RIVERBANK RESTORATION MANUAL

Prepared for:

MEEWASIN VALLEY AUTHORITY

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1. INTRODUCTION

This document comprises a portion of the product arising from the Riverbank Restoration Study. It has been produced as a separate volume with the intent that it may be used as a manual by planners, managers and field crews who are involved in site development, maintenance and restoration work in the Meewasin Valley. It is intended to serve as a guide throughout the restoration process and has therefore been organized to present each phase of the process in a step-by-step fashion so that it can be used like a 'cookbook'. However, because the field of site restoration is relatively new (especially in a local context), this manual should not be considered the 'last word' in restoration, complete with a full set of time-tested techniques. Although a variety of specific techniques, procedures and prescriptions is presented, the 'best' methods will only be arrived at through experimentation and monitoring the success of restoration measures. It is therefore expected that the contents of this manual will be revised, refined and up-dated as experience and experimentation suggests.

1.1 ORGANIZATION OF THE MANUAL

This manual, as noted above, has been organized to take planners, managers and field personnel through the decision-making and action-taking phases of the site restoration process in a manner that will permit logical and comprehensive assessment of site problems, determination of appropriate restoration strategies and selection of suitable restoration techniques. Section 2 is devoted to a detailed discussion of the restoration process itself, and includes information related directly to the Meewasin Valley that will be of use in identifying priorities for restoration, determining strategies, selecting techniques and implementing restoration procedures in the field.

Section 3 is concerned with descriptions of the problems that have, to date, been identified as problems in the Valley. It includes descriptions of the symptons and possible causes of each problem; it outlines problems that may be associated with or related to a specific problem; and it

identifies possible techniques that may be successfully applied to restore a site suffering from a given problem.

Section 4 is a catalogue of restoration techniques that may be used in rectifying the problems outlined in Section 3. Each technique is dealt with by identifying its potential applications and by thoroughly but concisely setting out, in written and graphic form, instructions for applying the technique in the field.

Throughout Sections 3 and 4, widespread cross-referencing among problems and restoration techiques is utilized to increase the efficiency with which the manual may be used. Given that, over time, new problems will be identified and new or refined restoration techniques will be developed, a loose-leaf format for the manual will facilitate replacement and addition of information as it becomes available. In addition, this format will permit, at any time, removal of information for use in the field, thereby further increasing utility of the manual to field crew-chiefs and field managers.

The concept of a comprehensive, species-specific data base is introduced in Section 5. Such a data base will, as it grows over time, provide prescriptions regarding the use of many specific plant species in the restoration of degraded sites in the Meewasin Valley.

1.2 HOW TO USE THE MANUAL

As noted earlier in this section, this manual is only a part of the product arising from the Riverbank Restoration Strategy. A separate volume has also been prepared, which documents the methods used in carrying out the study, results of a field program undertaken to identify site degradation problems, delineation of 'restoration units', determination of restoration objectives, priorities and strategies, recommendations relating to on-going monitoring procedures and case study examples of how the restoration manual should be used. Some of the information presented in the main report is duplicated in this manual to reduce the need for cumbersome cross-referencing between volumes as this manual is used on a day-to-day basis.

Nevertheless, effective use of this manual will require that key people involved in site restoration (including planners, managers and field crew chiefs) have a common understanding of the intent, objectives, priorities and possible strategies of the riverbank restoration program, and of the techniques available for implementing the program. Further, it is important that this common understanding goes beyond the Meewasin Valley Authority itself, to those agencies who may also be involved in the funding, planning and/or implementation of the restoration program; specifically the City of Saskatoon Parks & Recreation and Engineering Departments and the University of Saskatchewan. To ensure co-ordinated planning and implementation, it is therefore considered essential that all of these participating bodies receive an initial orientation to the program and that periodic joint reviews be held to re-assess what is sure to be a dynamic situation of site degradation and restoration.

With reference to the 'day-to-day' use of this manual, it is anticipated that there will be a relatively distinct division of tasks among planners, managers and field personnel (these tasks are specifically described in Section 2). However, it is envisioned that overall responsibility for co-ordination of a riverbank restoration program be assigned to one individual within the MVA administration who would serve as 'riverbank restoration co-ordinator'. This individual will be required to co-ordinate the restoration program, both in terms of overall annual planning of the entire program and in terms of site-specific planning and implementation.

When using the manual, it must be remembered that the restoration process described relates to the most complex cases that could be encountered, requiring the most extensive restoration work. In most cases, it is fully expected that some of the steps included in the process as described will be left out or ignored, and the integrity of the restoration program in such cases will in no way be jeopardized. Although writing the manual to deal with the most complex cases tends to make the process appear more cumbersome than is usually necessary, it is generally considered easier to 'skip' certain steps in a fully documented process than it is to 'make up' additional steps to accommodate situations not accounted for in a less thorough approach.

It should also be remembered that, when the tasks and responsibilities of various individuals are described in this manual, the terms used to describe the various individuals that could be involved are intended to describe the role played by that individual in the restoration program, not the title or position of any individual within the M.V.A. or other administration structure. In many cases, it is expected that an individual will play more than one role in the restoration of a given site. Indeed, in some cases, it is conceivable that all tasks related to restoring a site (including co-ordination, planning and field implementation) could be effectively undertaken by one individual. Generally speaking there are four key roles to be filled in the entire site restoration process:

1. A co-ordination role, to be filled in all cases by a single individual, referred to in this manual as the "restoration program co-ordinator" or "restoration co-ordinator". The co-ordination function is essential at both the overall program level and the site-specific level.

2. A restoration planning role, which will vary according to the specific circumstances relating to a site. In many cases, this role could be filled by the restoration co-ordinator, although where site planning or site design is required to incorporate facilities, services or features related to human activities or needs, it may be necessary to have this role fulfilled by a professional site planner/ landscape architect.

3. A construction management role which, depending on specific circumstances, could be fulfilled by the restoration co-ordinator or an individual with specialized expertise in the field of construction co-ordination and management.

4. A field construction role, which is the actual field implementation of restoration techniques. This role is typically expected to be filled by field crews headed by crew chiefs, although in some cases (usually small, simple cases), others may be able to carry out field restoration measures.

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2. THE RESTORATION PROCESS

The process of restoring degraded sites or areas can be broken into four major phases (Figure 1):

1. Planning, which includes identification of sites or areas to be restored, determination of specific problems, determination of the intended use or role of the site, selection of an appropriate strategy for restoration and preparation of a restoration plan.

2. Scheduling/budgeting, which includes organization of the field work required to implement the restoration plan.

3. Implementation, which is the actual field work required to restore the site or area to desired conditions or to establish the conditions required for natural restoration.

4. Management, which is a continuing process of monitoring and maintenance to evaluate the success of restoration procedures and/or to undertake remedial intervention to correct subsequent problems through the application of refined or new restoration techniques.

This process ultimately involves those involved in overall master planning of the Valley, site planners/designers, construction and maintenance managers and field personnel. It is a process that, by its very nature, requires the integrated and co-ordinated involvement of all participants. Further, it is a process that requires considerable lead time to allow for proper planning and scheduling before implementation is begun. It is clear that there will be instances where, for any of a variety of reasons, there will be a need to 'short-circuit' this process (e.g. major storms causing severe run-off erosion or flood damage; unexpected outbreaks of vegetation pests; etc.), to permit rapid response to problems for the purposes of ensuring public safety or structural integrity of affected facilities. Where possible, however, the restoration program should be carried out using the process described in detail below. By following such an orderly, co-ordinated process, adequate fiscal arrangements, annual operational and manpower planning and efficient materials acquisition will all be facilitated.

FIGURE 1: THE RESTORATION PROCESS

PHASE	TASK	PRIMARY RESPONSIBILITY	SECONDARY INVOLVEMENT
1. PLANNING	1. Identification of candidate sites and problems	- Restoration Co-ordinator	
	2. Determining intended use or role of a candidate site	- Restoration Co-ordinator	- MVA Program Co-ordinators - U. of S. Physical Plant Department - C. of S. Parks & Recreation, Engineering & Planning Department
	3. Determining a restoration strategy	- Restoration Co-ordinator	- MVA Resource Conservation Co-ordinator
	4. Preparing a facilities prescription	- Restoration Co-ordinator	- MVA Program Co-ordinators - consultants
	5. Base information / documentation of existing conditions	- Restoration Planner	- technical support staff - consultants
	6. Preparing the restoration plan	- Restoration Planner	- MVA Resource Conservation Co-ordinator - consultants
	7. Submission of the restoration plan	- Restoration Planner - Restoration Co-ordinator	
2. SCHEDULING/ BUDGETING	1. Examination of the restoration plan	- Restoration Co-ordinator	
	2. Determination of tasks	- Restoration Co-ordinator	- field crew chiefs - consultants
	3. Work schedule/ budget	- Construction Manager/Field Crew Chief - Restoration Co-ordinator	- C. of S. Parks & Recreation Department - U. of S. Physical Plant Department
3. IMPLEMENTATION	1. Acquisition of materials and labour	- Restoration Co-ordinator - Construction Manager	
	2. Supervision	- Restoration Planner - Field Crew Chief	- Restoration Co-ordinator - Construction Manager
4. MANAGEMENT	1. Monitoring program	- Restoration Co-ordinator	- consultants - field staff
	2. Care and Maintenance of a restored site	- C. of S. Parks & Recreation Department - U. of S. Physical Plant	- Restoration Co-ordinator

Key to the concept of an orderly, co-ordinated program is the notion of a 'cyclical' approach to planning and implementing site restoration efforts. An annual cycle is considered appropriate for this type of program, with the process 'returning to the beginning' each year, when progress is evaluated, 'new' problems flagged, the overall situation re-assessed and planning for the next year initiated.

2.1 PLANNING

This phase of the restoration process includes all of the tasks required to plan the necessary improvements in site conditions which will allow a given site or area to provide for its intended use or role while providing protection for the resource base.

2.1.1 Identification of Candidate Sites & Problems

The first task in the planning phase of the program is to determine which problem sites or areas are to be considered priority candidate sites for restoration. For the purposes of this restoration manual, a 'site' is considered to be the specific area where biophysical restoration techniques will need to be applied to rectify degradation problems. It could take on any size from a few square metres and up and it could be of any shape. It is envisioned that, typically, sites would be relatively small. For example, the Cranberry Flats property could consist of a large number of sites, each being restored to rectify a specific problem or set of problems (e.g. a trail suffering from denudation and erosion, a blow-out, etc.)

The basis for selection of candidate sites will be dependent upon a number of factors, including the following:

a. The overall priority assigned to a site, regardless, of the nature, cause or severity of degradation problems at the site.

b. The severity of any problems occurring at a given site, and the implications (both short and long term) of <u>not</u> taking action to restore the site to desired conditions.

c. The cause of any problems (natural or human-induced) occurring at a site.

a. Site Priorities

During the course of the Riverbank Restoration Study, a series of 32 areas, or 'restoration units' were delineated within the study area (refer to Map 1). These restoration units were then assessed and ranked (on the basis of a number of factors described in more detail in the main report of the Riverbank Restoration Study) in terms of their importance or priority for restoration, regardless of the nature, cause or severity of degradation problems that may be occurring within the units. This ranking is illustrated in Table 1.

It should be noted that the basis for ranking the restoration units consists of a number of factors which are subject to considerable and, at times rapid, change. Thus, while the rankings reflect conditions at the time the units were assessed (late 1984), they should be re-assessed on an annual basis when restoration planning is initiated to ensure that unit priorities reflect their current situation.

The first step in evaluating potential candidate restoration sites, then, is to determine the restoration unit in which each problem site is situated and the priority group within which it falls.

b. Problem Priorities and Problem Severity

As part of the data collection, analysis and assessment work in the Riverbank Restoration Study, preliminary field investigations led to the identification of 33 general site degradation problems in the study area and to a general assessment of the severity of each of these problems in each of the restoration units (Table 2). Each problem was assessed in terms of its impact (regardless of its present extent or severity in the study area) from two perspectives: the ecological impact of the problem; and the perceived impact of the problem. Details of this assessment are documented in the main report. Table 3 illustrates the priority ranking of identified problems, in terms of their combined significance (i.e. both ecological and perceived impacts).

TABLE 1

RESTORATION UNIT RANKINGS (AUTUMN 1984)

RANK	UNIT NO. AND NAME		PRIORITY GROUP
1	22	Kiwanis Park	
2	12	Rotary Park	GROUP 1
3	19	Victoria Park	
4	20	South Downtown	
5	24	West Bank (Queen - Circle)	
6	4	Beaver Creek	GROUP 2
7	10	Diefenbaker Park	
8	14	U. of S. Lands	
	25	Meewasin Park	
9	23	Kinsmen/Mendel	
10	1	Brown's Flats	
	6	Cranberry Flats	
11	13	Cosmopolitan Park	GROUP 3
12	32	Clarkboro Ferry	
13	21	Friendship Park	
14	18	Holiday Park - Water T.P.	
15	2	Floodplain (west)	
16	5	C. of S. property	
	9	Equestrian area and S.P.C. site	
	15	Sutherland Beach	
	17	Q.E.G.S. - C.N. Bridge	
17	3	Floodplain (east)	
	7	Jenneau property	GROUP 4
	8	Rifle range	
	26	Saskatoon Chemicals	
	28	Gravel pit	
	29	Gravel pit	
	30	Gravel pit	
	31	Grazed valley wall	
18	11	East Bank South	
	16	East Bank	
19	27	Tipperary Creek	

PROBLEMS	SITES																											
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
1. Riverbank Sloughing				M				L		L							M								M							
2. Garbage	M							M		M	M		M	M			M	M	M	L				M	L						L
3. Pedestrian Traffic - Denudation, Erosion, Gullying	M			M		M		M		M	L				M	M				L	L	M	M	L	M						
4. Vehicle Traffic - Denudation and Erosion	M		L	M		M		M			L		L		M	M	M			L					L	L	M	M	M	M	M	M
5. Sewer Outfalls - Gullying and Headward Erosion											L			M			M	M	L	L	L			M	M							
6. Seepage/Springs - Gullying and Piping				L				L		M	L		L	M		M	L						L	L	L							
7. Rubble Dumping	M										M					M	M	M	M	L						L						L
8. Beaver	L		L	M	M	M	L	L		M	L	L	L	L	L	L	M	L	L		L	L	M	M	M	L	L		L		M	L
9. Inappropriate and Improper Pruning and Clearing													L		L		M	L					L									
10. Vegetation Pests, Diseases, and Blights	L	L	L	L	M	M	M	L	L	M	L	L	L	L	L	L	M	M	L		L	L	M	M	M	M	M	L	L	M	L	L
11. Major Slumping				M				M		M	M		L																			
12. Natural Piping Failures										M				M		M																
13. Vehicles Abandoned	M		L					L								M	M									M					
14. Road Cuts - Sloughing/Rill and Gully Erosion	L					L								L	L		L								L							L
15. Vandalism - Broken Bottles, Stripped Birch, Shot Signs	M		L	L				L		M	L			L		M																
16. Outfall Construction														L		L	M	M	L	L	L			M	M							
17. Overgrazing																													M	L	M	
18. Ground Squirrels (Gophers)				L				L	M	M						M			M	M	L						M		M	M		
19. Pocket Gophers			L	L				L	M	M																L	L					
20. Porcupines				L			L	L	L				L				M	L					L			L	L					
21. Boat Launch and Dock Areas												L																				L
22. Skating Rinks on Lawns																						H										
23. Grade Changes Around Trees																									M							
24. Tree Forts, Etc.																									L							
25. Seepage Along Trails - Mud				L									L		L								M	L	L							
26. Archaeological Excavations																											M					
27. Gravel Extraction																												M	M	M		
28. Cultivation Along Lip of Valley Wall			L																									L				
29. Burning	L	L		M											L	L	L								L					M		
30. Abandoned Fence Wire														L		L										L	L					L
31. Weed Growth on Disturbed Soil									M		M				M	M			M				M		M			M	M	L		L
32. Sand Excavation						L												L														
33. Snow Dumping											M								M	M			M	M								
34. Trail Construction (Cuts, Fills, Brush Piles)				L								L	L	L	L	L			L	L	L				L							

TABLE 2: DISTRIBUTION AND SEVERITY OF PROBLEMS (refer to Map 1)
(AUTUMN 1984)

TABLE 3 PROBLEM PRIORITY RANKINGS (AUTUMN 1984)

PROBLEM NO.	AND NAME	PRIORITY GROUP
5	Sewer outfalls	GROUP 1
4	Vehicle traffic - denudation and erosion	
14	Road cuts - sloughing/rill erosion	
27	Gravel extraction	
15	Vandalism	GROUP 2
7	Rubble dumping	
11	Major slumping	
32	Sand excavation	
33	Snow dumping	
1	Riverbank sloughing	GROUP 3
3	Pedestrian traffic - denudation, erosion and gullying	
2	Garbage	
13	Vehicles abandoned	
10	Vegetation pests, diseases and blights	
17	Overgrazing	
25	Seepage along trails	
31	Weed growth on disturbed soils	
23	Grade changes around trees	
29	Burning	
21	Boat launch and dock areas	
26	Archaeological excavations	
30	Abandoned fence wire	
8	Beaver	
28	Cultivation along lip of valley wall	
6	Seepage/springs - gullying and piping	
18	Ground squirrels	
9	Inappropriate and improper pruning	
22	Skating rinks on lawns	
34	Trail construction - cuts, fills, brush piles	
12	Natural piping failures	
19	Pocket gophers	
20	Porcupines	
24	Tree forts, etc.	

