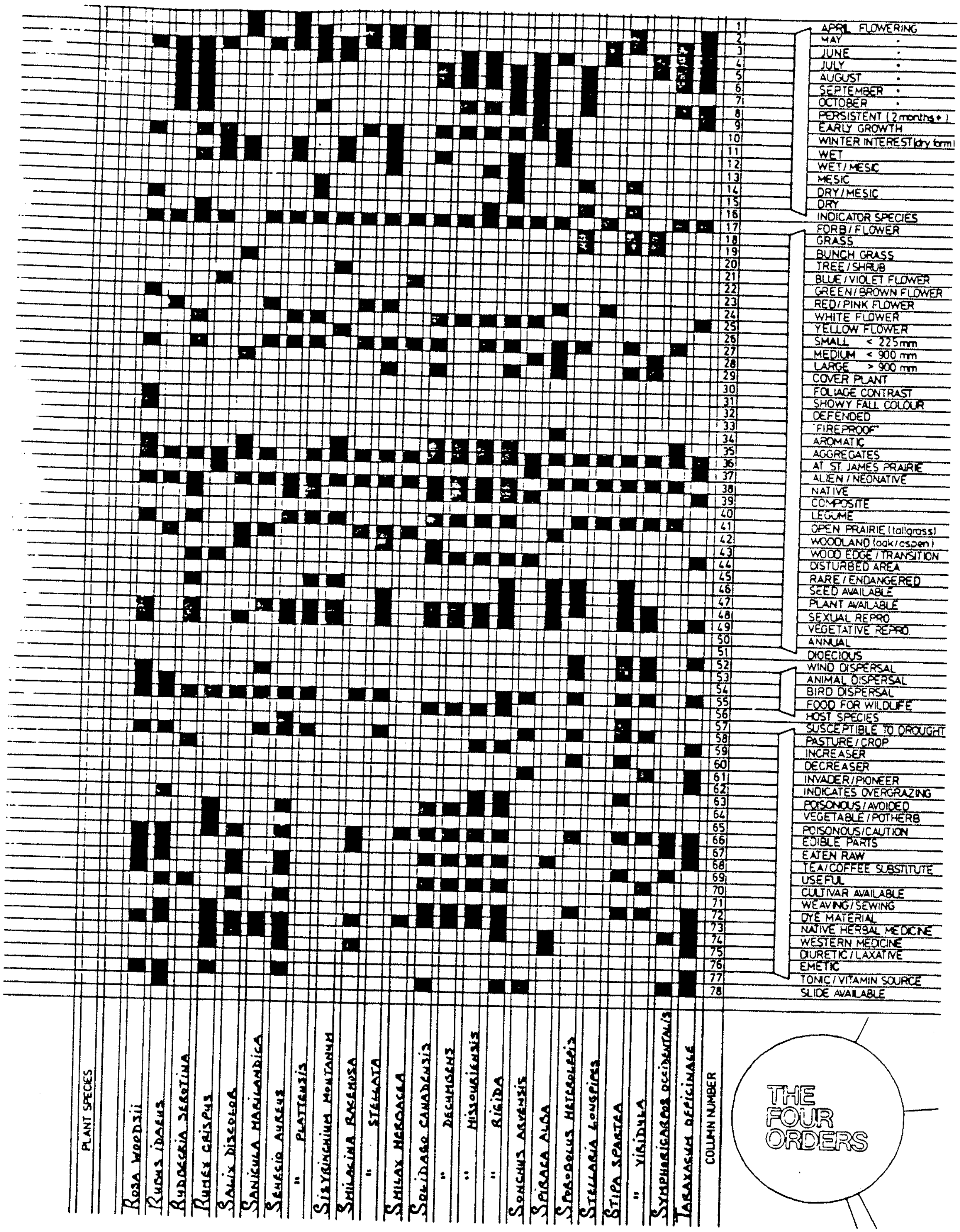


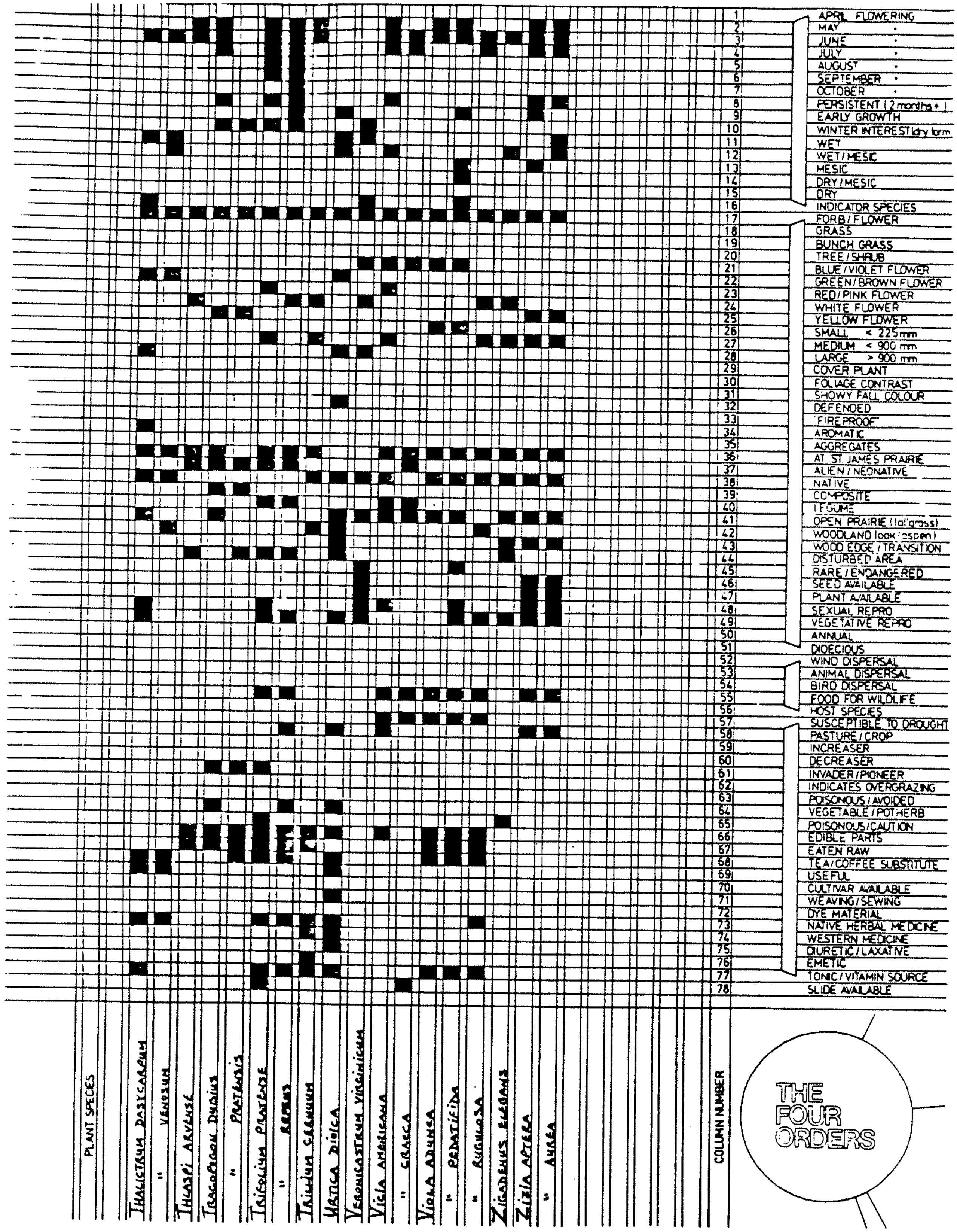
THE FOUR ORDERS


PLANT SPECIES
Galium septentrionale
Gentiana crinita
" puberulenta
Geum aleppicum
" triflorum
Glycyrrhiza lepidota
Grindelia squarrosa
Helianthus annus
" laetiflorus
" maximiliani
" tuberosus
Heliopsis helianthoides
Hesperis matronalis
Heuchera richardsonii
Hieracium umbellatum
Hordeum jubatum
Hypoxis hirsuta
Iva axillaris
" xanthifolia
Koeleria cristata
Lactuca pulchella
Lathyrus ochroleucus
" venosus
Lepidium densiflorum
COLUMN NUMBER
THE FOUR ORDERS
SLIDE AVAILABLE
TONIC/VITAMIN SOURCE
EMETIC
DIURETIC/LAXATIVE
WESTERN MEDICINE
NATIVE HERBAL MEDICINE
DYE MATERIAL
WEAVING/SEWING
CULTIVAR AVAILABLE
USEFUL
TEA/COFFEE SUBSTITUTE
EATEN RAW
EDIBLE PARTS
POISONOUS/CAUTION
VEGETABLE/POTHERB
POISONOUS/AVOIDED
INDICATES OVERGRAZING
INVADER/PIONEER
DECREASER
INCREASER
PASTURE/CROP
SUSCEPTIBLE TO DROUGHT
HOST SPECIES
FOOD FOR WILDLIFE
BIRD DISPERSAL
ANIMAL DISPERSAL
WIND DISPERSAL
DIOECIOUS
ANNUAL
VEGETATIVE REPRO
SEXUAL REPRO
PLANT AVAILABLE
SEED AVAILABLE
RARE/ENDANGERED
DISTURBED AREA
WOOD EDGE/TRANSITION
WOODLAND (oak/aspen)
OPEN PRAIRIE (tallgrass)
LEGUME
COMPOSITE
NATIVE
ALIEN/NEONATIVE
AT ST. JAMES PRAIRIE
AGGREGATES
AROMATIC
"FIREPROOF"
DEFENDED
SHOWY FALL COLOUR
FOLIAGE CONTRAST
COVER PLANT
LARGE > 900 mm
MEDIUM < 900 mm
SMALL < 225 mm
YELLOW FLOWER
WHITE FLOWER
RED/PINK FLOWER
GREEN/BROWN FLOWER
BLUE/VIOLET FLOWER
TREE/SHRUB
BUNCH GRASS
GRASS
FORB/FLOWER
INDICATOR SPECIES
DRY
DRY/MESIC
MESIC
WET/MESIC
WET
WINTER INTEREST(dry form)
EARLY GROWTH
PERSISTENT (2 months+)
OCTOBER
SEPTEMBER
AUGUST
JULY
JUNE
MAY
APRIL FLOWERING


1 APRIL FLOWERING
2 MAY "
3 JUNE "
4 JULY "
5 AUGUST "
6 SEPTEMBER "
7 OCTOBER "
8 PERSISTENT (2 months +)
9 EARLY GROWTH
10 WINTER INTEREST (dry form)
11 WET
12 WET/MESIC
13 MESIC
14 DRY/MESIC
15 DRY
16 INDICATOR SPECIES
17 FORB/FLOWER
18 GRASS
19 BUNCH GRASS
20 TREE/SHRUB
21 BLUE/VIOLET FLOWER
22 GREEN/BROWN FLOWER
23 RED/PINK FLOWER
24 WHITE FLOWER
25 YELLOW FLOWER
26 SMALL < 225mm
27 MEDIUM < 900 mm
28 LARGE > 900 mm
29 COVER PLANT
30 FOLIAGE CONTRAST
31 SHOWY FALL COLOUR
32 DEFENDED
33 "FIREPROOF"
34 AROMATIC
35 AGGREGATES
36 AT ST. JAMES PRAIRIE
37 ALIEN / NEONATIVE
38 NATIVE
39 COMPOSITE
40 LEGUME
41 OPEN PRAIRIE (tallgrass)
42 WOODLAND (oak/aspen)
43 WOOD EDGE / TRANSITION
44 DISTURBED AREA
45 RARE / ENDANGERED
46 SEED AVAILABLE
47 PLANT AVAILABLE
48 SEXUAL REPRO
49 VEGETATIVE REPRO.
50 ANNUAL
51 DIOECIOUS
52 WIND DISPERSAL
53 ANIMAL DISPERSAL
54 BIRD DISPERSAL
55 FOOD FOR WILDLIFE
56 HOST SPECIES
57 SUSCEPTIBLE TO DROUGHT
58 PASTURE / CROP
59 INCREASER
60 DECREASER
61 INVADER / PIONEER
62 INDICATES OVERGRAZING
63 POISONOUS / AVOIDED
64 VEGETABLE / POTHERB
65 POISONOUS / CAUTION
66 EDIBLE PARTS
67 EATEN RAW
68 TEA/COFFEE SUBSTITUTE
69 USEFUL
70 CULTIVAR AVAILABLE
71 WEAVING / SEWING
72 DYE MATERIAL
73 NATIVE HERBAL MEDICINE
74 WESTERN MEDICINE
75 DIURETIC / LAXATIVE
76 EMETIC
77 TONIC / VITAMIN SOURCE
78 SLIDE AVAILABLE
PLANT SPECIES
LIATRIS LIGULISTYLIS
" PUNCTATA
LILIUM PHILADELPHICUM
LINUM LEWISII
LITHOSPERMUM CANESCENS
LOBELIA SPICATA
LONICERA TARTARICA
MATRICARIA MATRICARIOIDES
MEDICAGO LUPULINA
" SATIVA
MELILOTUS ALBA
" OFFICINALIS
MIANTHEMUM CANADENSE
MOLDAVICA PARVIFLORA
MONARDA FISTULOSA
OENOTHERA BIENNIS
" SERRULATA
ORTHOCARPUS LUTEUS
OXYTROPIS SPLENDENS
PANICUM LEIBERGII
PENSTEMON GRACILIS
PETALOSTEMUM CANDIDUM
" PURPUREUM
PHLEUM PRATENSE
COLUMN NUMBER
THE FOUR ORDERS