The second step in evaluating potential candidate restoration sites is thus to identify the specific problem(s) occurring at a given site and to determine (based on Table 3) the general priority of such problems for restoration.

In association with this determination of problem priority is the need to consider the relative severity of the problem(s) occurring at possible candidate sites. This severity may be 'measured' in terms of the implications of not designating a problem site for restoration in a given year. Implications to be considered include the following:

1. Will public safety be threatened if the site is not designated this year?
2. Are there any buildings or facilities whose structural or operational integrity will be jeopardized if the site is not designated this year?
3. Will there be irreperable damage to the site if it is not designated this year?
4. Will the costs of restoration be significantly higher or will the difficulty of restoration be significantly greater if the site is not designated this year?

Answers to some of these questions will clearly be based solely on 'judgement calls'. Nevertheless, if the answer to any, some or all of them is 'yes' for any problem site, there would be a reasonable case for designating such a site for restoration, regardless of problem type, site priority or problem cause.

c. Problem Causes

The cause or causes of a specific site degradation problem may also affect decisions with respect to designation of candidate restoration sites. Generally speaking, problem causes may be categorized as either 'natural' or 'human-induced'. Given that the Meewasin Valley Authority has, as one of its responsibilities, the conservation of the natural resources of the Meewasin Valley, it may be that site degradation problems caused by natural processes that have not been induced by human activity should not be

ameliorated. This may be especially true in natural or near-natural areas of the Valley, where on-going natural processes (wildlife activity, river-bank erosion, etc.) are integral to the natural evolution or succession of these dynamic natural areas.

Nevertheless, should such natural processes cause problems which might threaten public safety in high use areas or the structural or operational integrity of existing facilities, sites affected in this manner will need to be considered as high priority sites for restoration. The key in these cases will be the selection of an appropriate strategy to deal with such problems. This will be dealt with in Section 2.1.3 of this manual.

In the process of identifying candidate restoration sites each year, all three of the above factors must be considered together; none should be considered in isolation. It is recognized, however, that the severity of a problem or problems at any site may justify designation of that site regardless of other factors.

2.1.2 Determining Intended Use or Role of a Candidate Site

Once a problem site has been designated for restoration, decisions must be made, by the riverbank restoration co-ordinator, about the intended character, role and intensity of use that is appropriate to both the resource base of the candidate site and any development plans that have been approved for the site and/or surrounding areas. These decisions may be based on existing approved plans or policies or, in the absence of same, on consultation with those responsible for overseeing this development (e.g. M.V.A. program co-ordinators, University of Saskatchewan Physical Plant Department representatives, City of Saskatoon Parks & Recreation, Engineering and/or Planning Department representatives.

2.1.3 Determining a Restoration Strategy

Based on the intended use or role of the candidate site, the restoration program co-ordinator, in consultation with Meewasin's Resource Conservation Co-ordinator, will then need to decide upon a restoration strategy which will alter present site conditions to provide for the intended use or role.

Two different sets of possible strategies are set out below: one set relating to human-induced problems; and one relating to naturally-induced problems.

a. Human-Induced Problems

Three optional strategies are apparent for restoration of candidate sites where degradation problems have been caused by human activity. They are as follows:

1. Permanent closure of the site and restoration of desired conditions.

2. Temporary closure of the site and the development of 'hardened' conditions which can better withstand the present use or role of the site (i.e. no change in site function).

3. Temporary closure of the site and the development of 'hardened' conditions which can withstand the impacts of use which is lighter in intensity or different in type than the use which is currently being made of the site. This strategy provides an opportunity for the implementation of a change in site use or role as part of the restoration process.

Where restoration of vegetation is required, and regardless of the strategy selected, a period of site closure will be necessary to provide protection for such vegetation to become established on the candidate site. The actual duration of closure that will be needed will be dependent upon the type of vegetation being established, the nature of the problem being rectified and the level of intended or expected use of the site. In many cases, the required duration of closure will only be determined through experimentation and monitoring.

b. Naturally-Induced Problems

Two alternative strategies are apparent for restoration of candidate sites where degradation problems have been caused by natural agents and processes and where the level and type of human activity would not appreciably impact on site restoration measures. They are:

1. Removal or control of the agent(s) or process(es) causing the problem(s) and restoration of desired conditions.

2. Development of 'hardened' conditions which can withstand the impacts of the agent(s) or process(es) causing the problem(s).

In cases where the level or type of human activity on the site could have a significant impact on site restoration measures, temporary closure of the site may also be required.

In some cases, there may be only one feasible strategy to deal with naturally-induced problems. For example, problems of riverbank erosion or sloughing caused by river current action probably cannot be feasibly rectified by removal of the agent causing the problem (the river) or by controlling the agent (through channel training or flow regulation). Thus, development of hardened conditions which can withstand fluvial erosion forces would appear to be the only feasible strategy. On the other hand, wholesale replacement of mature vegetation susceptible to common insect pests with tolerant species would most likely not be economically feasible. In such instances, eradication or control of the agent causing the problem would be the only logical strategy.

When dealing with naturally-induced problems, the selection of an appropriate restoration strategy must also consider possible short and long term impacts of the restoration measures themselves, both on-site and off-site.

2.1.4 Preparing a Facilities Prescription

On the basis of the selected restoration strategy, the restoration coordinator then prepares a list of facilities (if any) that would be required to provide for the intended use or role of the candidate site.

2.1.5 Base Information/Documentation of Existing Conditions

A pre-requisite for preparation of a site restoration plan is thorough documentation of existing conditions at the candidate site. However, before site conditions can be inventoried and documented, it will be necessary to have an accurate base map prepared at an appropriate scale and level of detail.

a. Base Mapping

Specific base mapping requirements for a candidate site will be totally dependent upon the nature of the problems to be rectified, the nature of the restoration techniques to be utilized, the topographic character of the site and the types of facilities to be located on the site. In instances where structural design and development is envisioned for a site, detailed information will be required and base mapping no smaller in scale than 1:200 will be needed with topographic information (using either survey grids on relatively flat sites or profiles on steeply sloping sites) sufficiently precise to adequately depict the terrain conditions. For sites where restoration measures will not require highly accurate design drawings, field location of site elements would be preferable and base information needs would be correspondingly lower. In many instances, base maps compiled from existing contour mapping and aerial photography and which reasonably indicate the location and extent of vegetation, buildings, roads, trails, above-ground utilities, etc. at a scale as small as 1:500 would probably be sufficient. Sources of such existing mapping and photography in the Valley include the following:

1. Canada - Saskatchewan Flood Damage Reduction Program (F.D.R.P.) Flood Risk Mapping at 1:2000 (urban area only).

2. F.D.R.P. aerial photography (1979) at 1:5000 (urban area only).

3. City of Saskatoon Orthophotomosaics with contour information superimposed at 1:2000 (selected areas within Saskatoon).

4. M.V.A. aerial photography of the entire Valley (various dates and scales).

5. M.V.A. semi-controlled air photo mosaics of the entire valley (various scales up to 1:5000).

6. Project specific base maps prepared for various M.V.A. and City of Saskatoon projects in the river valley (various scales and levels of detail; some very detailed).

7. University of Saskatchewan base mapping at scales up to 1:500 of the campus area.

For any candidate sites in which permanent structures will be developed or re-grading or excavation is envisioned, the specific locations and depths of all buried services and utilities must also be documented. These would include sewer, water, power, gas and telephone. Information regarding the locations, depths and maximum/minimum cover and loading requirements are available from the following sources:

1. City of Saskatoon Engineering Department
2. Saskatchewan Power Corporation
3. Saskatchewan Telecommunications

Although this information is generally reliable, it is essential that buried services be field located when excavation or re-grading is envisioned in close proximity to these services or utility lines.

b. Documentation of Existing Conditions

Once an appropriate base map has been prepared, the restoration planner assumes responsibility for preparing an inventory of existing features and environmental conditions at the candidate site. Two separate inventory maps will be required to ensure that information is recorded with a minimum of confusion. The first will be used to record basic biophysical site information. The second will be used for recording existing land use, facilities, and site features in need of repair.

The general biophysical characteristics of the site should be understood and appreciated by the restoration planner. When on site, and perhaps with the assistance of a resource analyst, he/she would record the following information:

-soils
    -general textural characteristics (sand, clay, bouldery, etc.)
    -persistently wet areas

-vegetation
  -vegetative associations present on-site, and their relationships to slope, moisture and soil conditions.
  -dominant and sub-dominant overstorey, understorey and ground layer species in each association.
  -areas that are in heavy shade

The purpose of this analysis is to clearly understand the interrelationships among the various site components and to ensure that proposed restoration work reflects those interrelationships.

On the second map, the restoration planner should record:

-land use
  -any identifiable activity or land use 'zones'
  -traffic corridors (vehicle and pedestrian)
  -areas that receive or appear to receive relatively low levels of use.

-facilities
  -developed roads, parking areas, pathways
  -site furnishings (picnic tables, barbecues, shelters, docks, etc.)
  -buildings and other structures
  -utility poles, light fixtures, outfalls, etc.
  -other as appropriate.

-site problems (these are features of the site that will require repair)
  -damaged trees or other plant material (including ground cover)
  -damaged shorelines (eroding or sloughing banks)
  -damaged slopes (eroding)
  -construction debris
  -garbage, litter, etc.

The specific information to be recorded on each map will vary widely depending upon specific site conditions and the nature of the identified problem(s) that need to be rectified.

2.1.6 Preparing the Restoration Plan

The restoration planner will now have:

1. Base mapping, appropriate in scale and level of detail to the restoration planning needs of the candidate site.

2. Two maps documenting existing site conditions.

3. A restoration strategy and facilities prescription (from the restoration program co-ordinator indicating the type and intensity of use that the candidate site must eventually cater to or the intended role of the site).

With this information, the restoration planner can begin to prepare the restoration plan for the candidate site. For candidate sites requiring major complex restoration measures involving structural and/or facility development, the restoration plan, in its entirety could consist of as much as:

1. A proposed site plan illustrating the distribution of facilities, land use or activity areas and plant massing within the site, as they will exist at some point in the future.

2. A detailed site preparation and repairs plan indicating which site elements need to be removed, repaired or protected from subsequent restoration work.

3. A layout plan, specifically locating all 'hard' site facilities that are proposed.

4. A grading plan, indicating proposed site grades and any structures required to achieve and maintain proposed grades.

5. A planting plan, indicating the locations, species and sizes of plant material to be established on site.

6. Construction details, as required.

7. A materials and work summary which will provide a written description of the work (including identification of specific restoration techniques that could be utilized) and materials required to restore the site.

It is expected that, for less complex situations, the restoration plan will not be required to include all of the items listed above. Indeed, in many cases, it is anticipated that the preparation of a proposed site plan and a site preparation and repairs plan, in association with a materials and work summary would be sufficient, provided that the restoration planner is on-site during the implementation phase to field locate key site elements. It is expected, in this sense, that the restoration techniques described later in this manual should provide adequate direction to field crews (when considered in conjunction with other information provided to them and when the restoration planner is available for on-site consultation).

Thus, the detailed restoration techniques will be of use to both the restoration planner (in the preparation of major, complex restoration plans) and the field crews (during the implementation of relatively simple, straightforward restoration plans).

a. The Proposed Site Plan

The purpose of the proposed site plan will be to indicate, in relatively general terms, the ultimate intended appearance and function of the site, including facilities (if any), land use or activity 'zones, general plant massing and image or character. The nature of facilities and activity areas will be determined by the facilities prescription already provided to the restoration planner and by any approved plans or policies that relate to development of the candidate site. The role of the restoration planner will be to ensure that the required facilities and land use areas are located in a manner that respects the capability of the site to ultimately accommodate them without causing further site degradation.

This manual does not provide standards or guidelines for this aspect of site planning; such standards and guidelines lie beyond the scope of a manual oriented toward site restoration per se. Similarly, the image or character of the site that is proposed on the site plan (through proposed plant massing, landscaping strategy, etc.) is the domain of the site planner/landscape architect. However, decisions regarding restoration of both plant material and facilities must consider the biophysical conditions at the site that may limit or constrain restoration and development, including moisture availability, soil conditions, topographic situation, shade/sun conditions and wind exposure.

With the completion of the proposed site plan, the restoration planner should review all proposals with the restoration co-ordinator to ensure that the plan corresponds to the restoration and after-use intent of the site. Depending upon the specific circumstances, the co-ordinator may wish to consult with other program co-ordinators within the M.V.A. and representatives of other agencies that may be affected by or involved in site restoration, development and/or maintenance.

At this stage in the restoration process, the restoration planner will have prepared:

1. Two maps documenting existing site conditions.
2. An approved site plan showing site conditions as they will exist at some point in the future.

With this information, he/she will be able to determine all the changes required to restore the site to the conditions indicated on the site plan. To itemize the required changes, the restoration planner must prepare some or all (depending upon the specific nature and complexity of the restoration plan) of the following:

1. A site preparation and repairs plan.
2. A layout plan.
3. A grading plan.
4. A planting plan.
5. Required construction details.
6. A materials and work summary.

In order to prepare these items, the restoration planner will need to be well-informed about the types of repairs needed at the site, the specific restoration techniques most appropriate to rectify problems, the types of materials and methods used to construct any required facilities, and the choice of species and planting densities and sizes needed to establish or re-establish desired vegetation characteristics on the site.

b. Site Preparation and Repairs Plan

Site preparation includes the installation of barriers and signs to prevent unwanted public access to the site (where required) during the restoration process, the removal of all existing facilities not shown on the site plan, removal or protection of all vegetation and other facilities or features in areas where site re-grading is required and clean-up and removal of all debris, litter, etc. from the site. It is the responsibility of the restoration planner to indicate, on the site preparation and repairs

plan, where and to what extent such measures are required. In addition, recommended location and means of 'construction' access should be noted on this plan, along with any work required to provide such access.

It is also the restoration planner's responsibility to flag all the problems at the candidate site which require specific attention. The types of problems requiring the restoration planner's attention would include the following:

- damaged trees
  - dead or badly damaged trees should be felled (and in some cases removed) in areas subject to public use.
  - salvageable trees should be repaired (proper pruning, treatment of wounds, etc.)
- damaged slopes
  - denuded and/or eroding slopes where site re-grading is not required should be repaired using an appropriate restoration technique.
- damaged facilities
  - any damaged facilities which are to remain on-site should be repaired.

The locations at which these repairs are to be undertaken should be marked on the site preparation and repairs plan and the quantities of required materials should appear in a summary on the plan.

c. Layout Plan

For candidate sites where the restoration process is relatively complex or where major facilities or structures have been prescribed, a layout plan will be required which specifically locates these 'hard' site elements. In preparing this plan, the restoration planner will need to establish base-lines or 'survey' monuments' which can be easily and accurately located both on the plan and in the field. These 'monuments' or base-lines will serve as the reference points for precisely locating all required facilities.

The layout plan should also indicate the locations and extent of any long-term or permanent artificial barriers and/or signs needed to prevent public access or to re-direct circulation, as required in the restoration strategy for the candidate site. Further, it should illustrate the locations and extent of specific problems requiring rectification. On less complex sites, this information can be satisfactorily illustrated on the site preparation and repairs plan.

d. Grading Plan

Similarly, at sites when the restoration process is relatively complex or where site drainage is a critical issue and site re-grading is required, the restoration planner may need to prepare a grading plan. The level of detail of such a plan can vary greatly according to side area, site conditions and the nature of the proposed restoration, from a simple schematic 'sketch' to a detailed, fully documented 'working drawing' grading plan.