PLANT SPECIES
Physalis virginiana
Plantago eriopoda
Poa compressa
" pratensis
Polygala senega
Polygonatum canaliculatum
Populus tremuloides
Potentilla anserina
" arguta
" fruticosa
" millegrama
Prunus nigra
" virginiana
Psoralea argophylla
" esculenta
Quercus macrocarpa
Ranunculus acris
" repens
" rhomboides
Ratibida columnifera
Rhus radicans
Rosa acicularis
" arkansana
" blanda
COLUMN NUMBER
THE FOUR ORDERS
78 SLIDE AVAILABLE
77 TONIC/VITAMIN SOURCE
76 EMETIC
75 DIURETIC/LAXATIVE
74 WESTERN MEDICINE
73 NATIVE HERBAL MEDICINE
72 DYE MATERIAL
71 WEAVING/SEWING
70 CULTIVAR AVAILABLE
69 USEFUL
68 TEA/COFFEE SUBSTITUTE
67 EATEN RAW
66 EDIBLE PARTS
65 POISONOUS/CAUTION
64 VEGETABLE/POTHERB
63 POISONOUS/AVOIDED
62 INDICATES OVERGRAZING
61 INVADER/PIONEER
60 DECREASER
59 INCREASER
58 PASTURE/CROP
57 SUSCEPTIBLE TO DROUGHT
56 HOST SPECIES
55 FOOD FOR WILDLIFE
54 BIRD DISPERSAL
53 ANIMAL DISPERSAL
52 WIND DISPERSAL
51 DIOECIOUS
50 ANNUAL
49 VEGETATIVE REPRO
48 SEXUAL REPRO
47 PLANT AVAILABLE
46 SEED AVAILABLE
45 RARE/ENDANGERED
44 DISTURBED AREA
43 WOOD EDGE/TRANSITION
42 WOODLAND (oak/aspen)
41 OPEN PRAIRIE (tal grass)
40 LEGUME
39 COMPOSITE
38 NATIVE
37 ALIEN/NEONATIVE
36 AT ST JAMES PRAIRIE
35 AGGREGATES
34 AROMATIC
33 FIREPROOF
32 DEFENDED
31 SHOWY FALL COLOUR
30 FOLIAGE CONTRAST
29 COVER PLANT
28 LARGE > 900 mm
27 MEDIUM < 900 mm
26 SMALL < 225 mm
25 YELLOW FLOWER
24 WHITE FLOWER
23 RED/PINK FLOWER
22 GREEN/BROWN FLOWER
21 BLUE/VIOLET FLOWER
20 TREE/SHRUB
19 BUNCH GRASS
18 GRASS
17 FORB/FLOWER
16 INDICATOR SPECIES
15 DRY
14 DRY/MESIC
13 MESIC
12 WET/MESIC
11 WET
10 WINTER INTEREST (dry form)
9 EARLY GROWTH
8 PERSISTENT (2 months+)
7 OCTOBER
6 SEPTEMBER
5 AUGUST
4 JULY
3 JUNE
2 MAY
1 APRIL FLOWERING


1 APRIL FLOWERING
2 MAY "
3 JUNE "
4 JULY "
5 AUGUST "
6 SEPTEMBER "
7 OCTOBER "
8 PERSISTENT (2 months+)
9 EARLY GROWTH
10 WINTER INTEREST (dry form)
11 WET
12 WET/MESIC
13 MESIC
14 DRY/MESIC
15 DRY
16 INDICATOR SPECIES
17 FORB/FLOWER
18 GRASS
19 BUNCH GRASS
20 TREE/SHRUB
21 BLUE/VIOLET FLOWER
22 GREEN/BROWN FLOWER
23 RED/PINK FLOWER
24 WHITE FLOWER
25 YELLOW FLOWER
26 SMALL < 225mm
27 MEDIUM < 900 mm
28 LARGE > 900 mm
29 COVER PLANT
30 FOLIAGE CONTRAST
31 SHOWY FALL COLOUR
32 DEFENDED
33 "FIREPROOF"
34 AROMATIC
35 AGGREGATES
36 AT ST. JAMES PRAIRIE
37 ALIEN/NEONATIVE
38 NATIVE
39 COMPOSITE
40 LEGUME
41 OPEN PRAIRIE (tallgrass)
42 WOODLAND (oak/aspen)
43 WOOD EDGE/TRANSITION
44 DISTURBED AREA
45 RARE/ENDANGERED
46 SEED AVAILABLE
47 PLANT AVAILABLE
48 SEXUAL REPRO
49 VEGETATIVE REPRO
50 ANNUAL
51 DIOECIOUS
52 WIND DISPERSAL
53 ANIMAL DISPERSAL
54 BIRD DISPERSAL
55 FOOD FOR WILDLIFE
56 HOST SPECIES
57 SUSCEPTIBLE TO DROUGHT
58 PASTURE/CROP
59 INCREASER
60 DECREASER
61 INVADER/PIONEER
62 INDICATES OVERGRAZING
63 POISONOUS/AVOIDED
64 VEGETABLE/POTHERB
65 POISONOUS/CAUTION
66 EDIBLE PARTS
67 EATEN RAW
68 TEA/COFFEE SUBSTITUTE
69 USEFUL
70 CULTIVAR AVAILABLE
71 WEAVING/SEWING
72 DYE MATERIAL
73 NATIVE HERBAL MEDICINE
74 WESTERN MEDICINE
75 DIURETIC/LAXATIVE
76 EMETIC
77 TONIC/VITAMIN SOURCE
78 SLIDE AVAILABLE
PLANT SPECIES
Rosa woodsii
Rubus idaeus
Rudbeckia serotina
Rumex crispus
Salix discolor
Sanicula marilandica
Senecio aureus
" plattensis
Sisyrinchium montanum
Smilacina racemosa
" stellata
Smilax herbacea
Solidago canadensis
" decumbens
" missouriensis
" rigida
Sonchus arvensis
Spiraea alba
Sporobolus heterolepis
Stellaria longipes
Stipa spartea
" viridula
Symphoricarpos occidentalis
Taraxacum officinale
COLUMN NUMBER
THE FOUR ORDERS


1 APRIL FLOWERING
2 MAY "
3 JUNE "
4 JULY "
5 AUGUST "
6 SEPTEMBER "
7 OCTOBER "
8 PERSISTENT (2 months+)
9 EARLY GROWTH
10 WINTER INTEREST (dry form)
11 WET
12 WET/MESIC
13 MESIC
14 DRY/MESIC
15 DRY
16 INDICATOR SPECIES
17 FORB/FLOWER
18 GRASS
19 BUNCH GRASS
20 TREE/SHRUB
21 BLUE/VIOLET FLOWER
22 GREEN/BROWN FLOWER
23 RED/PINK FLOWER
24 WHITE FLOWER
25 YELLOW FLOWER
26 SMALL < 225mm
27 MEDIUM < 900 mm
28 LARGE > 900 mm
29 COVER PLANT
30 FOLIAGE CONTRAST
31 SHOWY FALL COLOUR
32 DEFENDED
33 "FIREPROOF"
34 AROMATIC
35 AGGREGATES
36 AT ST JAMES PRAIRIE
37 ALIEN/NEONATIVE
38 NATIVE
39 COMPOSITE
40 LEGUME
41 OPEN PRAIRIE (tallgrass)
42 WOODLAND (oak/aspen)
43 WOOD EDGE/TRANSITION
44 DISTURBED AREA
45 RARE/ENDANGERED
46 SEED AVAILABLE
47 PLANT AVAILABLE
48 SEXUAL REPRO
49 VEGETATIVE REPRO
50 ANNUAL
51 DIOECIOUS
52 WIND DISPERSAL
53 ANIMAL DISPERSAL
54 BIRD DISPERSAL
55 FOOD FOR WILDLIFE
56 HOST SPECIES
57 SUSCEPTIBLE TO DROUGHT
58 PASTURE/CROP
59 INCREASER
60 DECREASER
61 INVADER/PIONEER
62 INDICATES OVERGRAZING
63 POISONOUS/AVOIDED
64 VEGETABLE/POTHERB
65 POISONOUS/CAUTION
66 EDIBLE PARTS
67 EATEN RAW
68 TEA/COFFEE SUBSTITUTE
69 USEFUL
70 CULTIVAR AVAILABLE
71 WEAVING/SEWING
72 DYE MATERIAL
73 NATIVE HERBAL MEDICINE
74 WESTERN MEDICINE
75 DIURETIC/LAXATIVE
76 EMETIC
77 TONIC/VITAMIN SOURCE
78 SLIDE AVAILABLE
PLANT SPECIES
THALICTRUM DASYCARPUM
" VENOSUM
THLASPI ARVENSE
TRAGOPOGON DUBIUS
" PRATENSIS
TRIFOLIUM PRATENSE
" REPENS
TRILLIUM CERNUUM
URTICA DIOICA
VERONICASTRUM VIRGINICUM
VICIA AMERICANA
" CRACCA
VIOLA ADUNCA
" PEDATIFIDA
" RUGULOSA
ZIGADENUS ELEGANS
ZIZIA APTERA
" AUREA
COLUMN NUMBER
THE FOUR ORDERS

2.2 Limitations of the File

If criteria are to be combined sensibly, the user has to have some idea of how much documentation was available for the different criteria

Only documented information is in the file but not all criteria are comprehensively covered. Criteria with poor or incomplete coverage are indicated below (Fig. 2.1).

Poor Coverage	Incomplete Coverage
REPRODUCTIVE METHOD	EARLY GROWTH
METHOD OF DISPERSAL	SOIL MOISTURE PREFERENCE
DIOECIOUS	INDICATOR SPECIES (Soil moisture)
	COVER PLANT
	FORMS AGGREGATES
	SEED AVAILABLE
	PLANT AVAILABLE
	HOST SPECIES

Fig. 2.1 Coverage of criteria

The quantitative assessment of tallgrass prairie species, at St. James, gives an indication of how comprehensive the file is (refer Section 4.1). The fact that the data is processed by computer does not make stored information more accurate, since it was subject to all the errors of omission and contradiction that are a normal part of compiling any such file.

2.3 Sources of Information

Specific sources of information are listed below.

FLOWERING TIME/PERSISTENT
Department of Parks and Recreation (Winnipeg), Living Prairie Museum Plant Check List.

WINTER INTEREST
Jane Embertson, Pods.

SOIL MOISTURE CONDITIONS/INDICATOR SPECIES
Wehr Nature Center, "Five Prairie Segments," A Prairie Propagation Handbook.

Primary sources for the above: John T. Curtis, The Vegetation of Wisconsin; J. E. Weaver, North American Prairie.

BUNCH GRASS
J. E. Weaver, Prairie Plants and Their Environment.

COLOUR OF FLOWER
Department of Parks and Recreation (Winnipeg), Living Prairie Museum Plant Check List.

PLANT HEIGHT
Manitoba Department of Agriculture, Native Manitoba Plants in Bog, Bush and Prairie.

COVER PLANT
Wehr Nature Center, "Prairie Plant History," Prairie Propagation Handbook.

FIREPROOF
Henry T. Lewis, "Indian Fires of Spring, Natural History, (January 1980).

AGGREGATES
J. E. Weaver, Prairie Plants and Their Environment.

AT ST. JAMES
Department of Parks and Recreation (Winnipeg), Living Prairie Museum Plant Check List.

ALIEN/NEONATIVE/NATIVE/COMPOSITE/LEGUME
H. J. Scoggan, Flora of Manitoba.