The grading plan should also indicate (in conjunction with any required construction details), appropriate structures or features required to rectify slope erosion or shoreline erosion problems. At sites where a grading plan is not required, this information can be shown on the site preparation and repairs plan.

e. Planting Plan

At some candidate sites, vegetation establishment will be required. The information needed by the restoration planner in preparing a planting plan for the candidate site concerns the choice of species for different areas of the site, the density of planting and the size of plant material required to achieve the desired image, character and function of the site. This information in available in the form of:

1. The intended use or role of the site, previously determined.
2. The restoration strategy previously selected for the site.
3. The site conditions map, indicating existing vegetation conditions at and adjacent to the candidate site.

The degree to which existing (or previously existing) vegetation conditions are to be restored will be dependent primarily upon the intended use or role of the site and the selected restoration strategy. The primary concern of the restoration planner is to ensure that the species, sizes and densities chosen are appropriate to the level and type of use expected on the site, to the biophysical conditions at the site and to the intended image or character of the site.

Before the planting plan and an associated plant list can be compiled, the restoration planner will need to determine the most appropriate approach to vegetation establishment; that is how much of the plant material (and what sizes) will be 'installed' and how much reliance will be placed on natural processes for vegetation restoration. The two extreme approaches would be as follows:

1. Installation of all desired plant material, and for woody plants, installation of the largest specimens possible.
2. Installation of no plant material and complete reliance on natural processes.

Both extreme approaches have significant inherent weaknesses. In the first approach, restoration costs would be very high, large woody plant material may not be available in sufficient quantities and, at sites where the intent is to restore natural or near-natural vegetation conditions, many species are unavailable commercially or difficult to find or transplant from the wild.

In the second approach, failure to install at least a protective vegetative cover or nurse crop can, in many cases, lead to further site degradation through surface erosion by wind or runoff before pioneer species have an opportunity to become naturally established. Further, the required restoration period before the site can be re-opened for use may be unacceptably long. Finally, the fact that obnoxious or undesirable 'weed' species will often be the initial colonizing species on a barren site dictates, especially in heavily used or highly visible sites, that complete reliance on natural succession would not generally be appropriate.

Thus it is anticipated that the approach selected for vegetation establishment at most candidate sites requiring this type of restoration will lie somewhere between these two extremes. Clearly, the specific approach selected will be dependent upon the circumstances relating to a given site. As a general rule, however, it is recommended that the preferred approach for the establishment of plant material at a candidate site would emphasize the use of relatively small, inexpensive and easily available woody plant material and, in natural or near natural situations, a reliance on natural processes for the establishment of native herbaceous species.

On the planting plan, the restoration planner should indicate the location of all plant material to be installed as well as the extent of areas that are to be 'conditioned' to allow for natural restoration of vegetation. The planting plan should also include a plant list which itemizes all required plant material, by species, size and other required qualitative characteristics.

f. Construction Details

At many candidate sites, the schematic typical construction details which comprise a portion of the restoration techniques described in this manual (Section 4) will likely provide sufficient direction to field crews during implementation. However, at some sites, where complex restoration measures are required or where major structural development (e.g. retaining walls) is prescribed, it may be necessary for the restoration planner to prepare formal construction details for certain elements of the site restoration program. These details could include detailed plans, sections, elevations and construction notes. Further, for some elements, there may be a need to consult with professional specialists (e.g. geotechnical, civil or structural engineers) to ensure that these elements are designed to meet specific technical requirements.

g. Materials and Work Summary

Whether the restoration planner must prepare all of the above plans and details or not, he/she should compile a materials and work summary for the restoration of the candidate site. For more complex sites, the plans and details prepared by the restoration planner will provide specific information to the field crew regarding restoration measures to be undertaken. For relatively straightforward cases, the site preparation and repairs plan can merely be supplemented with the specific restoration technique descriptions found in Section 4 of this manual, and the materials and work summary should include a listing of the appropriate techniques that could be utilized.

In addition, the materials and work summary should include estimates of:

1. Materials required to construct all prescribed facilities (including pathways, site furnishings, structures, artificial drainage systems, temporary and permanent barriers, etc.)
2. Extent of repairs required (e.g. trees to be felled, removed and/or repaired, facilities to be repaired, eroding slopes, etc.)
3. Facilities to be removed.
4. Plant material required.

2.1.7 Submission of the Restoration Plan

When the restoration plan (complete with its appropriate constituent parts for the candidate site in question) has been completed, the restoration planner should review it with the restoration program co-ordinator. At this time, optional restoration techniques should be reviewed and perhaps refined.

It is recommended that the restoration plans for all candidate sites designated for restoration during the current planning period be reviewed together, to ensure that the overall impact of the year's proposed restoration program is more clearly understood from the perspectives of budgetary requirements and manpower needs. Should it be determined that available resources will not permit implementation of all the restoration plans

submitted, a refined list of candidate sites (based on priorities previously established and on the guidelines set out in Section 2.1.1 of this manual) can be defined. Any restoration plans that have been prepared but cannot be implemented during the current year should be set aside until the following year.

2.2 SCHEDULING/BUDGETING

2.2.1 Examination of the Restoration Plan

The restoration plan developed by the restoration planner details all of the major actions required to bring about the restoration of the candidate site. Included as part of the restoration plan is the site plan which illustrates how the restored site should appear when it is re-opened or when restoration is complete. The restoration co-ordinator should examine the restoration plan carefully, noting the prescribed actions and the list of required materials that have been provided by the restoration planner.

2.2.2 Determination of Tasks

In order to implement the restoration plan most efficiently, a detailed schedule of all the tasks involved should be prepared by the restoration co-ordinator. For each site problem requiring rectification, there may be several techniques or methods available for implementation. The co-ordinator should, therefore (perhaps in conjunction with field crew chiefs or others familiar with field construction work), review the optional techniques available (as outlined in Section 4) to develop a 'feel' for the work involved and then to decide upon the specific technique that will be used to rectify each of the problems requiring rectification. It is recommended that, initially, the co-ordinator should experiment with as many techniques as possible to develop refined techniques and guidelines for the implementation of subsequent restoration plans. As these techniques are refined and guidelines developed, this manual should be accordingly up-dated and the restoration planners should be made aware of them.

Once the specific techniques have been selected, each task should be assessed to determine the exact materials and labour requirements and to determine the proper sequence in which each of the tasks should be performed. These determinations are perhaps best made by a construction manager and/or field crew chief.

A summary of the tasks that might be required to implement any given restoration plan would include the following:

1. Site Preparation

-develop construction access
-install temporary barriers and signage
-remove dead vegetation or vegetation obstructing restoration work
-install any vegetation protection
-remove debris
-remove undesirable facilities

2. Repairs

-damaged vegetation
-damaged slopes
-damaged shorelines
-facilities

3. Construction

-site grading
-facilities/structures (drainage or slope stabilization structures, site furnishings, buildings, traffic corridors, permanent artificial barriers)

4. Establishing Vegetation

-collecting, growing and/or purchasing planting stock
-planting bed preparation
-seeding and/or planting
-fertilizing
-mulching
-establishment watering

2.2.3 Work Schedule/Budget

Once the restoration techniques and required tasks have been determined, a detailed work schedule and restoration budget should be prepared for the candidate site by the construction manager/field crew chief, and submitted

to the restoration program co-ordinator. In determining the most appropriate schedule, the construction manager should consider such factors as the need to co-ordinate restoration of more than one site during the year, preferred planting times for successful vegetation establishment (varies according to 'installation' technique to be used), periods during which the site is most easily accessed with the least impact of such access and, for river-edge sites, periods during which expected high river levels or critical spawning seasons could preclude restoration work.

Depending upon the specific site in question, the restoration program co-ordinator may need to review the detailed work schedule and budget with representatives of other agencies affected by or involved in restoration of the site to confirm suitability of the budget and schedule, availability of manpower, co-ordination with other work at the site or in the area, etc.

2.3 IMPLEMENTATION

2.3.1 Acquisition of Materials and Labour

Based on the materials and work summaries provided by the restoration planner and the detailed materials lists and work schedules compiled, the restoration co-ordinator or construction manager should make the necessary arrangements to acquire all materials, manpower and any specialized equipment required for implementation of the restoration plans during the current restoration 'cycle'.

2.3.2 Supervision

Since the restoration program co-ordinator will be deciding on the specific techniques to be used in the implementation of a restoration plan and will be responsible for co-ordinating and scheduling the required work, he/she should also assume ultimate responsibility for overseeing and supervising the restoration work.

2.3.3 Role of the Restoration Planner and Construction Manager

Notwithstanding the supervisory role of the restoration co-ordinator, it would be very useful to have the restoration planner (the individual who prepared the restoration plan) and the construction manager (the individual closely involved in co-ordinating the logistics of implementation) on-site during the early stages of implementation to assist the field crew chief in understanding the intent of the restoration plan and the means of achieving this intent.

The role of the restoration planner on-site will be especially crucial, given that the 'field location' of many site elements will be required and that 'field adjustments' to the site plan will often be unavoidable.

2.3.4 Technical Procedures

Section 4 of this manual deals with specific restoration techniques that have been identified as appropriate for the rectification of previously documented site degradation problems.

Depending upon the specific circumstances and degree of complexity of the required restoration program for a given site, these techniques will be of use to the restoration planner in the preparation of a detailed restoration plan and/or to the field crew chief who can take the technique descriptions to the site for instructional or reference purposes during the implementation phase.

2.4 MANAGEMENT

The implementation of a restoration plan at any site merely begins the transformation of that site from its present condition to the conditions indicated on the site plan. There will probably be a need for a continuing program of management to repair subsequent damage and to maintain the improvements which have been made.

There are two important components to a management program:

1. First, there is a need to monitor the progress of the rehabilitative process to determine which restoration techniques are successful and which are not, to determine when a site is ready to be re-opened for use, or to decide when a site is deteriorating and is in need of further remedial action.

2. Second, there is a need for remedial intervention to correct site problems as they develop or to select a new restoration technique to replace one that has failed to provide the conditions indicated in the restoration plan.

2.4.1 Monitoring Program

The nature of the monitoring program at restored sites will vary greatly according to the use, role and context of the sites. For instance, in 'urban park' situations, where the vegetative cover is horticultural in composition and 'formal' in appearance, there will be no need to monitor the progress of natural succession of shrub or groundlayer species, while in near-natural sites, such progress may be an important indicator of success of the restoration program. Further, the monitoring of 'changes' in site conditions is impossible without some type of 'base-line' or 'benchmark' set of conditions against which such changes may be measured. Thus at many sites, the primary purpose of any monitoring program should be to establish a comprehensive set of base-line site characteristics. As this information base grows incrementally over time, it will be possible to identify certain key indicators of restoration success (or, conversely, of site degradation) that will add to the effectiveness of the overall Riverbank Restoration Program.

Some possible key indicators (depending upon site use, role and context) that should be included as the monitoring program is initiated, would be the following:

1. Soils

   -determine infiltration rates, which are often good indicators of soil compaction and the need for scarification or other means of loosening the soil.

2. Ground Vegetation

-measure type and extent of coverage of groundlayer vegetation to determine species hardiness to site conditions and types and levels of use.

3. Mature Trees

-assess the condition of tree crowns (tip die-back, density of foliage, chlorophyll content, timing of leaf drop) as an indicator of overall tree health. The use of false-colour near-infrared large scale aerial photography is an efficient technique for such assessment (Kodak Aerochrome 2443 or similar film).

4. 'Installed' Vegetation

-determine planting success by measuring growth rates and percentage survival.
-in natural or near-natural areas, determine success of providing appropriate conditions for natural restoration processes, by measuring extent and type of naturally colonizing species.

5. Permanent Barriers

-determine the effectiveness of different types of barriers (shrubs, logs, fences, rocks, brush) in preventing access to sensitive site features or areas.

6. Slopes

-determine effectiveness of surface stabilization and drainage measures in reducing or eliminating erosion and allowing for desired revegetation.

7. Traffic Corridors

-determine the effectiveness and maintenance requirements of alternate surface materials and barriers to define pathways and to discourage undesired alternative traffic corridors.

2.4.2 Care and Maintenance of a Restored Site

This manual is not intended to be a manual on the maintenance of parkland or other riverbank areas. The field of landscape maintenance and groundskeeping is a highly sophisticated and complex field, and it should be left in the hands of professional experts who have the required training and experience. Such professionals are readily available for consultation within the City of Saskatoon Parks & Recreation Department, the University

of Saskatchewan and the private sector; and they should be consulted as a matter of course as the Riverbank Restoration Program is planned and implemented.

However, as this manual is concerned with the biophysical restoration of degraded sites in the Meewasin Valley, and as a portion of the restoration process will need to include remedial intervention to ensure that candidate sites are restored to desired conditions, some basic statements regarding care and maintenance of candidate sites is considered appropriate.

Most of the remedial intervention required during the management phase of the restoration program will involve either selecting a new technique to replace one that has failed to implement a certain aspect of the restoration plan, or to re-apply a technique that has failed, thereby giving it a 'second chance' (e.g. re-installing plant material which failed to survive). However, beyond those actions designed to correct faults in the initial implementation of the restoration plan, there are a few basic procedures which can be followed to continue the restoration process and which will contribute to the maintenance of features already established.

1. Soil Enrichment

- to maintain or enhance soil fertility, it is recommended (where aesthetic and land use factors permit) that leaf litter be allowed to accumulate on surfaces where it falls. This practice can also provide some protection against soil erosion.

2. Natural Barriers

- shrubs should be pruned back during their first few seasons to promote dense growth near their base. Once they are well established, the shrubs may need periodic thinning to maintain vigorous growth.
- if a barrier becomes too thin or 'leggy' over time, it should again be cut back to encourage renewed growth.
- in areas where repeated attempts to establish vegetative barriers fail, artificial barriers should be constructed.

3. Ground Cover

-periodically, as the ground becomes compacted through heavy use or foot traffic, the soils supporting the ground cover will need to be loosened (using a sharp-pointed instrument to break up the soil surface or an aerator to pull out soil 'plugs').

-after the soil has been scarified, loosened or aerated, the area should be fertilized. A general purpose lawn fertilizer, applied according to manufacturer's instructions, would usually be suitable.

4. Trees

-unless there is significant construction (i.e. re-grading) in close proximity to a tree or a significant change in the moisutre regime around a tree, decreases in tree vigour can usually be attributed to a pest, disease or blight, heavy use and soil compaction within the drip line of the tree, physical damage caused by vandalism or other human activity or decadence (i.e. old age) of the tree itself.

-trees suffering from a pest, disease or blight should be treated according to the appropriate technique described in Section 4 of this manual.

-for trees in heavy use areas, there should be a regular program of maintenance to loosen soil around their bases and to fertilize them (by injecting fertilizer into holes augered in the soil around the drip line of the crown).

-trees injured by human activity should be treated according to the appropriate technique described in Section 4 of this manual (pruning, wound treatment).

-trees showing decreased vigour because of overmaturity should be felled and, depending on the specific situation and/or the possibility of the presence of associated pests, diseases or blights, the deadfall may have to be removed from the site and burned or otherwise disposed.

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3. SITE DEGRADATION PROBLEMS - AN OVERVIEW

3.1 INTRODUCTION

During the field program carried out as part of the Riverbank Restoration Study, a variety of site degradation problems were identified in the Meewasin Valley. Consultation with knowledgeable resource people flagged additional problems that are known to occur, at least periodically, in the Valley. This Section of the Manual groups these problems into general categories (where possible) and provides a brief description of each problem. Descriptions are typically organized to provide the following information:

- symptoms
- possible causes
- related site degradation problems
- known problem sites (the restoration units in which the problem is known to exist and a subjective assessment of the severity of the problem within each unit)
- possible restoration techniques that may be useful in rectifying the problem

It is expected that, as the restoration program is implemented, new problems will be documented, new techniques may be found to rectify them and suggested techniques may prove inadequate for some problems or situations. Thus this section of the Manual should be periodically up-dated to reflect such new information.

3.2 SOIL EROSION

Introduction

Soil erosion is the process of removal and loss of soil by the action of water, ice, gravity or wind. This section of the manual deals principally with soil erosion caused by the force of falling and flowing water and by wind action. The figure below illustrates the types of erosion which are caused by water.

Wind erosion can occur on a variety of soil types, but evidence of the effects of wind is most prominent (especially in the Meewasin Valley) in sandy areas, where dunes and blow-outs are common results of its force.

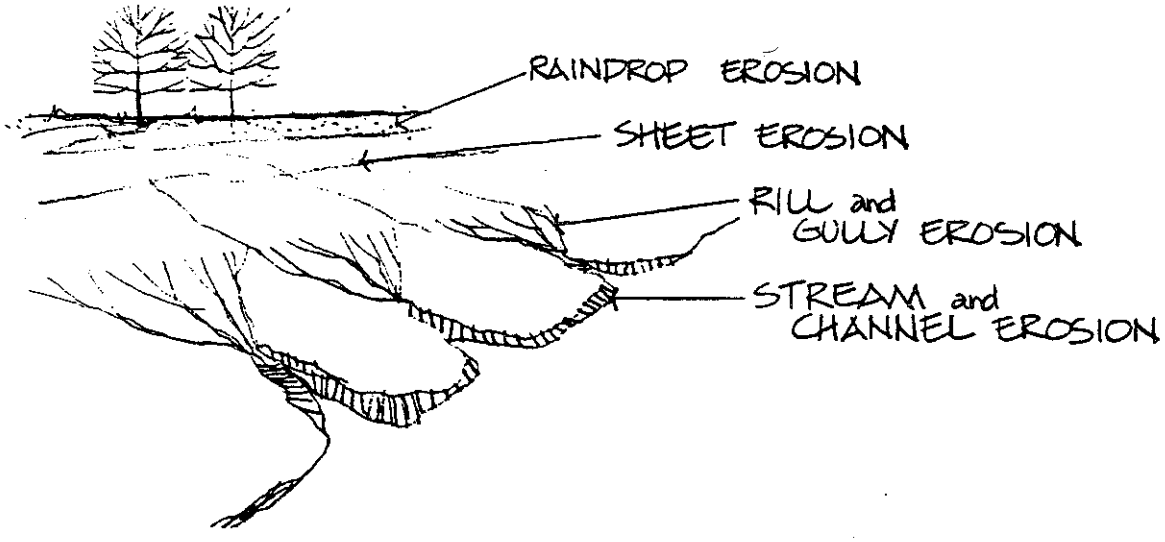
TYPES OF EROSION CAUSED BY FALLING AND FLOWING WATER

RAINDROP EROSION: Erosion resulting from the direct impact of falling drops of rain on soil particles. This impact dislodges soil particles and splashes them into the air. The dislodged soil particles can then be easily transported by the flow of surface runoff.

SHEET EROSION: The removal of a layer of exposed surface soil by the action of raindrop splash and runoff. The water moves in broad sheets over the land and is not confined in small depressions.

RILL and GULLY EROSION: As runoff flows it concentrates in rivulets cutting several inches deep into the soil surface. These grooves are called rills. Gullies may develop in unrepaired rills or in other areas where a concentrated flow of water moves over the soil.

STREAM and CHANNEL EROSION Increases in the volume and velocity of runoff may cause erosion of the stream or channel banks and bottom.



3.2.1 Raindrop Erosion

Symptoms:

Areas have no or sparse vegetative cover and are directly exposed to falling drops of rain.

Causes:

Soil particles are detached by the force of raindrops falling on bare or sparsely vegetated soil.

Related Problems:

- sheet erosion
- rill and gully erosion
- stream and channel erosion
- pedestrian traffic denudation
- vehicular traffic denudation
- borrow pits

Problem Sites:

Severe: 1, 4, 6, 8, 10, 11, 14, 15, 16, 22, 28, 29, 30
Moderate: 17, 18, 23, 24, 25, 27, 31, 32
Light: 3, 13, 19, 20, 21, 26

Restoration Techniques:

4.2.16
4.11.4
4.11.5
4.11.6
4.11.7
4.11.8
4.11.9

3.2.2 Sheet Erosion

Symptoms:

Sheet erosion progresses slowly and is therefore not readily discernible. It may be detected only by the gradual change in color of the topsoil and by the appearance of "galled" spots in the field.

Causes:

Sheet erosion is caused by heavy rainfall runoff loosening the soil on bare slopes. The flow of excess water then moves it down the slope giving the appearance of one continuous moving sheet.

Related Problems:

- raindrop erosion
- rill and gully erosion
- borrow pits

Problem Sites:

Severe: 4, 10, 11, 28, 29, 30
Moderate: 8, 13, 14, 16
Light: 6, 17, 18, 23, 24, 25

Restoration Techniques:

4.2.1
4.2.3
4.2.4
4.2.5
4.2.16

3.2.3 Rill and Gully Erosion

Symptoms:

A concentration of rills in the natural depressions of a slope or the uniform spreading of rills over a slope are the first indications of gullying. These rills are grooves cut into the soil surface and gullies are continuous trenches that have been broken through the surface soil and are into the subsoil.

Causes:

As run-off in the form of sheet washing flows down a slope, it accelerates and concentrates in rills. The continued cutting of the soil results in the formation of gullies.

Related Problems:

- raindrop erosion
- sheet erosion
- stream and channel erosion
- pedestrian traffic denudation
- vehicular traffic denudation
- borrow pits
- sewer outfalls

Problem Sites:

Severe: 1, 4, 6, 8, 10, 11, 14, 15, 16, 17, 22, 28, 29, 30
Moderate: 17, 18, 23, 24, 25, 27, 31, 32
Light: 3, 13, 19, 20, 21, 26

Restoration Techniques:

4.2.1
4.2.2
4.2.3
4.2.4
4.2.5
4.2.6
4.2.7
4.2.8
4.2.9
4.2.10
4.2.11
4.2.12
4.2.16

3.2.4 Stream and Channel Erosion

Symptoms:

Channel bank sloughing, especially where sharp bends occur in a stream or channel and steep banks with a lack of stabilizing material are indicators of stream and channel erosion.

Causes:

Increases in runoff volume and velocity may cause stream and channel erosion.

Related Problems:

- raindrop erosion
- sheet erosion
- rill and gully erosion
- sewer outfalls

Problem Sites:

Moderate: 4, 17, 25
Light: 8, 10

Restoration Techniques:

4.2.13
4.2.14

3.2.5 Wind Erosion (Sandy Areas)

Symptoms:

1) Active Dunes
   - U-shaped dune, unvegetated, whose 'arms' point into direction of prevailing wind.
   - deflated crescent-shaped patches of open sand on one-side (usually the south side) of ridges.
   - partially buried vegetation.
2) Blowouts
   - bowl-shaped, unvegetated depression with sand heaped in a rim around the depression

Causes:

Relatively strong winds in association with drought conditions and/or excessive trampling of vegetation by livestock, pedestrians and/or vehicles.

Related Problems:

- pedestrian traffic denudation
- vehicle traffic denudation
- borrow pits
- grade changes around trees

Problem Sites:

Severe: 4, 6
Moderate:
Light:

Restoration Techniques:

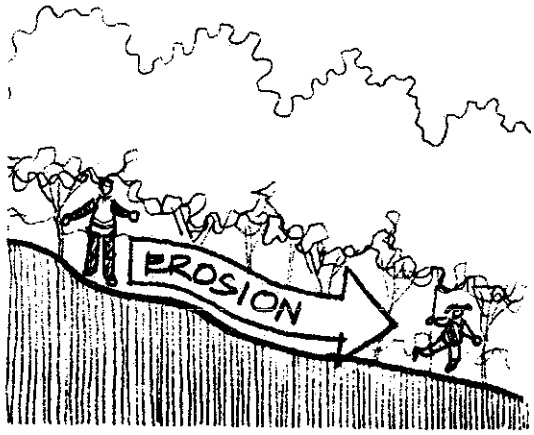
4.1
4.2.15
4.2.16

3.3 PEDESTRIAN PATHS AND TRAFFIC AREAS

Introduction

A variety of Trail 'types' exist within the study area, from formal asphalt pathways to natural, user-induced trails. Problems related to pedestrian traffic resulting in soil compaction, denudation, erosion and gullying are dealt with in this manual. The following figures illustrate these problems as they relate to pedestrian traffic.





3.3.1 Compaction, Denudation, Erosion, Gullying on Pedestrian Pathways

Symptoms:

Compacted soil and lack of ground cover are the initial symptoms of degradation along pedestrian pathways. Decreased plant vigour and soil erosion can soon follow, often resulting in gullying.

Causes:

Improper traffic control resulting in concentrated pedestrian traffic causes compaction and subsequent denudation and erosion on pedestrian routes.

Related Problems:

- soil erosion

Problem Sites:

Severe: 4, 6, 15, 16, 22
Moderate: 1, 8, 10, 23, 25
Light: 11, 20, 21, 24

Restoration Techniques:

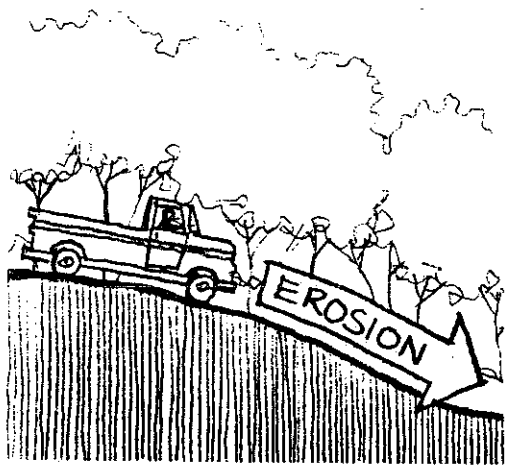
4.1
4.2.3
4.3.1
4.3.2
4.3.3
4.9
4.11

3.4 VEHICLE TRAFFIC

Introduction:

As is the case with pedestrian traffic, vehicular routes also induce hardship upon the landscape of the River Valley. With the popularity of four-wheel drive vehicles, it is clear that the lure of vehicle trails along the river valley is an appealing one. The use of these trails however, often leads to soil compaction, denudation and erosion which in turn endangers existing slopes and accompanying vegetation.





3.4.1 Compaction Denudation and Erosion on Vehicular Routes

Symptoms:

Compacted ground cover and topsoil along parallel strips are the initial signs of vehicular denudation. More extreme cases may show evidence of decreased plant vigour, bare soil and erosion problems.

Causes:

Most severe cases of vehicle denudation occur due to traffic concentrations that exceed the tolerance level of existing surface materials (i.e. ground cover), or in areas where the terrain is not suitable for such traffic (i.e. steep slopes).

Related Problems:

- soil erosion

Problem Sites:

Severe: 1, 4, 6, 15, 16
Moderate: 8, 17, 27, 28, 29, 30, 31, 32
Light: 3, 11, 13, 20, 25, 26

Restoration Techniques:

4.1
4.9
4.11

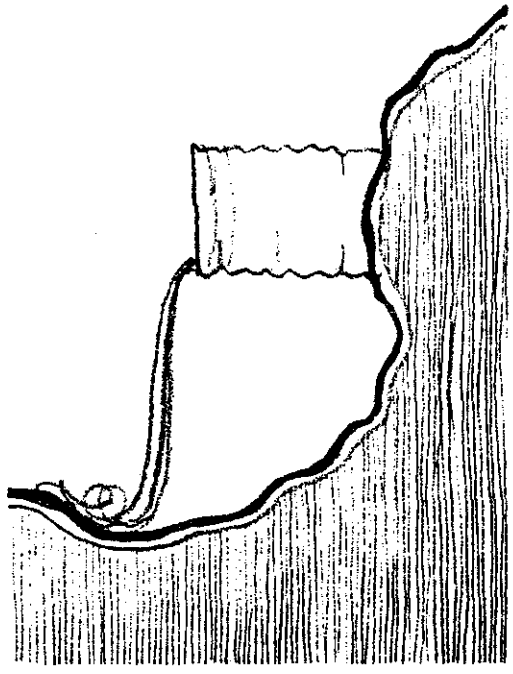
3.5 SEWER OUTFALLS

Introduction:

Within the city limits of Saskatoon, there are 64 storm sewer outfalls which empty into the South Saskatchewan River. Not all outfalls are the same but problems associated with them are similar. The restoration techniques in this manual respond to the two major concerns of gullying and headward erosion.



GULLYING



HEADWARD EROSION

3.5.1 Gullying and Headward Erosion around Outfalls

Symptoms:

The soil material around the storm sewer pipe has eroded away leaving the outfall exposed. The stream of water from the outfall has also cut a channel into the slope resulting in further erosion and slumping. The slopes also exhibit a lack of vegetation.

Causes:

The varying sewer outflow combined with the channel flow of the River act upon the slope lacking vegetation and/or proper rip-rap, causing soil erosion.

Related Problems:

- soil erosion

Problem Sites:

Severe: 14, 17
Moderate: 18, 24, 25
Light: 11, 19, 20, 21

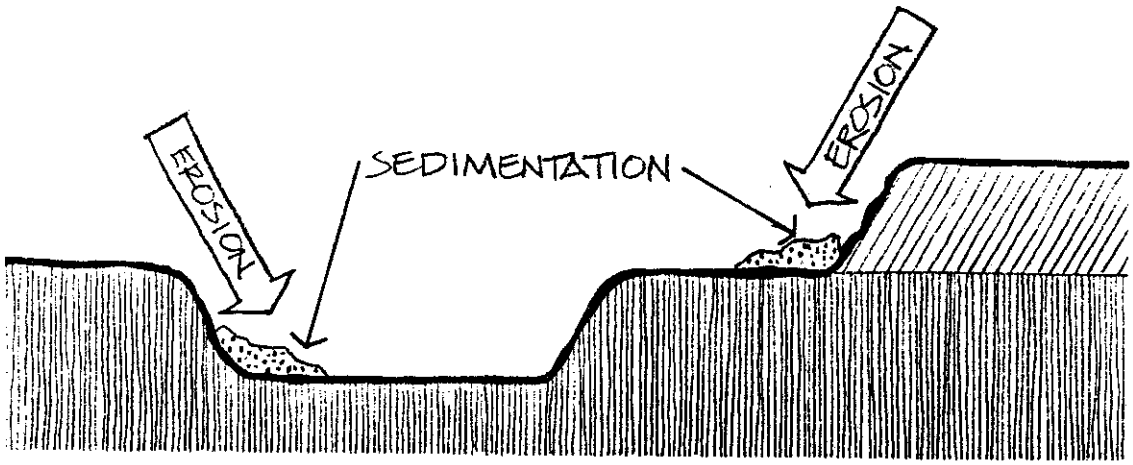
Restoration Techniques:

4.4.1
4.4.2
4.4.3

3.6 BORROW PITS AND STOCKPILES

Introduction:

Borrow pits present the same set of problems as cut and fill slopes. Exposed soils are erodible and measures must be taken to control erosion and sedimentation on these sites. Stockpiles and soil areas must also be stabilized to ensure the successful restoration of borrow areas.



SECTION THROUGH BORROW PIT AND STOCKPILE

3.6.1 Borrow Pits

Symptoms:

Borrow pits generally exhibit unstable slope surfaces. Slopes are bare of protective vegetation which results in soil erosion. Grades also exceed the angle of repose of loose soil which results in further surface slope failure and soil erosion.

Causes:

Once the pit is exhausted of useable material, it is usually left as is. Slopes have not been graded, and stockpiles of spoil are also left behind. Runoff is not controlled and this can cause severe soil erosion.

Related Problems:

- soil erosion
- vehicle traffic
- stockpiled material

Problem Sites:

Severe: 28, 29, 30
Light: 6, 18

Restoration Techniques:

4.13.1
4.11
4.2.16

3.6.2 Stockpile Areas

Symptoms:

As with borrow pits, stockpiles often exhibit unstable slope surfaces. Slopes can lack protective vegetation and grades exceed the angle of repose of loose soil.

Causes:

Response to the erosive forces of wind and water and the nature of the stockpiled material usually results in unstable slope surfaces, excessive exposure and loss of stockpiled material.

Related Problems:

- soil erosion
- borrow pits
- grade changes around trees
- vehicle traffic

Problem Sites:

Severe: 28, 29, 30
Light: 6, 18

Restoration Techniques:

4.13.2
4.11

3.7 GARBAGE DUMPING

Symptoms:

Debris along the South Saskatchewan River ranges from strewn papers along the walkways to abandoned vehicles in the bush and river channel and small former 'nuisance grounds'.

Causes:

Improper signage, ease of access and general public neglect are the general causes of unsightly garbage.

Related Problems:

Problem Sites:

Severe: 16
Moderate: 1, 11, 17, 18, 19
Light: 20, 26, 32

Restoration Techniques:

4.13.3

3.8 SKATING RINKS ON LAWNS

Symptoms:

Often, the entire turf area that was covered with ice for skating remains brown while the turf around it is healthy.

Causes:

Direct ice cover injury of turfgrass is due to the ice functioning as a barrier to the exchange of gases between the atmosphere and the turfgrass tissue.

Related Problems:

Problem Sites:

Severe: 22

Restoration Techniques:

4.13.4

3.9 WEED PROBLEMS

Introduction:

Although most people want a "weed-free" landscape, many problems associated with grassland plantings are more perceived than real. Agricultural weeds such as lambs-quarters, foxtail, and velvetleaf often dominate the initial stages of planting. They do however gradually decline as the planting matures. Young grassland species tend to emphasize root rather than stem growth. Native species can be distinguished from weedy species by their hairy stems and the inability to pull them from the soil with their roots.