HABITAT (OPEN PRAIRIE/WOODLAND/WOOD EDGE/DISTURBED AREA)
Department of Parks and Recreation (Winnipeg), Living Prairie Museum Plant Check List.

J. E. Weaver, Prairie Plants and Their Environment.

SEED AVAILABLE/PLANT AVAILABLE

Catalogues from:

- The Windrift Prairie Shop
- The Potting Shed, P.O. Box 1168, Milwaukie, Wis.
- LaFayette Home Nursery Inc., LaFayette, Ill.
- Prairie Nursery, Rt. 1, Box 116, Westfield, Wis.
- Prairie Ridge Nursery, Overland Rd., Mt. Horeb, Wis.

An extensive listing of sources of native plant materials is available from: The Natural Vegetation Subcommittee, Plant Resources Division of the Soil Conservation Society of America, 7515 N.E. Alkeny Road, Alkeny, Iowa 50021.

FOOD FOR WILDLIFE

Martin, Zim, Nelson, American Wildlife and Plants.

SUSCEPTIBLE TO DROUGHT/PASTURE

J. E. Weaver, Prairie Plants and Their Environment.

Canadian Department of Agriculture, Publication 964, Ninety-Nine Range Forage Plants.

CROP

Dilwyn J. Rogers, Edible Medicinal Useful and Poisonous Wild Plants of the Northern Great Plains - South Dakota Region.

INCREASER/DECREASER

J. E. Weaver, Prairie Plants and Their Environment.

INDICATES OVERGRAZING

J. E. Weaver, Prairie Plants and Their Environment.

May Watts, Reading the Landscape of America.

OTHER USES TO MAN

Jackson and Prine, Wild Plants of Central North America.

Nelson Coon, Using Wild and Wayside Plants.

Dilwyn J. Rogers, Edible Medicinal Useful and Poisonous Wild Plants of the Northern Great Plains - South Dakota Region.

Charlotte Ericksen-Brown, Use of Plants - for the past 500 years.

Frances Densmore, How Indians Use Wild Plants for Food, Medicine and Crafts.

APPENDIX 3
THE PROGRAM

```
C
C
C
C     THIS IS SORT2
C
C
      INTEGER ROW,COLMN,NCRIT(10),I,J,K,N,COUNT
C     NCRIT IS AN ARRAY FOR CHOSEN CRITERIA
C     I,J ARE USED TO CONTROL MOVEMENT THROUGH MATRIX
C     K IS THE DATUM POSITION WITHIN NCRIT
C     N IS THE NUMBER OF SORTING CRITERIA IE TOTAL
C
C
      CHARACTER*1 NAMES(186,80)
      CHARACTER*1 MATRIX(186,78)
C
C     DATA FOR NAMES AND MATRIX IS BY ROW FROM FILES.
C
      READ 5,((NAMES(ROW,COLMN),COLMN=1,80),ROW=1,186)
      READ 10,((MATRIX(ROW,COLMN),COLMN=1,78),ROW=1,186)
      EXECUTE INIT
      PRINT 50,(NCRIT(K),K=1,N)
      EXECUTE MATCH
      STOP
C
C
      REMOTE BLOCK INIT
      WRITE(6,20)
      WRITE(6,25)
      WRITE(6,30)
      WRITE(6,35)
      WRITE(6,40)
      WRITE(6,45)
      PRINT ,'HOW MANY CRITERIA ARE YOU COMBINING? (MAX 10)'
      READ,N
      PRINT ,'ENTER CHOSEN CODE NUMBERS.(ON SEPARATE LINES)'
      K=1
              WHILE(K.LE.N) DO
              READ,NCRIT(K)
              K=K+1
              END WHILE
      END BLOCK
C
C
      REMOTE BLOCK MATCH
      ROW=1
      COUNT=0
              WHILE(ROW.LE.186) DO
              K=1
                   WHILE(K.LE.N) DO
                   COLMN=NCRIT(K)
                   IF(MATRIX(ROW,COLMN).NE.'1') GO TO 1000
                   K=K+1
                   END WHILE
      PRINT 55,(NAMES(ROW,COLMN),COLMN=1,80)
      COUNT=COUNT+1
 1000 ROW=ROW+1
              END WHILE
      WRITE(6,60)COUNT
      END BLOCK
C
C
C
C
```

```
      5 FORMAT(80A1)
     10 FORMAT(78A1)
     20 FORMAT(' ',T4,'CODE',T11,'CRITERIA',T26,'CODE',T32,'CRITERIA'//
       *' ',T5,'01',T9,'APRIL FLOWER',T27,'41',T30,'OPEN PRAIRIE'/
       *' ',T5,'02',T9,'MAY',T27,'42',T30,'WOODLAND'/
       *' ',T5,'03',T9,'JUNE',T27,'43',T30,'WOOD EDGE'/
       *' ',T5,'04',T9,'JULY',T27,'44',T30,'DISTURBED AREA'/
       *' ',T5,'05',T9,'AUGUST'/
       *' ',T5,'06',T9,'SEPTEMBER',T27,'45',T30,'RARE/ENDANGERED'/
       *' ',T5,'07',T9,'OCTOBER')
     25 FORMAT(/
       *' ',T5,'08',T9,'PERSISTENT (2 M+)',T27,'46',T30,'SEED AVAILABLE'/
       *' ',T27,'47',T30,'PLANT AVAILABLE'/
       *' ',T5,'09',T9,'EARLY GROWTH'/
       *' ',T5,'10',T9,'WINTER INTEREST',T27,'48',T30,'SEXUAL REPRO.'/
       *' ',T27,'49',T30,'VEGETATIVE REPRO.'/
       *' ',T5,'11',T9,'WET SOIL'/
       *' ',T5,'12',T9,'WET/MESIC SOIL',T27,'50',T30,'ANNUAL'/
       *' ',T5,'13',T9,'MESIC SOIL',T27,'51',T30,'DIOECIOUS')
     30 FORMAT(' ',T5,'14',T9,'DRY/MESIC SOIL'/
       *' ',T5,'15',T9,'DRY SOIL',T27,'52',T30,'WIND DISPERSED'/
       *' ',T5,'16',T9,'INDICATOR SP.',T27,'53',T30,'ANIMAL DISPERSAL'/
       *' ',T27,'54',T30,'BIRD DISPERSAL'/
       *' ',T5,'17',T9,'FORB/FLOWER'/
       *' ',T5,'18',T9,'GRASS',T27,'55',T30,'FOOD FOR WILDLIFE'/
       *' ',T5,'19',T9,'BUNCH GRASS',T27,'56',T30,'HOST SPECIES')
     35 FORMAT(' ',T5,'20',T9,'TREE OR SHRUB'/
       *' ',T27,'57',T30,'SUSC. TO DROUGHT'/
       *' ',T5,'21',T9,'BLUE/VIOLET FL.'/
       *' ',T5,'22',T9,'GREEN/BROWN FL.',T27,'58',T30,'PASTURE/CROP'/
       *' ',T5,'23',T9,'RED/PINK FL.',T27,'59',T30,'INCREASER'/
       *' ',T5,'24',T9,'WHITE FL.',T27,'60',T30,'DECREASER'/
       *' ',T5,'25',T9,'YELLOW FL.',T27,'61',T30,'INVADER/PIONEER'/
       *' ',T27,'62',T30,'INDICATES OVERGRAZING'/
       *' ',T5,'26',T9,'SMALL <9"',T27,'63',T30,'POISONOUS/AVOIDED')
     40 FORMAT(' ',T5,'27',T9,'MEDIUM <36"'/
       *' ',T5,'28',T9,'LARGE >36"',T27,'64',T30,'VEGETABLE'/
       *' ',T27,'65',T30,'POISONOUS TO MAN'/
       *' ',T5,'29',T9,'GOOD COVER PLANT',T27,'66',T30,'EDIBLE PARTS'/
       *' ',T5,'30',T9,'FOLIAGE CONTRAST',T27,'67',T30,'EATEN RAW'/
       *' ',T5,'31',T9,'SHOWY FALL COLOR',T27,'68',T30,'TEA/COFFEE SUB.'/
       *' ',T5,'32',T9,'DEFENDED'/
       *' ',T5,'33',T9,'FIREPROOF',T27,'69',T30,'USEFUL'/
       *' ',T5,'34',T9,'AROMATIC',T27,'70',T30,'CULTIVAR AVAILABLE')
     45 FORMAT(' ',T5,'35',T9,'FORMS AGGREGATES',T27,'71'/
       *'+',T30,'WEAVING/SEWING'/
       *' ',T27,'72',T30,'DYE MATERIAL'/
       *' ',T5,'36',T9,'AT ST. JAMES'/
       *' ',T5,'37',T9,'ALIEN',T27,'73',T30,'NATIVE HERBAL MED.'/
       *' ',T5,'38',T9,'NATIVE SP.',T27,'74',T30,'WESTERN MED.'/
       *' ',T27,'75',T30,'DIURETIC/LAXATIVE'/
       *' ',T5,'39',T9,'COMPOSITE',T27,'76',T30,'EMETIC'/
       *' ',T5,'40',T9,'LEGUME',T27,'77',T30,'TONIC/VITAMIN SOURCE'/
       *' ',T27,'78',T30,'SLIDE AVAILABLE'/////)
     50 FORMAT(' ','NOW SEARCHING FOR CRITERIA NO''S..',T40,10I3,///)
     55 FORMAT(' ',80A1)
     60 FORMAT(///' ','TOTAL COUNT IS',I4,' PLANTS.')
        END

  $ENTRY
```

3.2 Examples of Formatted Output

The following examples are of printout from the three subprograms in SHARRA.

The first, from LIST1, is a listing of names (a plant inventory) and a display of the file. Data in the file relates to the four orders and runs from left to right (columns 1-78). A '1' indicates that a criterion is applicable to the record. A '0' indicates that a criterion is not applicable or that there was no information from the extensive search of literature which was undertaken in compiling the file.

The second example, from SORT1, is a display of a plant record for a species which the user specifies by typing in its genus (e.g. Psoralea).

The third example is from SORT2. Any combination of code numbers (column numbers) of criteria is typed in, after the checklist has been displayed to the user, and a list of complying species is printed out and totalled.

1

BOTANICAL NAME	COMMON NAME
ACER NEGUNDO	MANITOBA MAPLE,BOX ELDER
ACHILLEA MILLEFOLIUM	YARROW
ACTAEA RUBRA NEGLECTA	WHITE BANEBERRY
AGASTACHE FOENICULUM	AGASTACHE
AGOSERIS GLAUCA	FALSE DANDELION
AGROPYRON TRACHYCAULUM	SLENDER WHEATGRASS
ALLIUM CERNUUM	NODDING ONION
ALLIUM STELLATUM	WILD ONION
AMBROSIA TRIFIDA	GREAT RAGWEED
AMELANCHIER ALNIFOLIA	SASKATOON,JUNEBERRY,SHADBUSH
AMORPHA NANA	DWARF FALSE INDIGO
ANDROPOGON GERARDI	BIG BLUESTEM,TURKEYFOOT
ANDROPOGON SCOPARIUS	LITTLE BLUESTEM
ANEMONE CANADENSIS	CANADA ANEMONE
ANEMONE CYLINDRICA	THIMBLEWEED
ANEMONE MULTIFIDA MULTIFIDA	CUT LEAVED ANEMONE
ANEMONE PATENS WOLFGANGIANA	PRAIRIE CROCUS,PASQUEFLOWER
ANTENNARIA APRICA	ANTENNARIA
ANTENNARIA NEGLECTA NEGLECTA	CANADA EVERLASTING
APOCYNUM ANDROSAEMIFOLIUM	SPREADING DOGBANE
APOCYNUM SIBIRICUM	CLASPING LEAVED DOGBANE
ARABIS HIRSUTA PYCNOCARPA	ROCK CRESS
ARALIA NUDICAULIS	WILD SARSAPARILLA
ARCTIUM MINUS	COMMON BURDOCK
ARNICA CHAMISSONIS	ARNICA
ARTEMISIA ABSINTHIUM	WORMWOOD,ABSINTHE
ARTEMISIA BIENNIS	WORMWOOD
ARTEMISIA FRIGIDA	PASTURE SAGE
ARTEMISIA LUDOVICIANA GNAPHALODES	WHITE SAGE
ASCLEPIAS OVALIFOLIA	DWARF MILKWEED
ASCLEPIAS SYRIACA	COMMON MILKWEED
ASPARAGUS OFFICINALIS	ASPARAGUS
ASTER LAEVIS	SMOOTH ASTER
ASTER NOVAE-ANGLIAE	NEW ENGLAND ASTER
ASTER PANSUS	MANY FLOWERED ASTER
ASTER PTARMICOIDES	UPLAND WHITE ASTER
ASTER SIMPLEX	PANICLED ASTER
ASTRAGALUS CANADENSIS	CANADIAN MILKVETCH
ASTRAGALUS CARYOCARPUS	GROUND PLUM,BUFFALO BEAN
ASTRAGALUS FLEXUOSUS	SLENDER MILKVETCH
ASTRAGALUS GONIATUS	PURPLE MILKVETCH
ASTRAGALUS STRIATUS	ASCENDING PURPLE MILKVETCH
BOLTONIA ASTEROIDES	BOLTONIA
BOUTELOUA CURTIPENDULA	SIDE OATS GRAMA
BROMUS INERMIS	AWNLESS BROME GRASS
CAMPANULA ROTUNDIFOLIA	BLUEBELL,HAREBELL
CARAGANA ARBORESCENS	CARAGANA,PEA TREE
CERASTIUM ARVENSE	FIELD CHICKWEED
CERASTIUM VULGATUM	MOUSE EARED CHICKWEED
CIRSIUM ARVENSE	CANADA THISTLE
CIRSIUM FLODMANII	FLODMAN'S THISTLE
COMANDRA PALLIDA	PALE COMANDRA
COMANDRA RICHARDSIANA	RICHARD'S COMANDRA
CONVOLVULUS SEPIUM	WILD MORNING GLORY,DEVIL'S GUTS
CORNUS RUGOSA	ROUND LEAVED DOGWOOD
CORNUS STOLONIFERA	RED OSIER DOGWOOD
CORYLUS AMERICANA	AMERICAN HAZELNUT
CORYLUS CORNUTA	BEAKED HAZELNUT
CRATAEGUS SUCCULENTA	LONG SPINED HAWTHORN
CREPIS RUNCINATA	HAWKSBEARD
CUSCUTA GRONOVII	DODDER

CYPRIPEDIUM CALCEOLUS	YELLOW LADYSLIPPER
DODECATHEON MEDIA	SHOOTING STAR
ECHINACEA ANGUSTIFOLIA	PURPLE CONEFLOWER
ECHINOCYSTIS LOBATA	PRICKLY CUCUMBER
ELEAGNUS COMMUTATA	WOLFWILLOW,SILVERBERRY
ELYMUS CANADENSIS	NODDING RYEGRASS
EPILOBIUM ANGUSTIFOLIUM	FIREWEED
ERIGERON CESPITOSUS	TUFTED FLEABANE
ERIGERON STRIGOSUS	DAISY FLEABANE
FRAGARIA VIRGINIANA	WILD STRAWBERRY
GAILLARDIA ARISTATA	GAILLARDIA
GALIUM SEPTENTRIONALE	NORTHERN BEDSTRAW
GENTIANA CRINITA	FRINGED GENTIAN
GENTIANA PUBERULENTA	DOWNY GENTIAN
GEUM ALEPPICUM	AVEN
GEUM TRIFLORUM	THREE FLOWERED AVENS
GLYCYRRHIZA LEPIDOTA	WILD LICORICE
GRINDELIA SQUARROSA	GUMWEED
HELIANTHUS ANNUS	SHOWY SUNFLOWER
HELIANTHUS LAETIFLORUS	RHOMBIC LEAVED SUNFLOWER
HELIANTHUS MAXIMILIANI	SUNFLOWER
HELIANTHUS TUBEROSUS SUBCANESCENS	JERUSALEM ARTICHOKE
HELIOPSIS HELIANTHOIDES SCABRA	OX EYE DAISY
HESPERIS MATRONALIS	DAME'S ROCKET
HEUCHERA RICHARDSONII	ALUMROOT
HIERACIUM UMBELLATUM	HAWKWEED
HORDEUM JUBATUM	WILD BARLEY,FOXTAIL
HYPOXIS HIRSUTA	STARGRASS
IVA AXILLARIS	POVERTY-WEED
IVA XANTHIFOLIA	FALSE RAGWEED
KOELERIA CRISTATA	JUNEGRASS
LACTUCA PULCHELLA	COMMON BLUE LETTUCE
LATHYRUS OCHROLEUCUS	PALE VETCHLING
LATHYRUS VENOSUS INTONSUS	WILD PEAVINE
LEPIDIUM DENSIFLORUM	COMMON PEPPERGRASS
LIATRIS LIGULISTYLIS	MEADOW BLAZINGSTAR
LIATRIS PUNCTATA	DOTTED BLAZINGSTAR
LILIUM PHILADELPHICUM	PRAIRIE OR WOOD LILY
LINUM LEWISII	BLUE FLAX
LITHOSPERMUM CANESCENS	HOARY PUCOON
LOBELIA SPICATA HIRTELLA	PALE SPIKE LOBELIA
LONICERA TARTARICA	TARTARICAN HONEYSUCKLE
MATRICARIA MATRICARIOIDES	PINEAPPLE WEED
MEDICAGO LUPULINA	BLACK MEDICK
MEDICAGO SATIVA	PURPLE ALFALFA
MELILOTUS ALBA	WHITE SWEET CLOVER
MELILOTUS OFFICINALIS	YELLOW SWEET CLOVER
MIANTHEMUM CANADENSE	WILD LILY OF THE VALLEY
MOLDAVICA PARVIFLORA	DRAGONHEAD
MONARDA FISTULOSA	WILD BERGAMOT
OENOTHERA BIENNIS	YELLOW EVENING PRIMROSE
OENOTHERA SERRULATA	SHRUBBY EVENING PRIMROSE
ORTHOCARPUS LUTEUS	ORTHOCARPUS
OXYTROPIS SPLENDENS	SHOWY LOCOWEED
PANICUM LEIBERGII	PANICGRASS
PENSTEMON GRACILIS	LILAC FLOWERED BEARDTONGUE
PETALOSTEMUM CANDIDUM	WHITE PRAIRIE CLOVER
PETALOSTEMUM PURPUREUM	PURPLE PRAIRIE CLOVER
PHLEUM PRATENSE	TIMOTHY,MEADOW FOXTAIL
PHYSALIS VIRGINIANA	VIRGINIA GROUNDCHERRY
PLANTAGO ERIOPODA	PLANTAIN
POA COMPRESSA	CANADA BLUEGRASS
POA PRATENSIS	KENTUCKY BLUEGRASS
POLYGALA SENEGA	SENECA SNAKEROOT
POLYGONATUM CANALICULATUM	TRUE SOLOMON'S SEAL
POPULUS TREMULOIDES	TREMBLING ASPEN

POTENTILLA ANSERINA	SILVERWEED
POTENTILLA ARGUTA	TALL QUINQUEFOIL
POTENTILLA FRUTICOSA	SHRUBBY QUINQUEFOIL
POTENTILLA MILLEGRAMA	DIFFUSE QUINQUEFOIL
PRUNUS NIGRA	CANADA PLUM
PRUNUS VIRGINIANA	CHOKECHERRY
PSORALEA ARGOPHYLLA	SILVERLEAF PSORALEA
PSORALEA ESCULENTA	INDIAN BREADROOT
QUERCUS MACROCARPA	BURR OAK,MOSSYCUP OAK
RANUNCULUS ACRIS	COMMON TALL BUTTERCUP
RANUNCULUS REPENS	CREEPING BUTTERCUP
RANUNCULUS RHOMBOIDES	PRAIRIE BUTTERCUP
RATIBIDA COLUMNIFERA	LONGHEADED CONEFLOWER
RHUS RADICANS	POISON IVY
ROSA ACICULARIS	PRICKLY ROSE
ROSA ARKANSANA	LOW PRAIRIE ROSE
ROSA BLANDA	SMOOTH ROSE
ROSA WOODSII	WOOD'S ROSE
RUBUS IDAEUS STRIGOSUS	WILD RED RASPBERRY
RUDBECKIA SEROTINA	BLACK EYED SUSAN
RUMEX CRISPUS	CURLED DOCK
SALIX DISCOLOR	PUSSYWILLOW
SANICULA MARILANDICA	BLACK SNAKEROOT
SENECIO AUREUS	GROUNDSEL
SENECIO PLATTENSIS	RAGWORT
SISYRINCHIUM MONTANUM	BLUE EYED GRASS
SMILACINA RACEMOSA	FALSE SOLOMON'S SEAL
SMILACINA STELLATA	STARRY FALSE SOLOMON'S SEAL
SMILAX HERBACEA LASIONEURA	CARRIONFLOWER
SOLIDAGO CANADENSIS	CANADA GOLDENROD
SOLIDAGO DECUMBENS OREOPHILA	MOUNTAIN GOLDENROD
SOLIDAGO MISSOURIENSIS	LOW GOLDENROD
SOLIDAGO RIGIDA	STIFF GOLDENROD
SONCHUS ARVENSIS	SOW THISTLE
SPIRAEA ALBA	NARROW LEAVED MEADOWSWEET
SPOROBOLUS HETEROLEPIS	PRAIRIE DROPSEED
STELLARIA LONGPIPES	LONG STALKED STITCHWORT
STIPA SPARTEA	NEEDLEGRASS,PORCUPINEGRASS
STIPA VIRIDULA	GREEN NEEDLEGRASS
SYMPHORICARPOS OCCIDENTALIS	WESTERN SNOWBERRY
TARAXACUM OFFICINALE	COMMON DANDELION
THALICTRUM DASYCARPUM	TALL MEADOWRUE
THALICTRUM VENOSUM	VEINY MEADOWRUE
THLASPI ARVENSE	STINKWEED,PENNYCRESS
TRAGOPOGON DUBIUS	YELLOW GOATSBEARD
TRAGOPOGON PRATENSIS	GOATSBEARD
TRIFOLIUM PRATENSE	RED CLOVER
TRIFOLIUM REPENS	WHITE CLOVER
TRILLIUM CERNUUM	NODDING TRILLIUM
URTICA DIOICA	COMMON NETTLE
VERONICASTRUM VIRGINICUM	CULVER'S ROOT
VICIA AMERICANA	AMERICAN VETCH
VICIA CRACCA	TUFTED VETCH
VIOLA ADUNCA	EARLY BLUE VIOLET
VIOLA PEDATIFIDA	BIRDFOOT VIOLET
VIOLA RUGULOSA	WESTERN CANADA VIOLET
ZIGADENUS ELEGANS	WHITE CAMAS
ZIZIA APTERA	HEART LEAVED ALEXANDERS
ZIZIA AUREA	GOLDEN ALEXANDERS