Although a planting may appear to be a 'disaster' during the first or second season, the planting should not be reevaluated until the end of the third growing season. Failure may be attributed to seeds not germinating or it may reflect the inappropriateness of the site. It should be noted, however, that the MVA, University of Saskatchewan and City of Saskatoon are obligated to control designated "noxious weeds" when required by the Provincial Weed Inspector.

This manual deals with methods of weed control for grassland planting as well as the control of weed growth around newly planted trees and shrubs.

3.9.1 Grassland Weed Problems

Symptoms:

Weed infestation may be apparent in newly planted grasslands or areas where soil has been disturbed. Species may be annual, biennial, or perennial. Generally, desired plant species are forced to compete for moisture and nutrients in the soil with undesired weed species.

Causes:

Simply stated, if conditions arise whereby weed growth reaches an undesirable level, the cause is poor management.

Related Problems:

- borrow pits
- soil erosion

Problem Sites:

Severe: 9, 11, 25, 29
Moderate: 15, 16, 19, 23, 28
Light: 6, 18, 30, 32

Restoration Techniques:

4.6.1
4.6.2

3.9.2 Weed Problems Around Shrubs and Trees

Symptoms:

Newly planted shrubs and trees seem to be having difficulty getting established while there seems to be abundant weed growth around them.

Causes:

Competition between feeder roots of shrubs and trees and weed rhizomes is too great.

Related Problems:

Problem Sites:

Restoration Techniques:

4.6.3
4.9.1

3.10 RODENTS

Introduction:

A number of native rodents create problems whose significance and cause vary from one locale to another. These problems, however, are primarily associated with feeding activities. Specific identification of species and problems is necessary since specific habits may have a bearing on control practices. The following section deals with the specific rodent species identified in the study area as well as management options for the principal problems of destruction of seed in field and forest, damage to bark of ornamental and forest trees and damage to facilities and services.



3.10.1 Beaver

Symptoms:

The presence of beavers is indicated by a stick and mud dam across a stream, a large lodge of sticks and mud near the edge of a body of water or along a riverbank, and stumps of trees that bear the characteristic broad tooth marks. Their preferred tree species are aspen, poplar, birch, maple, willow and alder. Soil erosion may be evident as the beaver moves up-slope for his food and develops slides down the slope towards the water. Often people mistake these slides as paths resulting in further denudation.

Causes:

The destruction of vegetation, and denudation due to beaver slides, can cause soil erosion to develop. Their dam-building activities tend to cause undesirable flooding.

Related Problems:

- soil erosion
- pedestrian paths

Problem Sites:

Severe: 6, 17
Moderate: 4, 5, 10, 23, 24, 25, 31
Light: 1, 3, 7, 8, 11, 12, 13, 14, 15, 16, 18, 19, 21, 22, 26, 27, 29, 32

Restoration Techniques:

4.5.1
4.5.2
4.5.3
4.5.4

3.10.2 Ground Squirrel

Symptoms:

The Richardson Ground Squirrel is usually found near green vegetation in sage brush or grassland areas, as they feed principally on green vegetation. The Franklin and thirteen-lined ground squirrels feed on seeds and insects. The major symptoms of ground squirrel problems relate to extensive burrowing (particularly by thirteen-lined ground squirrels) in open grassland areas).

Causes:

Burrowing problems are significant when local ground squirrel populations become high.

Related Problems:

Problem Sites:

Severe: 19, 20, 28
Moderate: 9, 10, 16, 29, 30
Light: 4, 8, 21

Restoration Techniques:

4.5.5
4.5.6
4.5.7
4.5.8

3.10.3 Pocket Gophers

Symptoms:

The most obvious sign of the existence of pocket gophers is the unsightly mounds of soil associated with their extensive burrowing activity. Other symptoms may include extensive kill of ground vegetation and broken underground cable and plastic pipe.

Causes:

The extensive burrowing habit of the pocket gopher results in the large amount of soil being pushed above ground. The preferred foods of the pocket gopher are tuberous roots of alfalfa, root and bulb crops as well as the roots of grasses, trees and shrubs. The pocket gopher also gnaws on underground cables and underground plastic pipes.

Related Problems:

Problem Sites:

Severe:
Moderate: 9, 10
Light: 3, 4, 8, 26, 27

Restoration Techniques:

4.5.9
4.5.10
4.5.11

3.10.4 Porcupine

Symptoms:

The presence of porcupine is indicated by trees with tops barked. Often, broad incisor marks can be seen.

Causes:

The primary foods of porcupine are buds, small twigs and the inner barks of trees. This results in the top-killing of trees.

Related Problems:

Problem Sites:

Severe: 17
Light: 4, 7, 8, 9, 13, 18, 23, 26, 27

Restoration Techniques:

4.5.12
4.5.13

3.11 DAMAGED TREES AND SHRUBS

Introduction:

The health of tree and shrub vegetation can be affected by rodents (see Section 3.10), by disease, insects and environmental problems (see Section 3.12), and by such factors as lightning and a variety of problems related to human action or inaction.

This section of the manual relates to this last set of factors that lead to damaged trees and shrubs.

3.11.1 Damaged Trees

Symptoms:

Dead broken or split branches and stems, thin or uneven foliage, premature leaf drop, bark wounds and cavities, exposed roots, low chlorophyll content of leaves.

On coniferous trees, yellowing or browning of needles are also symptomatic of decreased tree vigour.

Causes:

- excessive competition with other individuals (crowding)
- lightning strikes
- snow load or ice load damage
- human activity, including heavy foot or vehicle traffic, vandalism, construction damage to roots or trunks, improper or inappropriate pruning and wound treatment.
- decadence (old age)

Related Problems:

- grade changes around trees
- road salt
- pedestrian traffic
- vehicle traffic
- rodents
- diseases, insects and environmental problems
- soil erosion

Problem Sites:

Severe: 1, 6, 10, 17, 25, 30
Moderate: 4, 5, 7, 15, 16, 18, 23, 24, 26, 27
Light: 2, 3, 8, 9, 11, 12, 13, 14, 19, 20, 21, 22, 28, 29, 31, 32

Restoration Techniques:

4.8.1
4.8.2

3.11.2 Damaged Shrubs

Symptoms:

Dead, broken or split branches and stems, thin or uneven foliage, premature leaf drop, bark wounds, exposed roots, low chlorophyll content of leaves.

On coniferous shrubs, yellowing or browning of needles, or bare patches are also symptomatic of decreased vigour.

Causes:

- excessive competition with other shrubs (crowding) with trees (insufficient light) or weeds (insufficient nutrients).
- insufficient pruning
- human activity, including heavy foot or vehicle traffic, vandalism, construction damage to roots or stems, improper or inappropriate pruning and wound treatment
- dog urine
- snow load or ice load damage
- decadence (old age)

Related Problems:

- grade changes
- road salt
- pedestrian traffic
- vehicle traffic
- rodents
- diseases, insects and environmental problems
- soil erosion

Problem Sites:

Restoration Techniques:

4.8.1

3.11.3 Grade Changes Around Trees

Symptoms:

Whether by natural or man-induced forces, when grades within the drip-line of an existing tree are altered, decreased tree vigour may result, with associated thin foliage, the presence of numerous suckers along the main trunk and branches, many dead twigs, and perhaps large dead branches.

Causes:

The addition or removal of soil may cause considerable damage or death to existing trees by disturbing the delicate relationship between roots and soil. The normal functioning of roots requires air, water and organic matter that serves as food. Tree roots establish themselves within areas in the soil that contain these essential elements; a blanket of soil over the existing level disrupts the balance between roots and these elements. The result is that roots die and the symptoms become visible in the above-ground parts. The removal of soil reduces the amount of valuable topsoil, feeding roots are exposed to drying out and low temperature injury, deeper roots may be injured, and the water table is altered.

Related Problems:

- damaged trees
- damaged shrubs
- disease
- insects
- soil erosion
- environmental problems

Problem Sites:

Moderate: 25

Restoration Techniques:

4.8.3
4.8.4
4.8.5

3.11.4 Road Salt

Symptoms:

Early symptoms of salt damage to evergreens appear as a yellowing of the needle points. Eventually, all trees, shrubs and ground covers take on the appearance of being burned. Salt spread on roads is collected and piled along the roadside as well as below bridges. These accumulations are associated with the sand and gravel usually mixed with the salt.

Causes:

Accumulations of salt are leached down into the roots of plants as spring thaw occurs. This results in the burning of the roots and injury or death to the plants.

Related Problems:

Problem Sites:

Restoration Techniques:

4.7.12

3.12 DISEASE, INSECTS AND ENVIRONMENTAL PROBLEMS WITH TREES AND SHRUBS

Introduction:

The correct diagnosis of the cause of disease on a plant from the symptoms is necessary before correct and effective control measures can be taken. Tree diseases may be grouped under the following headings:

A - Parasitic diseases caused by fungi, bacteria, viruses and seed plants

B - Environmental diseases due to some unfavourable condition for normal growth of the tree.[1]

A systematic procedure must therefore be applied in diagnosing the condition of a plant. The particular tree under examination should be identified. A thorough understanding of the structure, function of each part and reaction of the normal tree to changes in its environment is essential. To determine the actual cause of the trouble, one should examine the growth rate during the past few years, the condition of foliage, the soil, fungi and insect attacks, environmental conditions and possible mechanical injury to the plant in question. A complete list of the symptoms of all diseases, blights, insects and unfavorable environmental conditions which may affect a tree or shrub cannot be presented in detail; however, the following descriptions of symptoms and recommended treatment for their control may be helpful in determining the cause of the more common plant ailments and procedures for restoring normal plant growth.

[1] The Complete Modern Tree Experts Manual, Fenska, R.R. pg. 86

3.12.1 Canker Diseases (Parasitic)

Symptoms:

Canker diseases of a tree are some of the most destructive tree diseases. On deciduous trees, the dying and discoloration of the tips of small branches in the top portion of the tree are the first signs of this disease. The infection spreads downward into the large lateral branches. Further stages appear as reddish-brown to dark brown cankers on the bark with the cambium and wood beneath the canker also exhibiting this discolouring once the diseased area cracks open. Callus tissue forms over the cracked area, becomes infected and dies. This process is repeated annually and forms a characteristic concentric pattern of dead callus. On coniferous trees, excessive resin on the buds before the new growth begins may be the first signs of the disease. The fungus then produces resinous cankers on the trunk of trees as well as twigs and branches.

Causes:

Canker is usually confined to trees weakened by drought, winter injury, malnutrition, grading, fire, sunscald, suppression, pests or other factors which affect the vigor of the trees. It tends to be a wind-borne organism which gains entrance to the tree through old branch stubs, insect injuries, frost cracks, mechanical injuries, etc.

Related Problems:

- damaged trees
- rodents



Problem Sites:

Restoration Techniques:

4.7.1

3.12.2 Dwarf Mistletoe (Witches Broom)

Symptoms:

A thick group of branchlets, usually at the top of a tree that appear as large, sloppily built birds' nests or brooms.

Causes:

The buds of these branchlets are usually infested with mites which in turn effect the abnormal growth.

Related Problems:

Problem Sites:

Restoration Techniques:

4.7.2

3.12.3 Fire Blight (Parasitic) - affects ROSACAEA family only

Symptoms:

The first symptoms of fire blight appear in the spring as infected blossoms suddenly wilt and turn brown. Leaves and twigs later become brown and shrivelled, and appear to be scorched by fire. Droplets of clear or amber colored liquid may exude from infected parts in warm, humid weather. Leaves and fruits that are infected usually remain attached to the tree well after normal leaf fall.

Causes:

Fire blight is caused by bacteria that over winter in perennial cankers in the main stem and branches or infected twigs. As blossoms begin to open in the spring, the cankers exude drops of bacterial ooze that are disseminated to the blossoms and young leaves by rain, heavy dew and wind. Pollinating insects such as bees; sucking, chewing or boring insects; and unsanitary pruning tools may also spread fire blight.

Related Problems:

Problem Sites:

Restoration Techniques:

4.7.3

3.12.4 Powdery Mildew (Parasitic)

Symptoms:

Powdery mildew appears on the leaves and twigs of many deciduous trees and shrubs. This disease produces a grayish-white dusty material that appears powdery. It is most common during wet seasons toward the end of summer on trees growing in shaded and damp locations.

Causes:

Infection of plants by powdery mildew is caused by dissemination of the spores of the fungus by the wind.

Related Problems:

Problem Sites:

Restoration Techniques:

4.7.4

3.12.5 Black Knot (of Plum and Cherry)

Symptoms:

New infections of black knot appear as green swellings, commonly on twigs but also on branches or stems. The swellings are rough and elongated, enlarge, develop cracks and turn black with age. Black knots usually occur on one side of the twig and, with age, may be partially covered by a white to pinkish mold and riddled with insect holes.

Causes:

Black Knot is transferred to unwounded tissue by wind and rain. Winter spores formed in mature black knots, once transported, cause the new infection to occur until terminal growth stops and green swellings become visible - usually next spring.

Related Problems:

Problem Sites:

Restoration Techniques:

4.7.5

3.12.6 Aphids

Symptoms:

Initial symptoms of Aphid damage are spotty discolorations, usually on the underside of leaves, which later dry out and wilt. Other symptoms include galls, and distorted, curled or deformed leaves. Since most aphids secrete an abundance of a sweet, sticky substance called honeydew, severe infestations result in the leaves and other parts of the tree, as well as any other objects beneath the tree being coated by this substance.

Causes:

Aphids are attracted to nearly all species of plants. They cluster on the tender succulent terminal shoots and the underside of the leaves where they use their mouth parts to pierce the leaf and suck out the plant juices (sap).

Related Problems:

Problem Sites:

Restoration Techniques:

4.7.6

3.12.7 Gall Insects

Symptoms:

Abnormal growths ranging from a simple gall, leaf-roll, or pouch gall, to that of an artistic and complex structure that appears unrelated to the tissues from which it has developed are sure signs of gall insect activity. Both evergreen and deciduous trees and shrubs are prone to gall insect infestation where they may be found on the leaves, flowers, fruits, seeds, stems, roots or even the main trunk of the trees.

Causes:

The feeding habits of gall insects, the sucking of sap, stops any further growth at the point of attack. This causes an abnormal vegetable growth or "gall" to develop on the host plant. Galls in turn provide food and shelter for the small and fragile gall insects; midges, mites and aphids.

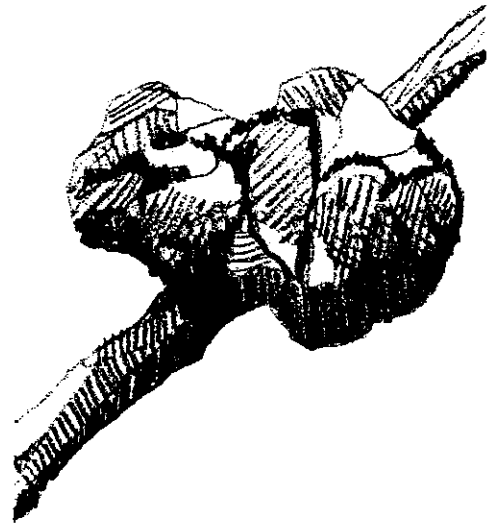
Related Problems:

- aphids

Problem Sites:

Restoration Techniques:

4.7.7



3.12.8 Forest-tent Caterpillar

Symptoms:

The first noticeable signs of an infestation of forest-tent caterpillars is clusters of these tiny black insects feeding on opening buds and developing foliage in mid to late May. As the season progresses, the caterpillars grow and eat more leaves, until all the foliage is consumed.

Causes:

Although Forest-tent caterpillars prefer trembling aspen, when extremely numerous they will feed upon any green foliage, including shrubs, fruit trees, some garden crops, and even spruce and tamarack in wooded areas.

Related Problems:

Problem Sites:

Restoration Techniques:

4.7.8

3.12.9 Cankerworms

Symptoms:

The first noticeable sign of an infestation of the cankerworm is small "shot-holes" in the young leaves. The tiny larvae can be found on the underside of these leaves. As the larvae grow, they continue feeding until almost all of the leaf tissues are eaten.

Causes:

The feeding habit of the Cankerworm causes the defoliation of trees and shrubs which after 3 or more years of consecutive attack can result in a slowed growth rate and branches in the crown die back.

Related Problems:

Problem Sites:

Restoration Techniques:

4.7.9

3.12.10 Bronze Birch Borer

Symptoms:

The bronze birch borer tunnels just under the bark in the cambium layer where tree growth takes place. As they continue to bore around the tree, their galleries girdle the tree, it loses its vigor and eventually dies.

Causes:

Most borers become established in trees low in vigor. Among the factors that tend to lower the vitality of a tree are prolonged dry spells, unfavorable changes in the environment, loss of roots in transplanting, repeated defoliation by insect or fungus parasites, and any bark injuries. Eggs are deposited in bark crevices and scar tissue. Later the larvae hatch and penetrate the bark in these locations.

Related Problems:

Problem Sites:

Restoration Techniques:

4.7.10

3.12.11 Birch Leaf Miner

Symptoms:

The first signs of birch leaf miner attack appear as small light green areas on the leaf surface in early June. These spots develop and turn into larger brown blotches - usually several per leaf. These blotches are caused by larvae feeding between the upper and lower surfaces of leaf and they usually increase in size, merge and eventually the entire leaf turns brown.

Causes:

The feeding habit combined with the fact that there are two or three generations of birch leaf miner per year are the cause of the unsightly brown leaves on a birch tree.

Related Problems:

Problem Sites:

Restoration Techniques:

4.7.11

3.12.12 Winter Browning of Evergreens

Symptoms:

The leaves of the evergreen tree have browned and appear to be scorched. This injury does not become apparent for three to six weeks after the damage has occurred to the plant.

Causes:

Winter browning of evergreen trees is caused by the low humidity and strong drying winds drawing moisture from the leaves. Since the roots are dormant the moisture is not replaced and the leaves brown out on the south and west facing branches which are subject to sun flare from snow in February and March.

Related Problems:

Problem Sites:

Restoration Techniques:

4.7.13

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4. RESTORATION TECHNIQUES

This Section of the Manual includes descriptions of restoration techniques that may be useful in rectifying specific degradation problems as part of the overall site restoration process. Techniques are grouped in the following general categories:

- Barriers
- Erosion Control
- Pedestrian and Vehicle Traffic Problem Control
- Sewer Outfalls
- Rodent Control
- Weed Control
- Controlling Vegetation Diseases, Insects and Environmental Problems
- Repairing Damaged Vegetation
- Site Preparation for Planting
- Acquisition of Plant Material
- Establishing Plant Material
- Establishment Maintenance of Plant Material
- Miscellaneous Restoration Techniques

Each technique is described in terms of its possible applications and step-by-step instructions are provided (with appropriate graphic explanation). Where required, extensive cross-referencing is made among related techniques.

This section should be of use to the restoration planner (in suggesting optional restoration techniques that could be used to achieve the intent of the restoration plan at a candidate site), to the restoration program manager (in selecting the most appropriate technique(s) for each site); to the construction manager (in determining required tasks and materials in setting out a work schedule) and to the field crew (in implementing the techniques on-site).

It is expected that, as the restoration program is implemented, new problems will be documented, new techniques may be found to rectify them and suggested techniques may prove inadequate for some problems or situations. Thus this section of the Manual should be periodically up-dated to reflect such new information.

4.1 BARRIERS

INTRODUCTION

Where access to certain site features must be limited or prevented, barriers must be constructed. Barriers are generally of two types: temporary and permanent. Temporary barriers should generally be artificial, to facilitate removal when they are no longer needed. Permanent barriers may be either natural or artificial, depending upon the levels and types of use expected and the proposed image or character of the candidate site.

ARTIFICIAL BARRIERS

In all cases, it is important that:

1. The appearance of permanent artificial barriers be consistent with the intended image or character of the site.
2. The purpose of artificial barriers be obvious to the public.
3. The artificial barriers create no hazard to public safety.

4.1.1 TEMPORARY ARTIFICIAL BARRIERS

APPLICATIONS:

- all sites where public access during the restoration process must be prevented or limited and all sites where existing facilities, features, vegetation, etc. must be protected during restoration operations.

INSTRUCTIONS:

1. Determine the limits of site restoration work and install a temporary perimeter fence along this line; provide a gate for construction access.

2. Determine all site features requiring protection and install a temporary fence around them; where necessary, provide required service access to these facilities.

3. Generally, standard snow fencing should be adequate for the above purposes in low use areas (page wire preferable in highly used areas).

4. Install public information signs (standard format) indicating the reason why the fence has been put up and providing general background information regarding the Riverbank Restoration Program. Signs should be located where the fence crosses popular pedestrian corridors and where the fence is adjacent to public roadways.

4.1.2 PERMANENT ARTIFICIAL BARRIERS - METHOD 1: PERMANENT FENCES

APPLICATIONS:

- sites where permanent closure, change of use or protection of special site features requires re-direction of pedestrian or vehicle circulation.

INSTRUCTIONS:

1. Actual fence design will depend on intended image or character of the site and should be prepared by the restoration planner (refer to restoration plan for the site).

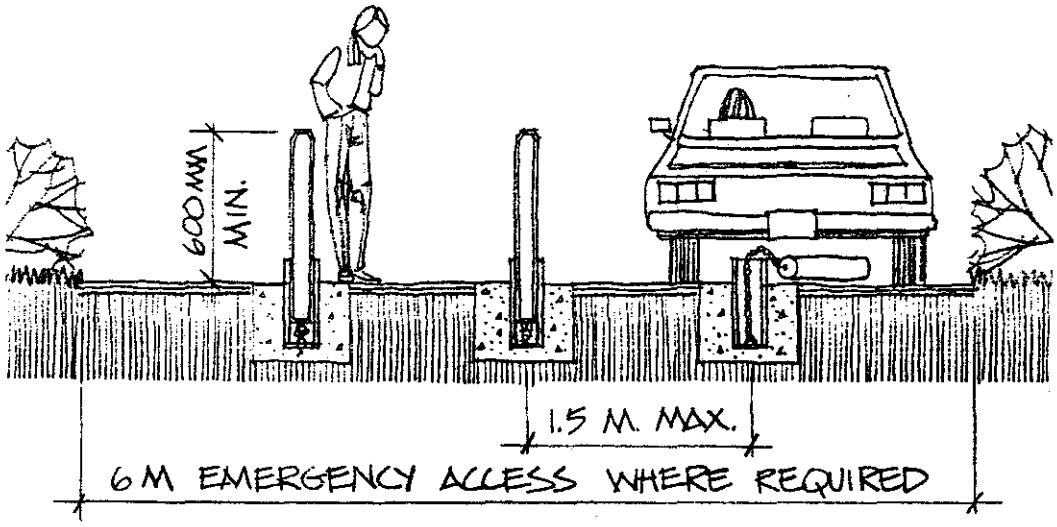
4.1.3 PERMANENT ARTIFICIAL BARRIERS - METHOD 2: BOLLARDS

APPLICATIONS:

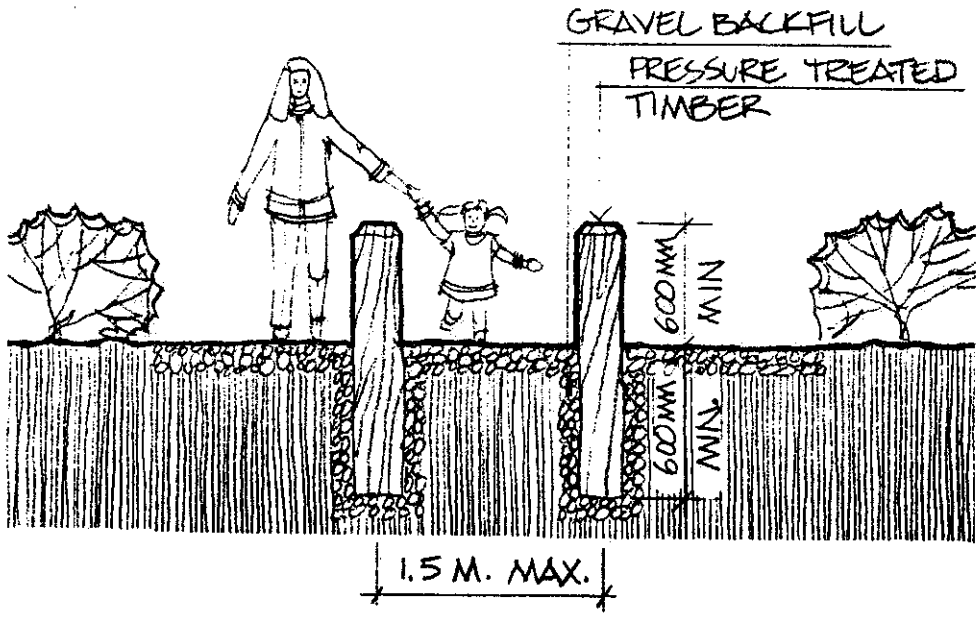
- sites where vehicle access to or circulation within the site must be prevented or controlled.

INSTRUCTIONS:

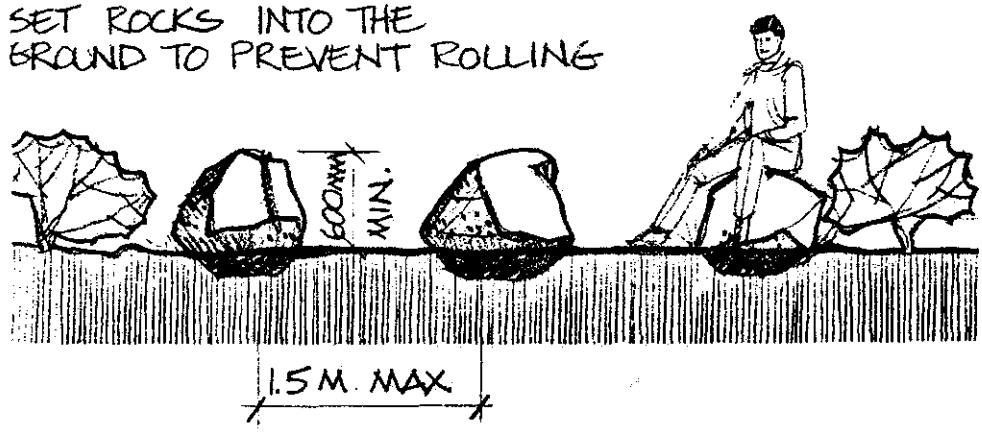
a. Removable Steel Bollards



b. Permanent Log or Timber Bollards



c. Permanent Rock Bollards

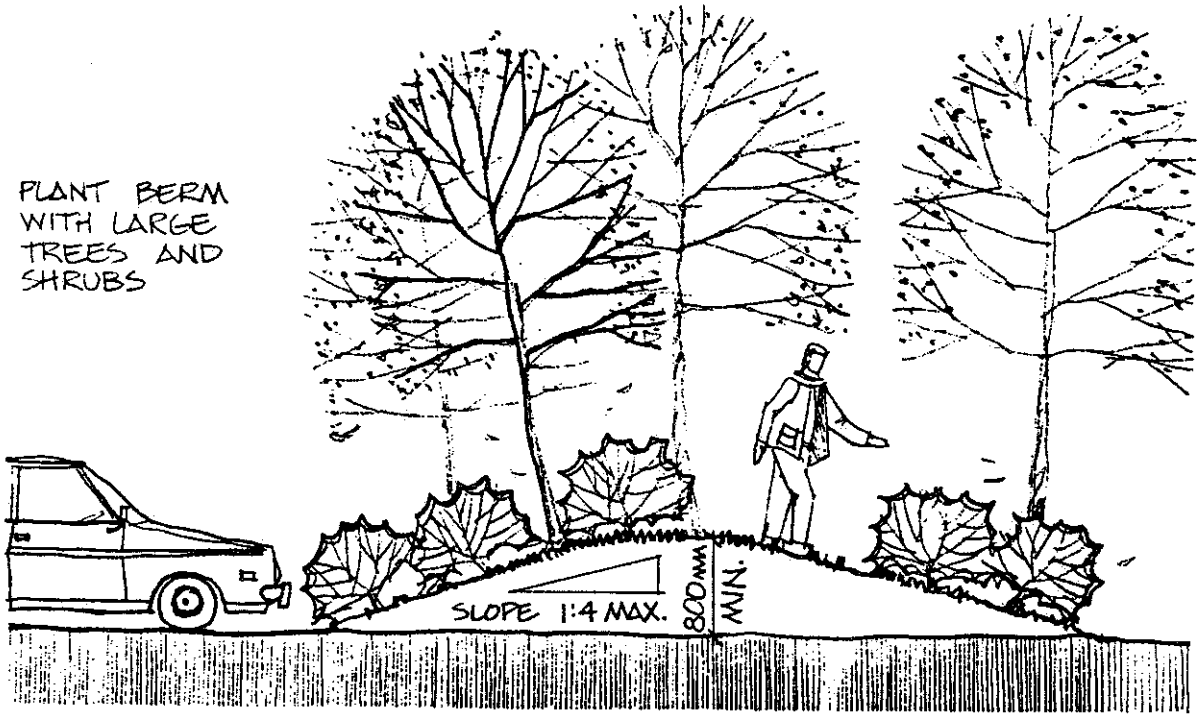


4.1.4 PERMANENT ARTIFICIAL BARRIERS - METHOD 3: BERMS

APPLICATIONS:

- sites where vehicle access must be prevented

INSTRUCTIONS:



4.1.5 PERMANENT ARTIFICIAL BARRIERS - METHOD 4: LOGS AND BRUSH

APPLICATIONS:

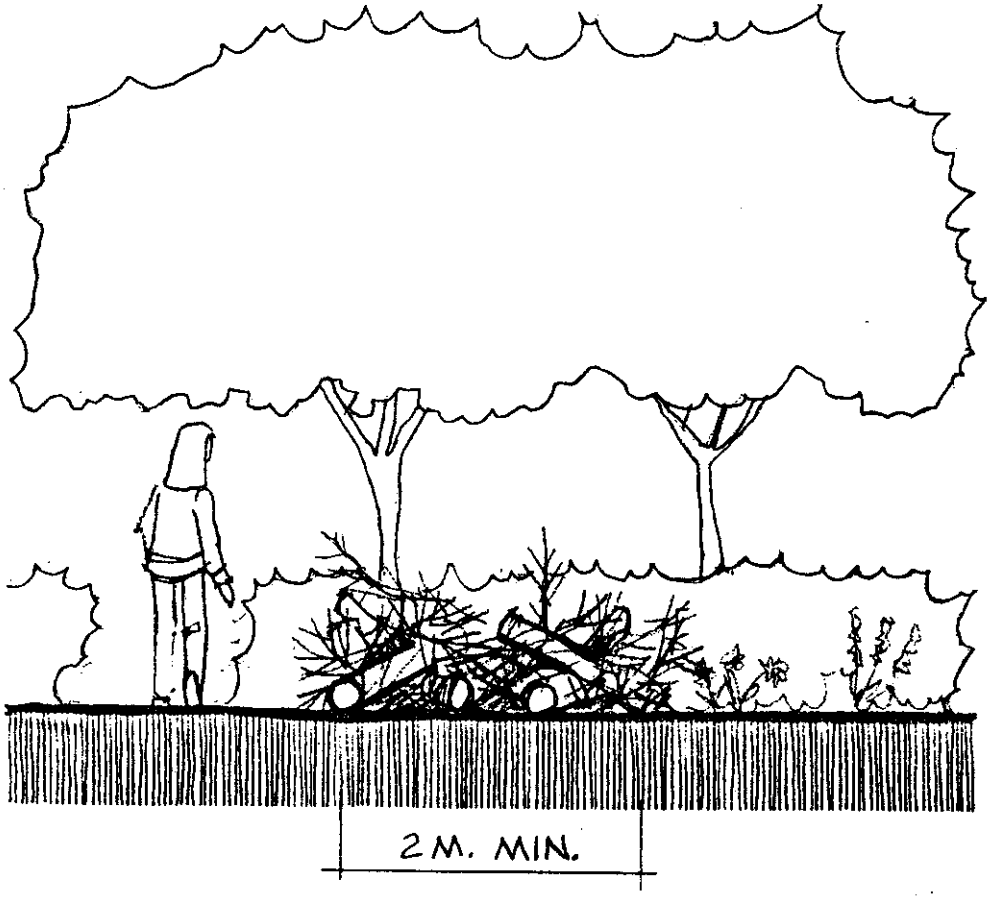
- natural or near-natural sites where access to a site must be prevented or controlled and where the use of fences or other artificial barriers is inappropriate to the intended image/ character of the site.

INSTRUCTIONS:

1. These barriers should be sufficiently deep (minimum 2 metres) to discourage pedestrians from attempting to step over them.

2. They should consist of randomly-placed, large (i.e. too heavy to lift) logs which are used to 'anchor' dead brush, thus creating a barrier that is difficult to walk through.

3. Appropriate shrubs should be planted within this artificial barrier, so that as the logs and brush decompose, they will be replaced with a natural vegetative one (refer to Technique 4.1.6 - Natural Barriers).