CUSCUTA GRONOVII	0000000000000000	1000000100000000000000100000000000010	00000	000000000000000000000000
CYPRIPEDIUM CALCEOLUS	0010000000010000	1000000010100000001010100011010000000	00000	000000000100000000000000
DODECATHEON MEDIA	0011000001111000	100010110100100000000010010100101100	00000	000000000000000000000000
ECHINACEA ANGUSTIFOLIA	0111100101000000	100010000100000000001011010000000100	C0000	000000000000000000100000
ECHINOCYSTIS LOBATA	0011000000000000	100000010001000000001010001100000110	C0000	000000000000000000000001
ELEAGNUS COMMUTATA	0011000000110000	000100001001010001010100011000000100	00010	000011000110000000000001
ELYMUS CANADENSIS	0001111111011000	011000000001010000000101001001010111 00	11010	110110000100010100000001
EPILOBIUM ANGUSTIFOLIUM	0011100101010000	100010100001000000010100111100010000	10010	010010010111000011 0010
ERIGERON CESPITOSUS	0001100001000000	100000110000000000001011010000000000	C0000	000000000000000000000000
ERIGERON STRIGOSUS	0011110101000110	100000010010100001010110100000000100	00000	000010000000000000100001
FRAGARIA VIRGINIANA	0111111100010001	100000010100100000001010010100011100	00010	110000000111010011101 0
GAILLARDIA ARISTATA	0011000000000100	100000101000000000001011010000100000	00000	000000000000010000000 00
GALIUM SEPTENTRIONALE	0011100100010001	100000010010100001010100100001111100	01000	000000010001100110100 00
GENTIANA CRINITA	0000000000010000	100010000010000000001001010100101 0	00000	000000000000000000000000
GENTIANA PUBERULENTA	0001100000001000	100010000000000000001010010000110000	00000	000000000000000000000000
GEUM ALEPPICUM	0000000000010000	100000001010000000000100101100010000	00000	000000000000000000000000
GEUM TRIFLORUM	0110000011000010	100000100010100000011010010100111100	00000	000000000001000000000 1
GLYCYRRHIZA LEPIDOTA	0011100101011100	100000001010000000010101101000000000	01000	000100000110010010100 1
GRINDELIA SQUARROSA	0001110101000000	100000001010000000010110100000000000	00000	000001000001000010000 0
HELIANTHUS ANNUS	0001111101000100	100000000100000000001011010010100010	00000	010000000111110000001 0
HELIANTHUS LAETIFLORUS	0000111101011110	100000000100110000011011010000101000	00010	000010000111110000000 0
HELIANTHUS MAXIMILIANI	0001100001010000	100000000100100000000011010100000000	00010	000000000111110000000 0
HELIANTHUS TUBEROSUS SUBCANESCENS	0000111101110000	100000000100100000011011010000001100	00010	010000000111110000000 0
HELIOPSIS HELIANTHOIDES SCABRA	0011100101001000	100000000100110000001011010000111100	00000	000000000000000000000000
HESPERIS MATRONALIS	0011000001000000	100010010000000000001100000110000000	00000	000000000000000000000000
HEUCHERA RICHARDSONII	0110000001010001	100001000010100000001010010100111100	00000	000000000111010010000 0
HIERACIUM UMBELLATUM	0000000001010000	100000000101000000000011010001000000	00010	010000000000010000000 0
HORDEUM JUBATUM	0011100100000000	010000000010001000010100100000001000	11010	010011100100000110000 1
HYPOXIS HIRSUTA	0111000001000001	100000000110010000001001001000001110 0	00000	000000000000000000000000
IVA AXILLARIS	0000000000100000	100000000101000000000011010000000000	00000	000010000000000000000 0
IVA XANTHIFOLIA	0000111100000000	100001000000000010001011010000000000	00000	000000001000000000000 0
KOELERIA CRISTATA	0011000000000101	011000000010100000001010010000111000	11010	110100000100000100000 0
LACTUCA PULCHELLA	0001110101100000	100010000010000000001011010010000100	00010	000010010110000010000 1
LATHYRUS OCHROLEUCUS	0111000101000110	100000000100000000000101010100000000 0	00010	010000000110000000010000
LATHYRUS VENOSUS INTONSUS	0100000001010001	100010000010100000001010110100001100	00010	010000000110010001001 10
LEPIDIUM DENSIFLORUM	0100000000010000	100000010010000000001010000010001010	00010	000000000111000010000 0
LIATRIS LIGULISTYLIS	0001100001001000	100010000000000000001011010000110000	00000	000000000000000000000000
LIATRIS PUNCTATA	0000110001000000	100010000010000000001011010000000000	00000	000000000100000000000000
LILIUM PHILADELPHICUM	0011000000000000	100000100110100000001010010101111100	00000	000000000100000000000000
LINUM LEWISII	0011000001000100	100010000010000000000010010010100000	00000	000000000100010000000 0
LITHOSPERMUM CANESCENS	0110000010011100	100000000110011000001010010010011100	C0000	000000000100000110000 0
LOBELIA SPICATA HIRTELLA	0011100100101000	100010010010100000001010010010101100	00000	000000101000000000100 00
LONICERA TARTARICA	0010000000000000	000100000000100000001100001100000000 0	00010	000000000110000010000 1
MATRICARIA MATRICARIOIDES	0111110101000000	100001000100000000010010100001000001 0	00000	000010000000110000000 0
MEDICAGO LUPULINA	0111110100000000	100000000100000000000011001000100000 00	00010	000000000000000000000000
MEDICAGO SATIVA	0111110100000000	100010000000000000001100100010000000	00010	010000010101010000001 0
MELILOTUS ALBA	0011111100000000	100000010000000000101100100010001000	00010	000000000001100000000 0
MELILOTUS OFFICINALIS	0011111100000000	100000000100000000010110010001000100 0	00010	010000000000101001000 00
MIANTHEMUM CANADENSE	0110000000000000	100000001010000000001101000100000000 0	00010	000000001000000010000 0
MOLDAVICA PARVIFLORA	0000000000000000	100010000010000000000010000000000001 0	00000	000000000000000000000000
MONARDA FISTULOSA	0001100001111110	100010000010100001110100111001111000	00000	000000010111101001000 01
OENOTHERA BIENNIS	0011111101000110	100000000100110000101010010010111100	00000	000000000100010011001 0
OENOTHERA SERRULATA	0111110100000000	100000000101000000001010010000000000	00000	000000000000000000000000
ORTHOCARPUS LUTEUS	0000100000000000	100000000101000000001010010000000010	00000	000000000000000000000000
OXYTROPIS SPLENDENS	0011000000000000	100010000010000000001010110000000000	00000	000000101000000000000 000
PANICUM LEIBERGII	0011100101010001	010000000010100000001010010000001100	11010	000000000100000100000 0
PENSTEMON GRACILIS	0011000001011100	100010000010000000001010010001000000	00010	000000000000000000100000
PETALOSTEMUM CANDIDUM	0011100101000101	100000010010100000001010110000111000	00000	000100000000000000000001
PETALOSTEMUM PURPUREUM	0011100101000011	100010000010100001010101100001110000	00000	000100000001100010000 0
PHLEUM PRATENSE	0011100111110000	010000000001000000001100010000001100	11010	010000000100010100000 0
PHYSALIS VIRGINIANA	0011100101000101	100000000101010000001010010000001100	00010	010000000100000010000 0
PLANTAGO ERIOPODA	0000000001110000	100000000010000000000010010000000000	00000	000000001011000001010 00
POA COMPRESSA	0011000000011000	010000000001000000001010010000001100	11010	011011000100000100000 0
POA PRATENSIS	0111100110011000	010000000001000000001100010000001100	11010	111010000100010100000 1
POLYGALA SENEGA	0110000000001000	100001010010100000001010010000110100	00000	000000000000010011110 0
POLYGONATUM CANALICULATUM	0011000001000000	100000010010000000001010001000000100	00000	000000000100000000000 0

POPULUS TREMULOIDES	1100000001111110	00010000000100100011010001000001101	10010	0110100001101101110011
POTENTILLA ANSERINA	0111110010111000	10000000110000000000101001001000100	00010	0000000001100000011001
POTENTILLA ARGUTA	0011100101000101	10000001001011000001010010100111100	00010	0000000000000000100000
POTENTILLA FRUTICOSA	0011110101111110	10000000101000000001010010000000000	00010	0100000000000000010010
POTENTILLA MILLEGRAMA	0010000001000000	10000000100000000001010010000000000	00010	0000000000000000000000
PRUNUS NIGRA	0110000000000000	00010000000100010001010001100000000	00010	0100000001110001000000
PRUNUS VIRGINIANA	0110000000001110	00010000000100100001010001100000000	00010	0000000011110000110011
PSORALEA ARGOPHYLLA	0001100000000000	10001000000100100000101011000001000	00000	0001000000001010100001
PSORALEA ESCULENTA	0100000000000010	10001000001010000000101011000000100	00000	0001000101100000000000
QUERCUS MACROCARPA	0110000001111110	00010000000100101001010001000001000	01010	0000001011101001110001
RANUNCULUS ACRIS	0011000000000000	10000000101000000001100010000000000	00000	0000001010000000000000
RANUNCULUS REPENS	0010000001000000	10000000100000000001100010000000000	00010	0000001010000000000000
RANUNCULUS RHOMBOIDES	1100000001000110	10000000110000000000101001000010110	00000	0000001010000000000000
RATIBIDA COLUMNIFERA	0011110101000110	10000000101000000001011010010101100	00000	0000000000010100100001
RHUS RADICANS	0001000000011100	10000000110000110000010001110000000	00010	0000001010000000000001
ROSA ACICULARIS	0011000001011010	10000010001000110011010010000001100	01110	0100000001111000100011
ROSA ARKANSANA	0011100101011010	10000010001000100011010010000011100	01110	0100000001111000110011
ROSA BLANDA	0011100101011010	10000010001000100011010010000001100	01110	0100000001111000100010
ROSA WOODSII	0010000001000010	10000010001000110011010010000001100	01110	0100000001111000100010
RUBUS IDAEUS STRIGOSUS	0011111100000000	10000001000000000001010001000000000	00110	0100001001110101100011
RUDBECKIA SEROTINA	0011111101010001	10000000101000000001011010010101100	00010	0010000000000100000000
RUMEX CRISPUS	0010000001110000	100001000000000000001100000010000000	00010	0000000111000001111010
SALIX DISCOLOR	1100000000110000	00010000000100000001101000110000100	00010	0000000001011010110000
SANICULA MARILANDICA	0010000000000000	10000001001000000001010001000001000	01010	0100000000000000110000
SENECIO AUREUS	1110000000110000	10000000101000000000110100000001100	00010	1100000101011010111010
SENECIO PLATTENSIS	0111000100000110	10000000101000000001011010000101100	00010	0100000000000000000000
SISYRINCHIUM MONTANUM	0011000000110000	10001000010000000001101001000101100	00000	0000000000000000000000
SMILACINA RACEMOSA	0110000001000000	10000001001000000001010001000000000	00010	0000000001100000101000
SMILACINA STELLATA	0110000001111000	10000001001010000000101000110001100	00010	0100000000000000000000
SMILAX HERBACEA LASIONEURA	0110000000000000	10000100001000000000101000100000000	00000	0000000001000000100000
SOLIDAGO CANADENSIS	0000110001010000	10000000101010000001101101011000110	00001	0000000101010101100001
SOLIDAGO DECUMBENS OREOPHILA	0001110101000000	10000000100000000001101101001000110	00001	0000000101010101100000
SOLIDAGO MISSOURIENSIS	0001110101001001	10000000101000000001101101001000110	00001	0010001101010101100000
SOLIDAGO RIGIDA	0000111101011110	10000000101010000001101101001011110	00011	0010001101010101110001
SONCHUS ARVENSIS	0001111111000000	10000000100100000001101000010000000	00010	0100100000000000000001
SPIRAEA ALBA	0001000001110000	10000001001110000010101000100011110	00000	0000000000001000011000
SPOROBOLUS HETEROLEPIS	0000111100000101	01100000000100000000101001000011100	11010	0101000000100001000000
STELLARIA LONGIPES	0011000000000000	10000001000000000001010010000000000	00000	0000000000000000000000
STIPA SPARTEA	0110000000000101	01100000001010000000101001000011110	11010	1101001001001001000000
STIPA VIRIDULA	0001100000000000	01100000001100000001010010000001100	11010	0100100001000101000000
SYMPHORICARPOS OCCIDENTALIS	0011110100000000	10000010001000000011010010000000000	00000	0000000001101000010001
TARAXACUM OFFICINALE	0111110110000000	10000000100000000001101000010000100	10010	0010110001110001111011
THALICTRUM DASYCARPUM	0010000000100001	10001000001000000101010010000001100	00010	0000000000011000100010
THALICTRUM VENUSUM	0010000000110000	10000100000000000101000100000000000	00000	0000000000011000100000
THLASPI ARVENSE	0110000000000000	10000001000000000001100000010000000	00000	0000000000110000000000
TRAGOPOGON DUBIUS	0111000101000000	10000000100000000001101010000000000	00000	0000100101100000000000
TRAGOPOGON PRATENSIS	0000000001000000	10000000100000000000101000010000000	00000	0000100001110000000000
TRIFOLIUM PRATENSE	0111110101000000	10000010001000000000110010001000100	00010	0000100011110000100011
TRIFOLIUM REPENS	0111111111100000	10000001000000000001100100010000100	00010	0100000101110000100010
TRILLIUM CERNUUM	0110000000000000	10000001001000000001010001000000000	00000	0000000001100000110110
URTICA DIOICA	0000000010110000	10001000001000100000100111100000100	00000	0100000101011010111010
VERONICASTRUM VIRGINICUM	0000000001100001	10001001000100000000010010001111100	00000	0000000000000000000000
VICIA AMERICANA	0111000100010000	10001010001000000000101011000001000	00010	1100000001000000000000
VICIA CRACCA	0011000000000000	10001000000000000000110011000000000	00010	1000000000000000000001
VIOLA ADUNCA	1100000000000000	10001000010000000001010010000000000	00010	1000000000111000000010
VIOLA PEDATIFIDA	1100000010001101	10001000010000000001010010001001100	00010	1000000000111000000010
VIOLA RUGULOSA	0110000000000000	10000001001000000001010001000000100	00010	1000000000111000010010
ZIGADENUS ELEGANS	0010000000010000	10000001001000000001010010110000100	00000	0000000001000000000000
ZIZIA APTERA	0111000110001000	10000000101000000001010010100111100	00010	0100000000000000000000
ZIZIA AUREA	0111000100110000	10000000101000000001010010100111100	00010	0100000000000000000000

3.2 Examples of Formatted Output

The following examples are of printout from the three subprograms in SHARRA.

The first, from LIST1, is a listing of names (a plant inventory) and a display of the file. Data in the file relates to the four orders and runs from left to right (columns 1-78). A '1' indicates that a criterion is applicable to the record. A '0' indicates that a criterion is not applicable or that there was no information from the extensive search of literature which was undertaken in compiling the file.

The second example, from SORT1, is a display of a plant record for a species which the user specifies by typing in its genus (e.g. Psoralea).

The third example is from SORT2. Any combination of code numbers (column numbers) of criteria is typed in, after the checklist has been displayed to the user, and a list of complying species is printed out and totalled.

1

BOTANICAL NAME	COMMON NAME
ACER NEGUNDO	MANITOBA MAPLE,BOX ELDER
ACHILLEA MILLEFOLIUM	YARROW
ACTAEA RUBRA NEGLECTA	WHITE BANEBERRY
AGASTACHE FOENICULUM	AGASTACHE
AGOSERIS GLAUCA	FALSE DANDELION
AGROPYRON TRACHYCAULUM	SLENDER WHEATGRASS
ALLIUM CERNUUM	NODDING ONION
ALLIUM STELLATUM	WILD ONION
AMBROSIA TRIFIDA	GREAT RAGWEED
AMELANCHIER ALNIFOLIA	SASKATOON,JUNEBERRY,SHADBUSH
AMORPHA NANA	DWARF FALSE INDIGO
ANDROPOGON GERARDI	BIG BLUESTEM,TURKEYFOOT
ANDROPOGON SCOPARIUS	LITTLE BLUESTEM
ANEMONE CANADENSIS	CANADA ANEMONE
ANEMONE CYLINDRICA	THIMBLEWEED
ANEMONE MULTIFIDA MULTIFIDA	CUT LEAVED ANEMONE
ANEMONE PATENS WOLFGANGIANA	PRAIRIE CROCUS,PASQUEFLOWER
ANTENNARIA APRICA	ANTENNARIA
ANTENNARIA NEGLECTA NEGLECTA	CANADA EVERLASTING
APOCYNUM ANDROSAEMIFOLIUM	SPREADING DOGBANE
APOCYNUM SIBIRICUM	CLASPING LEAVED DOGBANE
ARABIS HIRSUTA PYCNOCARPA	ROCK CRESS
ARALIA NUDICAULIS	WILD SARSAPARILLA
ARCTIUM MINUS	COMMON BURDOCK
ARNICA CHAMISSONIS	ARNICA
ARTEMISIA ABSINTHIUM	WORMWOOD,ABSINTHE
ARTEMISIA BIENNIS	WORMWOOD
ARTEMISIA FRIGIDA	PASTURE SAGE
ARTEMISIA LUDOVICIANA GNAPHALODES	WHITE SAGE
ASCLEPIAS OVALIFOLIA	DWARF MILKWEED
ASCLEPIAS SYRIACA	COMMON MILKWEED
ASPARAGUS OFFICINALIS	ASPARAGUS
ASTER LAEVIS	SMOOTH ASTER
ASTER NOVAE-ANGLIAE	NEW ENGLAND ASTER
ASTER PANSUS	MANY FLOWERED ASTER
ASTER PTARMICOIDES	UPLAND WHITE ASTER
ASTER SIMPLEX	PANICLED ASTER
ASTRAGALUS CANADENSIS	CANADIAN MILKVETCH
ASTRAGALUS CARYOCARPUS	GROUND PLUM,BUFFALO BEAN
ASTRAGALUS FLEXUOSUS	SLENDER MILKVETCH
ASTRAGALUS GONIATUS	PURPLE MILKVETCH
ASTRAGALUS STRIATUS	ASCENDING PURPLE MILKVETCH
BOLTONIA ASTEROIDES	BOLTONIA
BOUTELOUA CURTIPENDULA	SIDE OATS GRAMA
BROMUS INERMIS	AWNLESS BROME GRASS
CAMPANULA ROTUNDIFOLIA	BLUEBELL,HAREBELL
CARAGANA ARBORESCENS	CARAGANA,PEA TREE
CERASTIUM ARVENSE	FIELD CHICKWEED
CERASTIUM VULGATUM	MOUSE EARED CHICKWEED
CIRSIUM ARVENSE	CANADA THISTLE
CIRSIUM FLODMANII	FLODMAN'S THISTLE
COMANDRA PALLIDA	PALE COMANDRA
COMANDRA RICHARDSIANA	RICHARD'S COMANDRA
CONVOLVULUS SEPIUM	WILD MORNING GLORY,DEVIL'S GUTS
CORNUS RUGOSA	ROUND LEAVED DOGWOOD
CORNUS STOLONIFERA	RED OSIER DOGWOOD
CORYLUS AMERICANA	AMERICAN HAZELNUT
CORYLUS CORNUTA	BEAKED HAZELNUT
CRATAEGUS SUCCULENTA	LONG SPINED HAWTHORN
CREPIS RUNCINATA	HAWKSBEARD
CUSCUTA GRONOVII	DODDER

CYPRIPEDIUM CALCEOLUS	YELLOW LADYSLIPPER
DODECATHEON MEDIA	SHOOTING STAR
ECHINACEA ANGUSTIFOLIA	PURPLE CONEFLOWER
ECHINOCYSTIS LOBATA	PRICKLY CUCUMBER
ELEAGNUS COMMUTATA	WOLFWILLOW,SILVERBERRY
ELYMUS CANADENSIS	NODDING RYEGRASS
EPILOBIUM ANGUSTIFOLIUM	FIREWEED
ERIGERON CESPITOSUS	TUFTED FLEABANE
ERIGERON STRIGOSUS	DAISY FLEABANE
FRAGARIA VIRGINIANA	WILD STRAWBERRY
GAILLARDIA ARISTATA	GAILLARDIA
GALIUM SEPTENTRIONALE	NORTHERN BEDSTRAW
GENTIANA CRINITA	FRINGED GENTIAN
GENTIANA PUBERULENTA	DOWNY GENTIAN
GEUM ALEPPICUM	AVEN
GEUM TRIFLORUM	THREE FLOWERED AVENS
GLYCYRRHIZA LEPIDOTA	WILD LICORICE
GRINDELIA SQUARROSA	GUMWEED
HELIANTHUS ANNUS	SHOWY SUNFLOWER
HELIANTHUS LAETIFLORUS	RHOMBIC LEAVED SUNFLOWER
HELIANTHUS MAXIMILIANI	SUNFLOWER
HELIANTHUS TUBEROSUS SUBCANESCENS	JERUSALEM ARTICHOKE
HELIOPSIS HELIANTHOIDES SCABRA	OX EYE DAISY
HESPERIS MATRONALIS	DAME'S ROCKET
HEUCHERA RICHARDSONII	ALUMROOT
HIERACIUM UMBELLATUM	HAWKWEED
HORDEUM JUBATUM	WILD BARLEY,FOXTAIL
HYPOXIS HIRSUTA	STARGRASS
IVA AXILLARIS	POVERTY-WEED
IVA XANTHIFOLIA	FALSE RAGWEED
KOELERIA CRISTATA	JUNEGRASS
LACTUCA PULCHELLA	COMMON BLUE LETTUCE
LATHYRUS OCHROLEUCUS	PALE VETCHLING
LATHYRUS VENOSUS INTONSUS	WILD PEAVINE
LEPIDIUM DENSIFLORUM	COMMON PEPPERGRASS
LIATRIS LIGULISTYLIS	MEADOW BLAZINGSTAR
LIATRIS PUNCTATA	DOTTED BLAZINGSTAR
LILIUM PHILADELPHICUM	PRAIRIE OR WOOD LILY
LINUM LEWISII	BLUE FLAX
LITHOSPERMUM CANESCENS	HOARY PUCOON
LOBELIA SPICATA HIRTELLA	PALE SPIKE LOBELIA
LONICERA TARTARICA	TARTARICAN HONEYSUCKLE
MATRICARIA MATRICARIOIDES	PINEAPPLE WEED
MEDICAGO LUPULINA	BLACK MEDICK
MEDICAGO SATIVA	PURPLE ALFALFA
MELILOTUS ALBA	WHITE SWEET CLOVER
MELILOTUS OFFICINALIS	YELLOW SWEET CLOVER
MIANTHEMUM CANADENSE	WILD LILY OF THE VALLEY
MOLDAVICA PARVIFLORA	DRAGONHEAD
MONARDA FISTULOSA	WILD BERGAMOT
OENOTHERA BIENNIS	YELLOW EVENING PRIMROSE
OENOTHERA SERRULATA	SHRUBBY EVENING PRIMROSE
ORTHOCARPUS LUTEUS	ORTHOCARPUS
OXYTROPIS SPLENDENS	SHOWY LOCOWEED
PANICUM LEIBERGII	PANICGRASS
PENSTEMON GRACILIS	LILAC FLOWERED BEARDTONGUE
PETALOSTEMUM CANDIDUM	WHITE PRAIRIE CLOVER
PETALOSTEMUM PURPUREUM	PURPLE PRAIRIE CLOVER
PHLEUM PRATENSE	TIMOTHY,MEADOW FOXTAIL
PHYSALIS VIRGINIANA	VIRGINIA GROUNDCHERRY
PLANTAGO ERIOPODA	PLANTAIN
POA COMPRESSA	CANADA BLUEGRASS
POA PRATENSIS	KENTUCKY BLUEGRASS
POLYGALA SENEGA	SENECA SNAKEROOT
POLYGONATUM CANALICULATUM	TRUE SOLOMON'S SEAL
POPULUS TREMULOIDES	TREMBLING ASPEN

POTENTILLA ANSERINA	SILVERWEED
POTENTILLA ARGUTA	TALL QUINQUEFOIL
POTENTILLA FRUTICOSA	SHRUBBY QUINQUEFOIL
POTENTILLA MILLEGRANA	DIFFUSE QUINQUEFOIL
PRUNUS NIGRA	CANADA PLUM
PRUNUS VIRGINIANA	CHOKECHERRY
PSORALEA ARGOPHYLLA	SILVERLEAF PSORALEA
PSORALEA ESCULENTA	INDIAN BREADROOT
QUERCUS MACROCARPA	BURR OAK,MOSSYCUP OAK
RANUNCULUS ACRIS	COMMON TALL BUTTERCUP
RANUNCULUS REPENS	CREEPING BUTTERCUP
RANUNCULUS RHOMBOIDES	PRAIRIE BUTTERCUP
RATIBIDA COLUMNIFERA	LONGHEADED CONEFLOWER
RHUS RADICANS	POISON IVY
ROSA ACICULARIS	PRICKLY ROSE
ROSA ARKANSANA	LOW PRAIRIE ROSE
ROSA BLANDA	SMOOTH ROSE
ROSA WOODSII	WOOD'S ROSE
RUBUS IDAEUS STRIGOSUS	WILD RED RASPBERRY
RUDBECKIA SEROTINA	BLACK EYED SUSAN
RUMEX CRISPUS	CURLED DOCK
SALIX DISCOLOR	PUSSYWILLOW
SANICULA MARILANDICA	BLACK SNAKEROOT
SENECIO AUREUS	GROUNDSEL
SENECIO PLATTENSIS	RAGWORT
SISYRINCHIUM MONTANUM	BLUE EYED GRASS
SMILACINA RACEMOSA	FALSE SOLOMON'S SEAL
SMILACINA STELLATA	STARRY FALSE SOLOMON'S SEAL
SMILAX HERBACEA LASIONEURA	CARRIONFLOWER
SOLIDAGO CANADENSIS	CANADA GOLDENROD
SOLIDAGO DECUMBENS OREOPHILA	MOUNTAIN GOLDENROD
SOLIDAGO MISSOURIENSIS	LOW GOLDENROD
SOLIDAGO RIGIDA	STIFF GOLDENROD
SONCHUS ARVENSIS	SOW THISTLE
SPIRAEA ALBA	NARROW LEAVED MEADOWSWEET
SPOROBOLUS HETEROLEPIS	PRAIRIE DROPSEED
STELLARIA LONGPIPES	LONG STALKED STITCHWORT
STIPA SPARTEA	NEEDLEGRASS,PORCUPINEGRASS
STIPA VIRIDULA	GREEN NEEDLEGRASS
SYMPHORICARPOS OCCIDENTALIS	WESTERN SNOWBERRY
TARAXACUM OFFICINALE	COMMON DANDELION
THALICTRUM DASYCARPUM	TALL MEADOWRUE
THALICTRUM VENOSUM	VEINY MEADOWRUE
THLASPI ARVENSE	STINKWEED,PENNYCRESS
TRAGOPOGON DUBIUS	YELLOW GOATSBEARD
TRAGOPOGON PRATENSIS	GOATSBEARD
TRIFOLIUM PRATENSE	RED CLOVER
TRIFOLIUM REPENS	WHITE CLOVER
TRILLIUM CERNUUM	NODDING TRILLIUM
URTICA DIOICA	COMMON NETTLE
VERONICASTRUM VIRGINICUM	CULVER'S ROOT
VICIA AMERICANA	AMERICAN VETCH
VICIA CRACCA	TUFTED VETCH
VIOLA ADUNCA	EARLY BLUE VIOLET
VIOLA PEDATIFIDA	BIRDFOOT VIOLET
VIOLA RUGULOSA	WESTERN CANADA VIOLET
ZIGADENUS ELEGANS	WHITE CAMAS
ZIZIA APTERA	HEART LEAVED ALEXANDERS
ZIZIA AUREA	GOLDEN ALEXANDERS