4.1.6 NATURAL BARRIERS

APPLICATIONS:

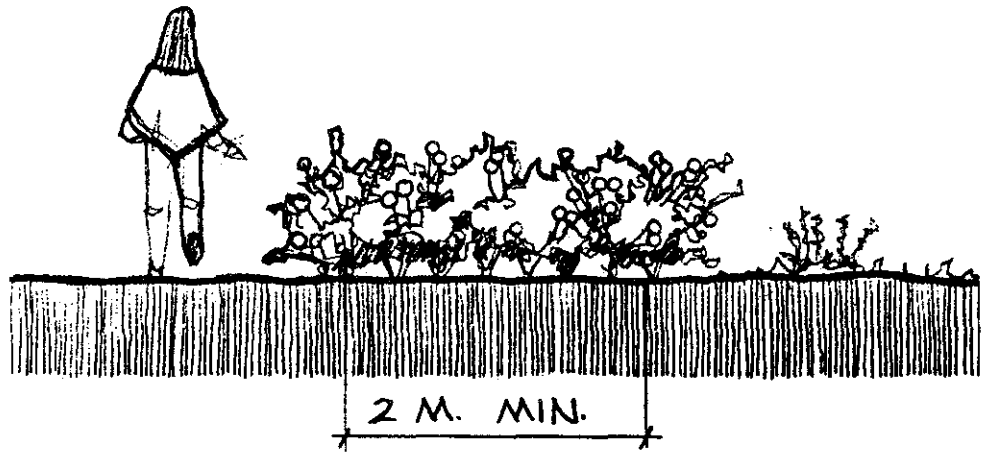
- sites where permanent closure, change of use or protection of special site features requires re-direction of pedestrian and vehicle circulation and where artificial barriers are inappropriate to the intended image or character of the site.

INSTRUCTIONS:

1. To be effective, vegetative barriers should be a minimum of two metres deep with individual plants installed on 300 mm centres (see 4.11.1, 4.11.3, 4.11.10).

2. During the first few years of growth, a natural barrier may need to be supplemented with a temporary artificial barrier (Technique 4.1.1) or an artificial log and brush barrier (Technique 4.1.5). Informational signage should also be installed.

3. Selection of appropriate barrier species will depend on site conditions and intended image/character of the site.



4.2 EROSION CONTROL

INTRODUCTION

The rectification of soil erosion problems may be achieved through the application of one of a number of restoration techniques. The specific technique selected will be dependent upon several factors, including:

- the agent causing the erosion (water or wind)
- soil type
- the severity of the problem
- the areal extent of the problem
- the topographic situation (river or stream bank, steeply sloping, etc.)
- the intended use or role and proposed image or character of the site in question

4.2.1 SLOPE SURFACE STABILIZATION - METHOD 1: STRAW MULCHING

APPLICATIONS:

- extensive slopes of 1.5:1 or flatter, subject to sheet or rill erosion.

INSTRUCTIONS:

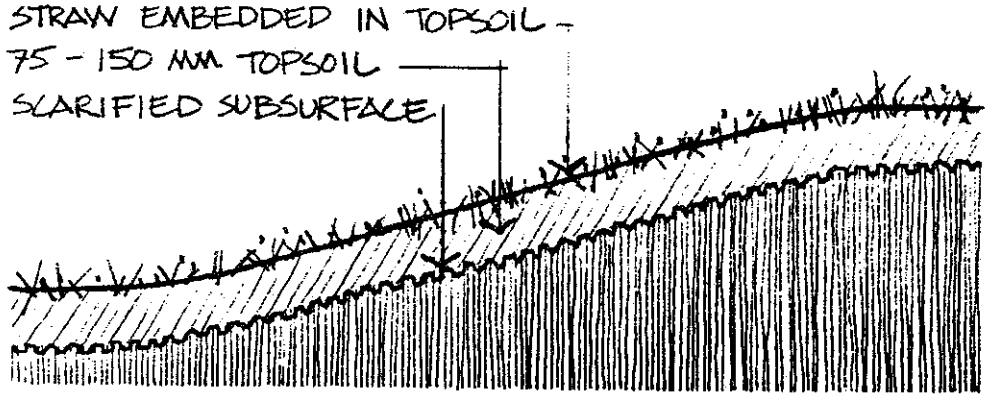
1. Roughen 'cut' slopes on a rough contour with a scarifier or cultivator-type implement, in a series of longitudinal grooves or corrugations.

2. Cover 'cut' slopes with 75-150 mm topsoil. If topsoil is not available, cultivate slope 100-150 mm deep and apply fertilizer as required. 'Fill' slopes will not ordinarily require cultivation or topsoil unless very sterile or compacted.

3. Cover slope with straw at the rate of about 4 tons/acre. Embed straw into loose soil with a sheeps-foot roller.

4. Plant ground cover or other vegetation through straw into topsoil (see 4.11).

5. If slope is to be seeded, sow seed before placing straw (see 4.11).



Note: See also 4.2.16 as an alternative technique.

4.2.2 SLOPE SURFACE STABILIZATION - METHOD 2: BRUSH-LAYERING

APPLICATIONS:

- 'fill' slopes consisting of highly erodible soils; the intent is to provide protection against gullying should any surface protection measures fail.

INSTRUCTIONS:

1. At required elevations, smooth edge of fill bench on contour to width of mat.

2. Lay brush, leafy ends outward, flush with edge of fill to such depth that after compaction the finished mat will be approximately 150 mm thick.

3. Place additional fill material on top of brush and compact as for remainder of fill.

4. At convenient stages of construction, spread straw evenly over slope at rate of 4 tons/acre. Roll with a sheeps-foot roller until straw is thoroughly incorporated into the soil. At least four passes of the roller will be required.

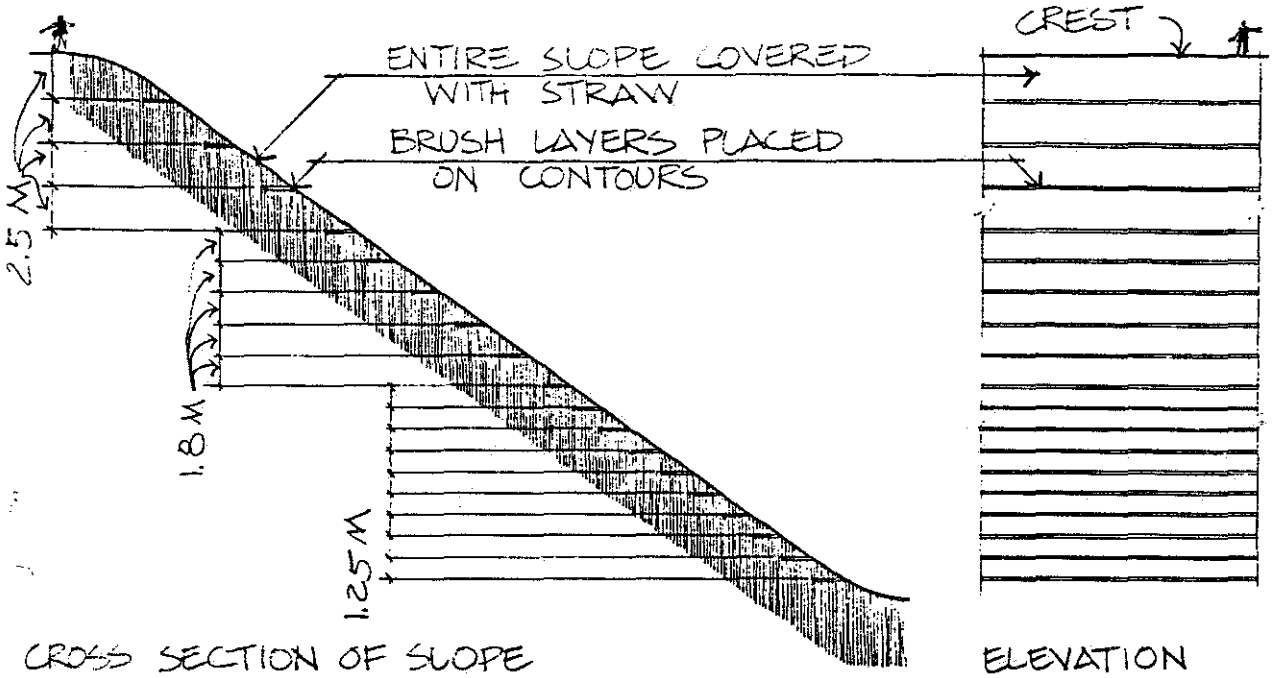
5. Sow an annual nurse crop over the slope (see 4.11.4 or 4.11.5).

6. Spread second application of straw at a rate of 4 tons/acre. Repeat rolling operation until straw is thoroughly embedded in soil.

7. Plant perennial vegetation between mats for permanent vegetative protection (see 4.11.1, 4.11.2 or 4.11.3).

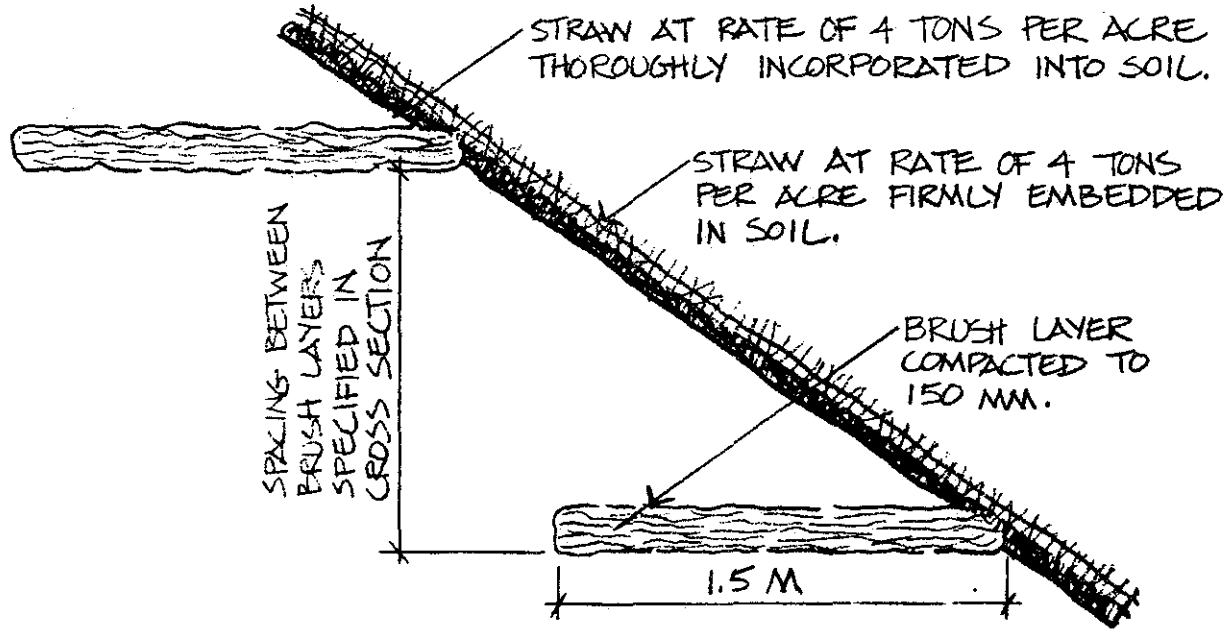
8. If slope is to be seeded, sow seed before second application of straw (see 4.11.4, 4.11.5 or 4.11.6).

NOTE: The quantity of straw applied will vary according to the character of the soil. Loose, granular soils usually require more straw per acre for an adequate cover (6-10 tons/acre) than does a more consolidated or finer-textured soil (4-8 tons/acre).



CROSS SECTION OF SLOPE

ELEVATION



DETAIL OF BRUSH LAYERS

(after Conover, 1977)

4.2.3 SLOPE SURFACE STABILIZATION - METHOD 3: SOIL LOOSENING/GUTTERS

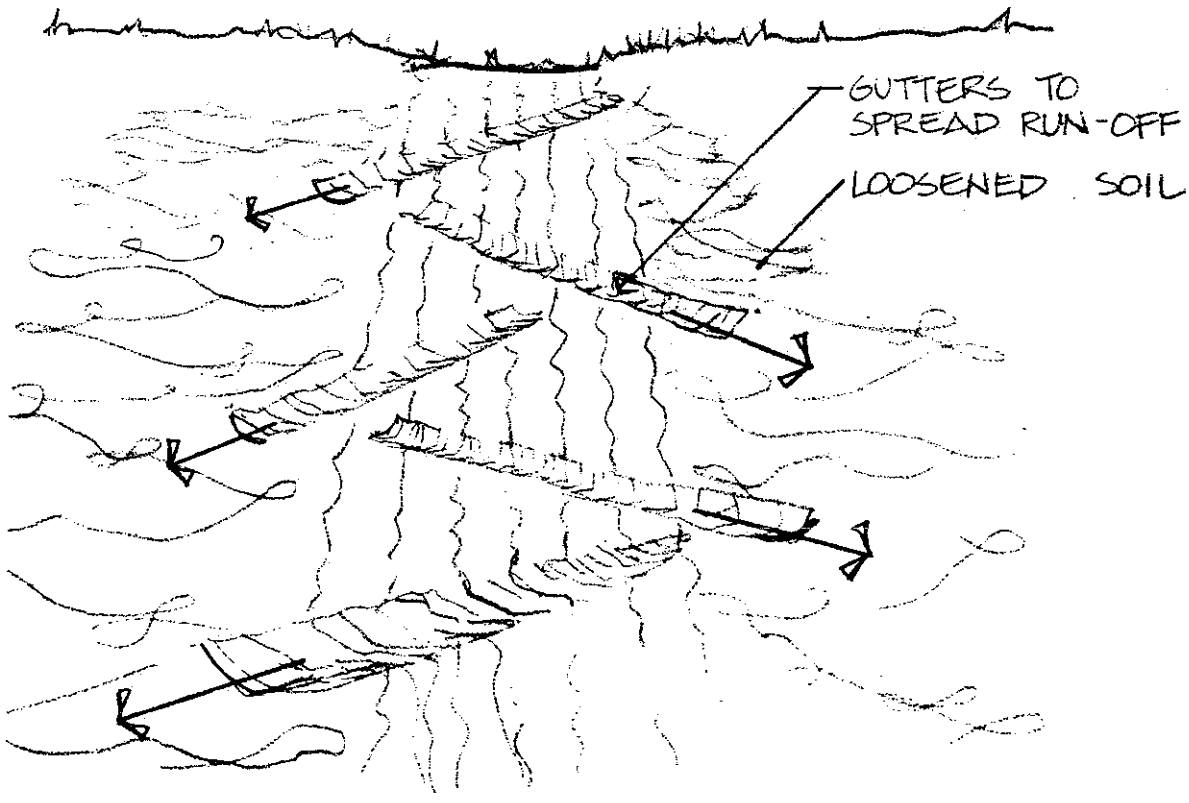
APPLICATIONS:

- small areas subject to sheet, rill or small gully erosion and where pedestrian traffic is relatively light.

INSTRUCTIONS:

1. Where the problem is not severe, erosion may be checked simply by loosening the compacted soil surface (hand tools should be sufficient) so that water infiltrates the surface rather than running off.

2. For areas on slopes, such as trails (which generate more runoff than adjacent areas), small 'gutters' can be sculpted into the soil (at angles to the slope) to intercept the runoff and deliver it safely to a portion of the site which can absorb it. By 'spreading' the run-off water, erosive forces will be diminished.



ENCOURAGING RUN-OFF TO INFILTRATE THE SOIL

4.2.4 SLOPE SURFACE STABILIZATION - METHOD 1: LOG CRIBS

APPLICATIONS:

- areas subject to sheet, rill and small gully erosion and where pedestrian traffic is relatively heavy.

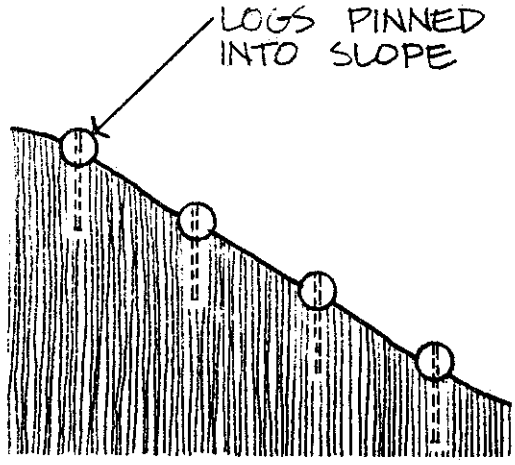
INSTRUCTIONS:

1. Cribbing can be used to construct small 'terraces' on slopes that pose erosion problems, since the terraces effectively break up the length of the runoff path. These terraces also reduce the erosive effects of foot traffic by providing a series of horizontal surfaces for walking, thus minimizing the downslope movement of soil.