POPULUS TREMULOIDES	1100000001111110	0001000000001001000110100010000001101	10010	0110100001101101110011
POTENTILLA ANSERINA	0111110010111000	100000001100000000001010010010000100	00010	0000000001100000011001
POTENTILLA ARGUTA	0011100101000101	10000001001011000001010010100111100	00010	0000000000000000100000
POTENTILLA FRUTICOSA	0011110101111110	1000000010100000000101001000000000	00010	0100000000000000010010
POTENTILLA MILLEGRAMA	0010000001000000	1000000010000000000101001000000000	00010	0000000000000000000000
PRUNUS NIGRA	0110000000000000	00010000000100010001010001100000000	00010	0100000001110001000000
PRUNUS VIRGINIANA	0110000000001110	00010000000100100001010001100000000	00010	0000000011110000110011
PSORALEA ARGOPHYLLA	0001100000000000	1000100000010010000010101100000001000	00000	00010000000001010100001
PSORALEA ESCULENTA	0100000000000010	1000100000101000000101011000000000100	00000	0001000101100000000000
QUERCUS MACROCARPA	0110000001111110	00010000000100101001010001000001000	01010	0000001011101001110001
RANUNCULUS ACRIS	0011000000000000	10000000101000000001100010000000000	00000	0000001010000000000000
RANUNCULUS REPENS	0010000001000000	10000000100000000001100010000000000	00010	0000001010000000000000
RANUNCULUS RHOMBOIDES	1100000001000110	10000000110000000001010010000101100	00000	0000001010000000000000
RATIBIDA COLUMNIFERA	0011110101000110	10000000101000000001011010010101100	00000	0000000000010100100001
RHUS RADICANS	0001000000011100	10000000110000110000010001110000000	00010	0000001010000000000001
ROSA ACICULARIS	0011000001011010	10000010001000110011010010000001100	01110	0100000001111000100011
ROSA ARKANSANA	0011100101011010	10000010001000100011010010000011100	01110	0100000001111000110011
ROSA BLANDA	0011100101011010	10000010001000100011010010000001100	01110	0100000001111000100010
ROSA WOODSII	0010000001000010	10000010001000110011010010000001100	01110	0100000001111000100010
RUBUS IDAEUS STRIGUSUS	0011111100000000	10000001000000000001010001000000000	00110	0100001001110101100011
RUDBECKIA SEROTINA	0011111101010001	10000000101000000001011010010101100	00010	0010000000000100000000
RUMEX CRISPUS	0010000001110000	10000100000000000001100000010000000	00010	0000000111000001111010
SALIX DISCOLOR	1100000000110000	000100000000100000011010001100000100	00010	0000000001011010110000
SANICULA MARILANDICA	0010000000000000	10000001001000000001010001000001000	01010	0100000000000000110000
SENECIO AUREUS	1110000000110000	10000000101000000000110100000001100	00010	1100000101011010111010
SENECIO PLATTENSIS	0111000100000110	10000000101000000001011010000101100	00010	0100000000000000000000
SISYRINCHIUM MONTANUM	0011000000110000	10001000010000000001101001000101100	00000	0000000000000000000000
SMILACINA RACEMOSA	0110000001000000	10000001001000000001010001000000000	00010	0000000001100000101000
SMILACINA STELLATA	0110000001111000	10000001001010000001010001100011100	00010	0100000000000000000000
SMILAX HERBACEA LASIONEURA	0110000000000000	10000100001000000001010001000000000	00000	0000000001000000100000
SOLIDAGO CANADENSIS	0000110001010000	10000000101010000011011010110001100	00001	0000000101010101100001
SOLIDAGO DECUMBENS OREOPHILA \	0001110101000000	10000000100000000011011010010001100	00001	0000000101010101100000
SOLIDAGO MISSOURIENSIS	0001110101001001	10000000101000000011011010010001100	00001	0010001101010101100000
SOLIDAGO RIGIDA	0000111101011110	10000000101010000011011010010111100	00011	0010001101010101110001
SONCHUS ARVENSIS	0001111111000000	10000000100100000001101000010000000	00010	0100100000000000000001
SPIRAEA ALBA	0001000001110000	10000001001110000101010001000111100	00000	0000000000010000011000
SPOROBOLUS HETEROLEPIS	0000111100000101	01100000001000000001010010000111000	11010	0101000001000001000000
STELLARIA LONGIPES	0011000000000000	10000001000000000001010010000000000	00000	0000000000000000000000
STIPA SPARTEA	0110000000000101	01100000001010000001010010000111100	11010	1101001001001001000000
STIPA VIRIDULA	0001100000000000	01100000000110000000101001000001100	11010	0100100001000101000000
SYMPHORICARPOS OCCIDENTALIS	0011110100000000	10000010001000000001101001000000000	00000	0000000001101000010001
TARAXACUM OFFICINALE	0111110110000000	10000000100000000001101000010000100	10010	0010110001110001111011
THALICTRUM DASYCARPUM	0010000000100001	10000100000100000101010010000001100	00000	0000000000110001000010
THALICTRUM VENUSUM	0010000000110000	10000100000000000001010001000000000	00000	0000000000011000100000
THLASPI ARVENSE	0110000000000000	10000001000000000001100000010000000	00000	0000000001100000000000
TRAGOPOGON DUBIUS	0111000101000000	10000000100000000001101010000000000	00000	0000100101100000000000
TRAGOPOGON PRATENSIS	0000000001000000	10000000100000000000101000010000000	00000	0000100001110000000000
TRIFOLIUM PRATENSE	0111110101000000	10000010001000000001100100010001100	00010	0000100011110000100011
TRIFOLIUM REPENS	0111111111000000	10000001000000000001100100010000100	00010	0100000101110000100010
TRILLIUM CERNUUM	0110000000000000	10000001001000000001010001000000000	00000	0000000001100000110110
URTICA DIOICA	0000000010110000	10001000001000100000100111100000100	00000	0100000101011010111010
VERONICASTRUM VIRGINICUM	0000000001100001	10001001000100000000010010001111100	00000	0000000000000000000000
VICIA AMERICANA	0111000100010000	10001010001000000001010110000001000	00010	1100000001000000000000
VICIA CRACCA	0011000000000000	10001000000000000001100110000000000	00010	1000000000000000000001
VIOLA ADUNCA	1100000000000000	10001000010000000001010010000000000	00010	1000000001110000000010
VIOLA PEDATIFIDA	1100000010001101	10001000010000000001010010001001100	00010	1000000001110000000010
VIOLA RUGULOSA	0110000000000000	10000001001000000001010001000000100	00010	1000000001110000100010
ZIGADENUS ELEGANS	0010000000010000	10000001001000000001010010110000100	00000	0000000010000000000000
ZIZIA APTERA	0111000110001000	10000000101000000001010010100111100	00010	0100000000000000000000
ZIZIA AUREA	0111000100110000	10000000101000000001010010100111100	00010	0100000000000000000000

2

THE FOLLOWING PLANT RECORDS ARE ON FILE...

PSORALEA

PSORALEA ARGOPHYLLA COMMONLY CALLED SILVERLEAF PSORALEA

0-NOT APPLICABLE 1-APPLICABLE

0 APRIL FLOWER	1 BLUE/VIOLET FL.	1 OPEN PRAIRIE	0 PASTURE/CROP
0 MAY	0 GREEN/BROWN FL.	0 WOODLAND (OAK/ASPEN)	0 INCREASER
0 JUNE	0 RED/PINK FL.	0 WOOD EDGE/TRANSITION	1 DECREASER
1 JULY	0 WHITE FL.	0 DISTURBED AREA	0 INVADER/PIONEER
1 AUGUST	0 YELLOW FL.		0 INDICATES OVERGRAZING
0 SEPTEMBER		0 RARE/ENDANGERED	0 POISONOUS/AVOIDED
0 OCTOBER	0 SMALL <9" (225MM)		
	1 MEDIUM <36" (900MM)	0 SEED AVAILABLE	0 VEGETABLE/POTHERB
0 PERSISTENT (2M+)	0 LARGE >36"	0 PLANT AVAILABLE	0 POISONOUS TO MAN
			0 EDIBLE PARTS
0 EARLY GROWTH	0 COVER PLANT	1 SEXUAL REPRO.	0 EATEN RAW
0 WINTER INTEREST	1 FOLIAGE CONTRAST	0 VEGETATIVE REPRO.	0 TEA/COFFEE SUB.
	0 SHOWY FALL COLOR		
0 WET SOIL	0 DEFENDED	0 ANNUAL	1 USEFUL
0 WET/MESIC SOIL	0 FIREPROOF	0 DIOECIOUS	0 CULTIVAR AVAILABLE
0 MESIC SOIL	0 AROMATIC		1 WEAVING/SEWING
0 DRY/MESIC SOIL	0 FORMS AGGREGATES'+	0 WIND DISPERSAL	0 DYE MATERIAL
0 DRY SOIL		0 ANIMAL DISPERSAL	
0 INDICATOR SP.	1 AT ST. JAMES	0 BIRD DISPERSAL	1 NATIVE HERBAL MED.
	0 ALIEN		0 WESTERN MED.
1 FORB/FLOWER	1 NATIVE SP.	0 FOOD FOR WILDLIFE	0 DIURETIC/LAXATIVE
0 GRASS		0 HOST SPECIES	0 EMETIC
0 BUNCH GRASS	0 COMPOSITE		0 TONIC/VITAMIN SOURCE
0 TREE OR SHRUB	1 LEGUME	0 SUSC. TO DROUGHT	1 SLIDE AVAILABLE

PSORALEA ESCULENTA COMMONLY CALLED INDIAN BREADROOT

0-NOT APPLICABLE 1-APPLICABLE

0 APRIL FLOWER	1 BLUE/VIOLET FL.	1 OPEN PRAIRIE	0 PASTURE/CROP
1 MAY	0 GREEN/BROWN FL.	0 WOODLAND (OAK/ASPEN)	0 INCREASER
0 JUNE	0 RED/PINK FL.	0 WOOD EDGE/TRANSITION	1 DECREASER
0 JULY	0 WHITE FL.	0 DISTURBED AREA	0 INVADER/PIONEER
0 AUGUST	0 YELLOW FL.		0 INDICATES OVERGRAZING
0 SEPTEMBER		0 RARE/ENDANGERED	0 POISONOUS/AVOIDED
0 OCTOBER	0 SMALL <9" (225MM)		
	1 MEDIUM <36" (900MM)	0 SEED AVAILABLE	1 VEGETABLE/POTHERB
0 PERSISTENT (2M+)	0 LARGE >36"	0 PLANT AVAILABLE	0 POISONOUS TO MAN
			1 EDIBLE PARTS
0 EARLY GROWTH	1 COVER PLANT	0 SEXUAL REPRO.	1 EATEN RAW
0 WINTER INTEREST	0 FOLIAGE CONTRAST	1 VEGETATIVE REPRO.	0 TEA/COFFEE SUB.
	0 SHOWY FALL COLOR		
0 WET SOIL	0 DEFENDED	0 ANNUAL	0 USEFUL
0 WET/MESIC SOIL	0 FIREPROOF	0 DIOECIOUS	0 CULTIVAR AVAILABLE
0 MESIC SOIL	0 AROMATIC		0 WEAVING/SEWING
0 DRY/MESIC SOIL	0 FORMS AGGREGATES'+	0 WIND DISPERSAL	0 DYE MATERIAL
1 DRY SOIL		0 ANIMAL DISPERSAL	
0 INDICATOR SP.	1 AT ST. JAMES	0 BIRD DISPERSAL	0 NATIVE HERBAL MED.
	0 ALIEN		0 WESTERN MED.
1 FORB/FLOWER	1 NATIVE SP.	0 FOOD FOR WILDLIFE	0 DIURETIC/LAXATIVE
0 GRASS		0 HOST SPECIES	0 EMETIC
0 BUNCH GRASS	0 COMPOSITE		0 TONIC/VITAMIN SOURCE
0 TREE OR SHRUB	1 LEGUME	0 SUSC. TO DROUGHT	0 SLIDE AVAILABLE

....THAT'S ALL THAT ARE ON FILE.

3

CODE	CRITERIA	CODE	CRITERIA
01	APRIL FLOWER	41	OPEN PRAIRIE
02	MAY	42	WOODLAND
03	JUNE	43	WOOD EDGE
04	JULY	44	DISTURBED AREA
05	AUGUST		
06	SEPTEMBER	45	RARE/ENDANGERED
07	OCTOBER		
08	PERSISTENT (2 M+)	46	SEED AVAILABLE
		47	PLANT AVAILABLE
09	EARLY GROWTH		
10	WINTER INTEREST	48	SEXUAL REPRO.
		49	VEGETATIVE REPRO.
11	WET SOIL		
12	WET/MESIC SOIL	50	ANNUAL
13	MESIC SOIL	51	DIOECIOUS
14	DRY/MESIC SOIL		
15	DRY SOIL	52	WIND DISPERSED
16	INDICATOR SP.	53	ANIMAL DISPERSAL
		54	BIRD DISPERSAL
17	FORB/FLOWER		
18	GRASS	55	FOOD FOR WILDLIFE
19	BUNCH GRASS	56	HOST SPECIES
20	TREE OR SHRUB		
		57	SUSC. TO DROUGHT
21	BLUE/VIOLET FL.		
22	GREEN/BROWN FL.	58	PASTURE/CROP
23	RED/PINK FL.	59	INCREASER
24	WHITE FL.	60	DECREASER
25	YELLOW FL.	61	INVADER/PIONEER
		62	INDICATES OVERGRAZING
26	SMALL <9"	63	POISONOUS/AVOIDED
27	MEDIUM <36"		
28	LARGE >36"	64	VEGETABLE
		65	POISONOUS TO MAN
29	GOOD COVER PLANT	66	EDIBLE PARTS
30	FOLIAGE CONTRAST	67	EATEN RAW
31	SHOWY FALL COLOR	68	TEA/COFFEE SUB.
32	DEFENDED		
33	FIREPROOF	69	USEFUL
34	AROMATIC	70	CULTIVAR AVAILABLE
35	FORMS AGGREGATES	71	WEAVING/SEWING
		72	DYE MATERIAL
36	AT ST. JAMES		
37	ALIEN	73	NATIVE HERBAL MED.
38	NATIVE SP.	74	WESTERN MED.
		75	DIURETIC/LAXATIVE
39	COMPOSITE	76	EMETIC
40	LEGUME	77	TONIC/VITAMIN SOURCE
		78	SLIDE AVAILABLE

PRAIRIE AT ST JAMES NATIVE HERBAL MEDICINE

HOW MANY CRITERIA ARE YOU COMBINING? (MAX 10)
ENTER CHOSEN CODE NUMBERS.(ON SEPARATE LINES)
NOW SEARCHING FOR CRITERIA NO'S.. 41 36 73

ACHILLEA MILLEFOLIUM	YARROW
ALLIUM CERNUUM	NODDING ONION
ALLIUM STELLATUM	WILD ONION
AMBROSIA TRIFIDA	GREAT RAGWEED
ANDROPOGON GERARDI	BIG BLUESTEM,TURKEYFOOT
ANEMONE CANADENSIS	CANADA ANEMONE
ANEMONE PATENS WOLFGANGIANA	PRAIRIE CROCUS,PASQUEFLOWER
ANTENNARIA NEGLECTA NEGLECTA	CANADA EVERLASTING
APOCYNUM ANDROSAEMIFOLIUM	SPREADING DOGBANE
APOCYNUM SIBIRICUM	CLASPING LEAVED DOGBANE
ARTEMISIA FRIGIDA	PASTURE SAGE
ARTEMISIA LUDOVICIANA GNAPHALODES	WHITE SAGE
ASCLEPIAS OVALIFOLIA	DWARF MILKWEED
ASCLEPIAS SYRIACA	COMMON MILKWEED
ASTER LAEVIS	SMOOTH ASTER
ASTER PANSUS	MANY FLOWERED ASTER
ASTER PTARMICOIDES	UPLAND WHITE ASTER
ASTER SIMPLEX	PANICLED ASTER
ASTRAGALUS CANADENSIS	CANADIAN MILKVETCH
CAMPANULA ROTUNDIFOLIA	BLUEBELL,HAREBELL
CIRSIUM FLODMANII	FLODMAN'S THISTLE
ECHINACEA ANGUSTIFOLIA	PURPLE CONEFLOWER
EPILOBIUM ANGUSTIFOLIUM	FIREWEED
ERIGERON STRIGOSUS	DAISY FLEABANE
FRAGARIA VIRGINIANA	WILD STRAWBERRY
GALIUM SEPTENTRIONALE	NORTHERN BEDSTRAW
GLYCYRRHIZA LEPIDOTA	WILD LICORICE
GRINDELIA SQUARROSA	GUMWEED
HEUCHERA RICHARDSONII	ALUMROOT
HORDEUM JUBATUM	WILD BARLEY,FOXTAIL
LACTUCA PULCHELLA	COMMON BLUE LETTUCE
LATHYRUS VENOSUS INTONSUS	WILD PEAVINE
LITHOSPERMUM CANESCENS	HOARY PUCOON
MONARDA FISTULOSA	WILD BERGAMOT
OENOTHERA BIENNIS	YELLOW EVENING PRIMROSE
PENSTEMON GRACILIS	LILAC FLOWERED BEARDTONGUE
PETALOSTEMUM PURPUREUM	PURPLE PRAIRIE CLOVER
PHYSALIS VIRGINIANA	VIRGINIA GROUNDCHERRY
POLYGALA SENEGA	SENECA SNAKEROOT
POTENTILLA ARGUTA	TALL QUINQUEFOIL
PSORALEA ARGOPHYLLA	SILVERLEAF PSORALEA
RATIBIDA COLUMNIFERA	LONGHEADED CONEFLOWER
ROSA ACICULARIS	PRICKLY ROSE
ROSA ARKANSANA	LOW PRAIRIE ROSE
ROSA BLANDA	SMOOTH ROSE
ROSA WOODSII	WOOD'S ROSE
SOLIDAGO CANADENSIS	CANADA GOLDENROD
SOLIDAGO DECUMBENS OREOPHILA	MOUNTAIN GOLDENROD
SOLIDAGO MISSOURIENSIS	LOW GOLDENROD
SOLIDAGO RIGIDA	STIFF GOLDENROD
THALICTRUM DASYCARPUM	TALL MEADOWRUE

TOTAL COUNT IS 51 PLANTS..

BIBLIOGRAPHY

BIBLIOGRAPHY

Ahenakew, Edward. Voices of the Plains Cree, ed. Ruth M. Buck. Toronto: McClelland and Stewart, 1973.

Assiniwi, Bernard. Survival in the Bush. Toronto: Copp-Clark, n.d.

Breymeyer, A. I., and G. M. Van Dyne, eds. IBP19--Grasslands, Systems Analysis and Man. London: Cambridge University Press, 1980.

Collens, P. A., R. J. Collens, C. R. Peterkin, D. H. Scuse, and R. G. Stanton. Structured Fortran with Watfiv-s and Watfor-11s. St. Pierre, Manitoba: CBRC Box 370, 1976.

Copway, G. The Traditional History and Characteristic Sketches of the Ojibway Nation, 1850. Toronto: Facsimile edition by Coles Publishing Co., 1972.

Costello, David F. The Prairie World--Plants and Animals of the Grassland Sea. New York: Thomas Y. Crowell Co., 1975.

Dansereau, Pierre. Inscape and Landscape. CBC Learning Systems, 1973.

Embertson, Jane. Pods--Wildflowers and Weeds in Their Final Beauty. New York: Charles Scribner's Sons, 1979.

Erichsen-Brown, Charlotte. Use of Plants--for the past 500 years. Toronto: Breezy Creeks Press, 1979.

Falk, John Howard. "The Energetics of a Suburban Lawn," Ecology 57 (1976), 141-150.

Farallones Institute. The Integral Urban House. San Francisco: Sierra Club Books, 1979.

Farb, Peter. Man's Rise to Civilization--The Cultural Accent of the Indians of North America. New York: Bantam Books Inc., 1978.

Farney, Dennis. "The Tallgrass Prairie: Can It Be Saved?" National Geographic (January 1980), 37-61.

Gould, Stephen Jay. Ever Since Darwin--Reflections in Natural History. New York: W. W. Norton and Company, 1979.

Harburn, Norman. Living Prairie Museum Interpretation Plan. Winnipeg: City Parks Department, 1978.

Harp, H. F. The Prairie Gardener. Edmonton: Hurtig Publishers, 1970.

Hungry Wolf, Adolf. My Cree People--Told by Fine Day. Invermere, B.C.: Good Medicine Books, 1973.

Jackson, Stephen, and Linda Prine. Wild Plants of Central North America for Food and Medicine. Winnipeg: Peguis Publishers Ltd., 1978.

Jenness, Diamond. Indians of Canada. Ottawa: University of Toronto Press, 1979.

Jenny, H. Factors of Soil Formation. New York: McGraw-Hill, 1941.

Johnston, Basil. Ojibway Heritage--The Ceremonies, Rituals, Songs, Dances, Prayers and Legends of the Ojibway. Toronto: McClelland and Stewart, 1979.

Leslie, Dr. W. R. "Indian Gardening," The Prairie Garden (1972), 24-27.

Lewis, Henry T. "Indian Fires of Spring--Hunters and gatherers of the Canadian boreal forest shaped their habitat with fire," Natural History (January 1980), 76-80.

Mandelbaum, David G. The Plains Cree--An Ethnographic, Historical, and Comparative Study. Regina: Canadian Plains Research Center, 1979.

Margalef, Ramón. Perspectives in Ecological Theory. Chicago: University of Chicago Press, 1968.

Martin, Alexander, Herbert Zim, and Arnold Nelson. American Wildlife and Plants--A Guide to Wildlife Food Habits. New York: Dover Publications, Inc., 1961.

McCaffrey, Anne. Dragondrums. New York: Bantam Books, 1980.

McHarg, Ian L. Design with Nature. Garden City, New York: Doubleday & Company, Inc., 1971.

McLuhan, T. C. Touch the Earth--A Self-Portrait of Indian Existence. New York: Promontory Press, 1971.

Mondor, Claude. "The Canadian Plains: The Vanishing Act," Nature Canada (June 1976), 32-39.

Mulligan, Gerald A. Common Weeds of Canada. Toronto: McClelland and Stewart/Dept. of Agriculture, and Publishing Centre, Supply and Services, Canada, 1978.

Neihardt, John G. Black Elk Speaks--Being the Life Story of a Holy Man of the Oglala Sioux. New York: Pocket Books, 1975.

Odum and Odum. Energy Basis for Man and Nature. New York: McGraw-Hill Book Co., 1976.

Peterkin, Craig R., and David H. Scuse. Fortran with Business Application. Waterloo: WATFAC, Box 803, Waterloo, Ontario, Canada, 1974.

Price, John. Indians of Canada--Cultural Dynamics. Scarborough: Prentice-Hall, 1979.

Schumacher, E. F. A Guide for the Perplexed. New York: Harper and Row, 1977.

Southwich, Charles H. Ecology and the Quality of our Environment. 2nd ed. New York: D. Van Nostrand Company, 1976.

Van Bruggen, Theodore. Wildflowers of the Northern Plains and Black Hills. Interior, South Dakota 57750: Bulletin No. 3, Badlands Natural History Association, 1976.

Vance, F. R., J. R. Jowsey, and J. S. McLean. Wildflowers Across the Prairies. Saskatoon, Saskatchewan: Western Producer Prairie Books, 1977.

Watts, May Theilgaard. Reading the Landscape of America. New York: Collier Books, 1975.

Weaver, J. E. North American Prairie. 1954 (out of print).

________. Prairie Plants and Their Environment--A Fifty-Year Study in the Midwest. Lincoln: University of Nebraska Press, 1968.

Wehr Nature Center. A Prairie Propagation Handbook. Whitnell Park, 5879 S. 92 St., Hales Corners, Wisconsin 53130.