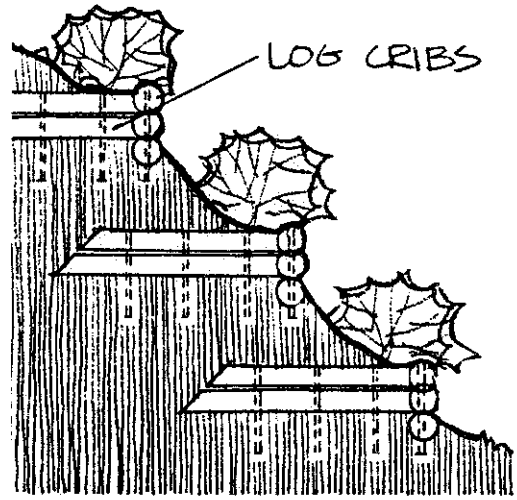
2. Cribs can be constructed simply by anchoring logs into the slope (at nearly right angles to the run of the slope) at more or less regular intervals ('a', below), or complete frames can be constructed and filled with earth ('b', below).

3. With either method, anchoring is achieved by augering holes through the logs (squared timbers can also be used) and then driving pins (lengths of concrete re-bar) through the augered holes and into the slope.

a.



b.



NOTE: Cedar, fir, tamarack or pressure treated lumber will have a relatively long life expectancy on istes where future use will require same.

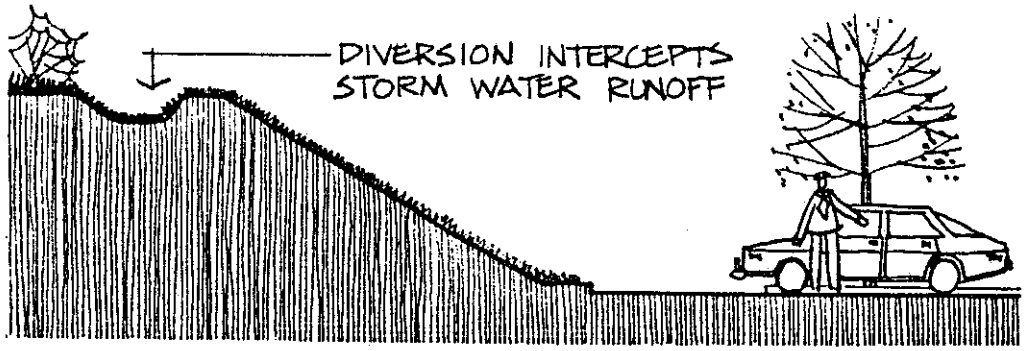
4.2.5 DIVERSION MEASURES

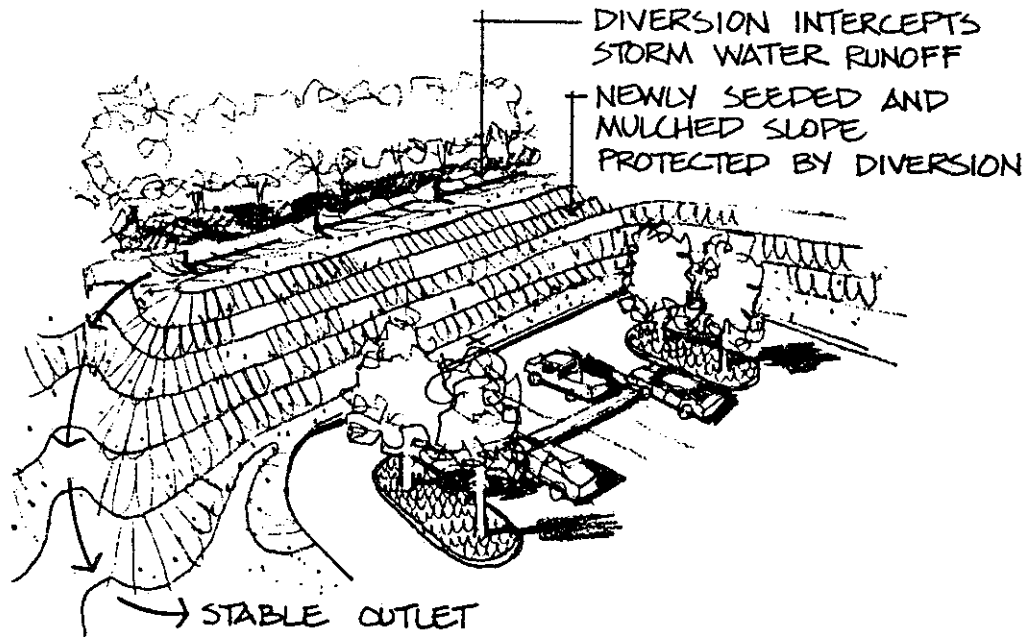
APPLICATIONS:

- sites where slopes must be protected from excessive surface runoff until surfaces have been re-stabilized or permanently re-vegetated.

- diversion ditches can be bare channels, vegetatively stabilized channels or channels lined with a hard surface material.

- the size and design characteristics of a diversion will depend upon the amount of runoff to be diverted, the velocity of run-off in the diversion and the erodibility of the soils on the slope to be protected and in the diversion itself.





DIVERSION CONTROL MEASURES CAN INTERCEPT STORM WATER RUNOFF BEFORE IT REACHES SLOPES
(after B.J.R. Inc., 1981)

a. Grassed Diversions/Slope Drains

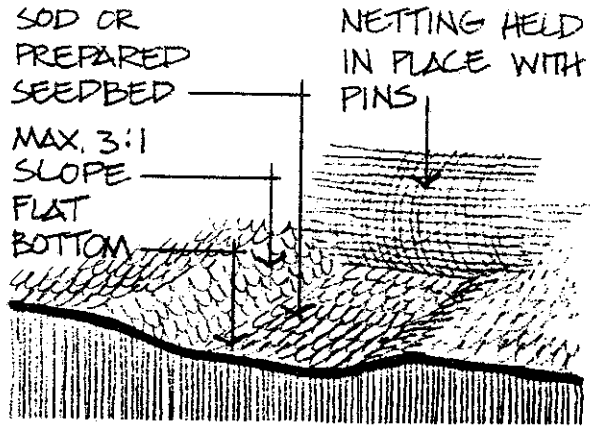
INSTRUCTIONS:

1. Grade the diversion as shown below.

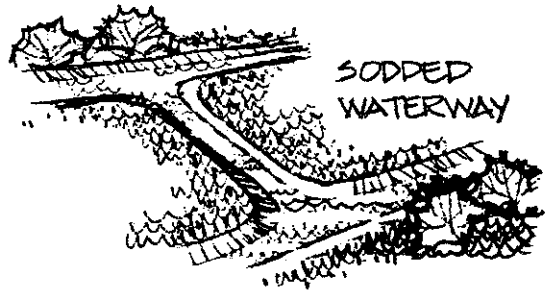
2. Seed or sod the channel (see 4.11.5 or 4.11.8) to achieve a dense, uniform vegetative cover. Jute netting, burlap, excelsior blankets or other mulching techniques may be required to protect the channel until the vegetation becomes well established.

3. In some cases, channel bank protection (e.g. rip rap) may also be required (see 4.2.13).

4. See also 4.2.10.



GRASSED WATERWAY WITH NETTING



GRASSED DITCH SLOWS RUNOFF VELOCITY

GRASSED SLOPE DRAIN

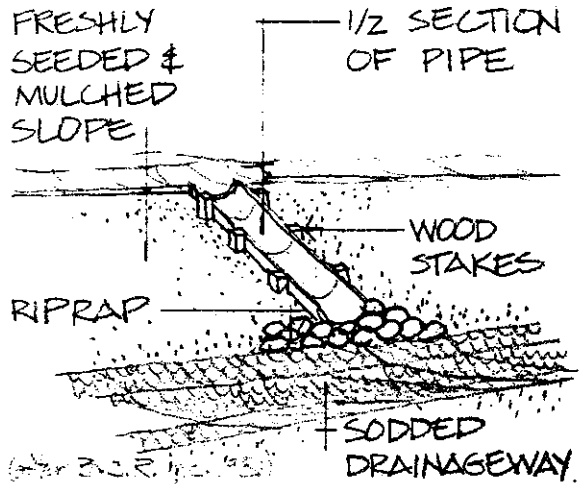
(after B.J.R. Inc., 1981)

b. Hard Surface Diversions and Slope Drains

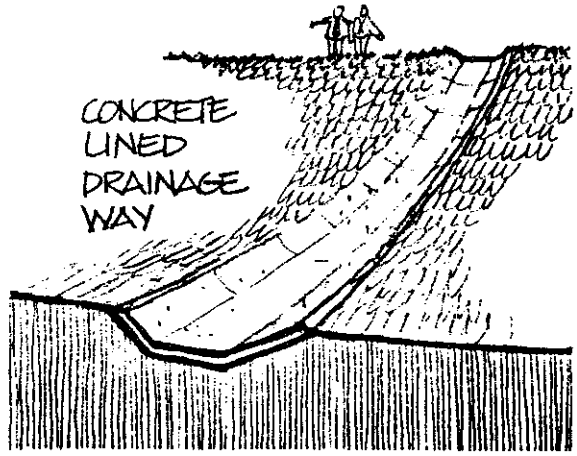
INSTRUCTIONS:

1. For temporary diversions or slope drains, ½ sections of corrugated metal pipe can be laid into a channel, backfilled and staked (see sketch).

2. Ensure that soil at the lip of the drain is fully compacted and protected with rip rap to dissipate the energy of the water and to prevent undercutting of the drain.

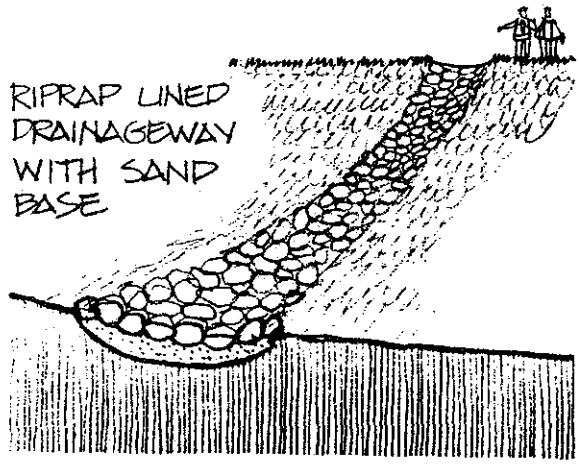


3. Where permanent slope drains or diversions are required, and where runoff velocities or durations preclude vegetated waterways, concrete asphalt or rip rap linings are often required. Concrete or asphalt-lined channels should be properly designed by a competent professional prior to installation.



(after B.J.R Inc., 1981)

4. Construction of rip rap lined channels should include installation of a granular base prior to placing of rip rap. Depth of granular base, and depth and size of rip rap will depend on runoff quantity and slope gradient.



(after B.J.R. Inc., 1981)

4.2.6 GULLY EROSION CONTROL: METHOD 1 - LOG OR PLANK CHECK DAMS

APPLICATIONS:

- gullies which have large volumes of runoff but which can be stabilized by certain types of vegetation.

INSTRUCTIONS:

1. Since vegetation will ultimately be providing the protection, the spacing and height of the check dams must be such that breaks will not occur in the gully bottom after the structure has decayed. A desirable height is 600 mm measured from the top of the apron to bottom of the spillway notch. The maximum height should be no more than 900 mm (see sketches below).

2. Slope the gully banks to a 1:1 slope for the entire length of the dam and apron. Sloping should extend up the sides of the gully to the full height of the dam, tapering down to a minimum of 300 mm at the lip of the apron. The excavation for the dam should be 300-600 mm deep and should extend into the banks 0.6 to 1.2 m, measured at right angles to the slope.

3. Set two upright posts to a minimum depth of 600 mm in the downstream edge of the excavation, in order to form the sides of the spillway notch of the dam. Set an additional post in the centre if the width of the spillway notch exceeds 1.8 m.

4. Set additional posts, at intervals not exceeding 1.8 m between the spillway posts and the points where the top cross logs or planks enter the gully banks.

5. Place a 50 mm layer of straw, grass or leaves in the bottom of the excavation to prevent leakage under the dam.

6. Place horizontal logs or planks of sufficient length to span the entire width of the gully on the upstream side of the posts. Short top logs or planks extending into the gully banks and fastened to the central upright posts form the spillway notch.

7. If logs are used, the space between the logs should not exceed 10 mm and should be chinked tightly with straw or grass.

8. Backfill, on a 2:1 slope, the upstream face and wings of the dam.

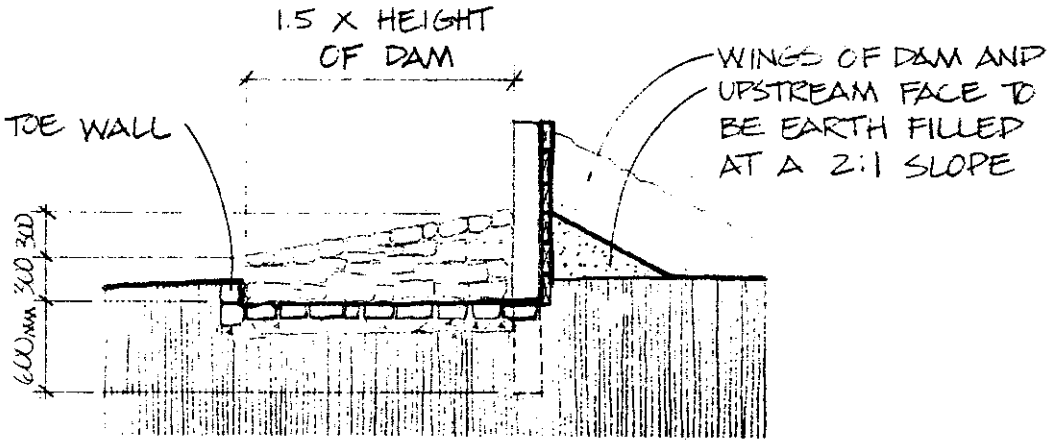
9. The length of the apron should be at least 1.5 times the height of the dam, measured from the top of the spillway to the normal gully floor, and should be at least 300 mm wider than the bottom of the spillway notch and at least as wide at the lip as at the base of the dam.

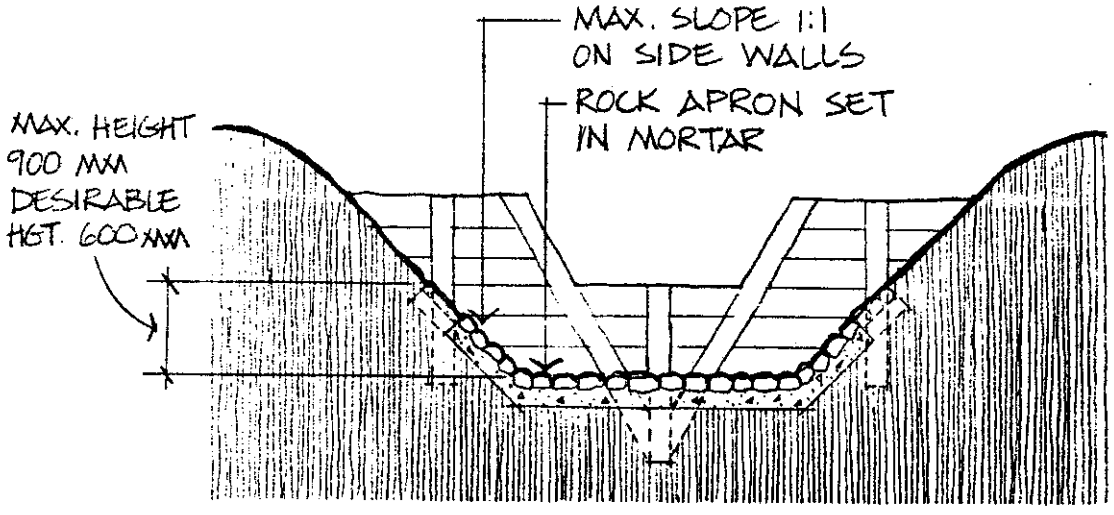
10. The side walls should be set below the surface of the gully banks on a slope of not less than 1:1. They should be at least 600 mm high at the dam, and may taper to 300 mm at the lip of the apron.

11. A toe log or wall should be set at the lip of the apron and extend into the ground 150 mm below the floor of the apron and into the bank not less than 300 mm beyond the width of the spillway of the dam. The top of the finished toe log should be flush with, or slightly below, the normal floor of the channel.

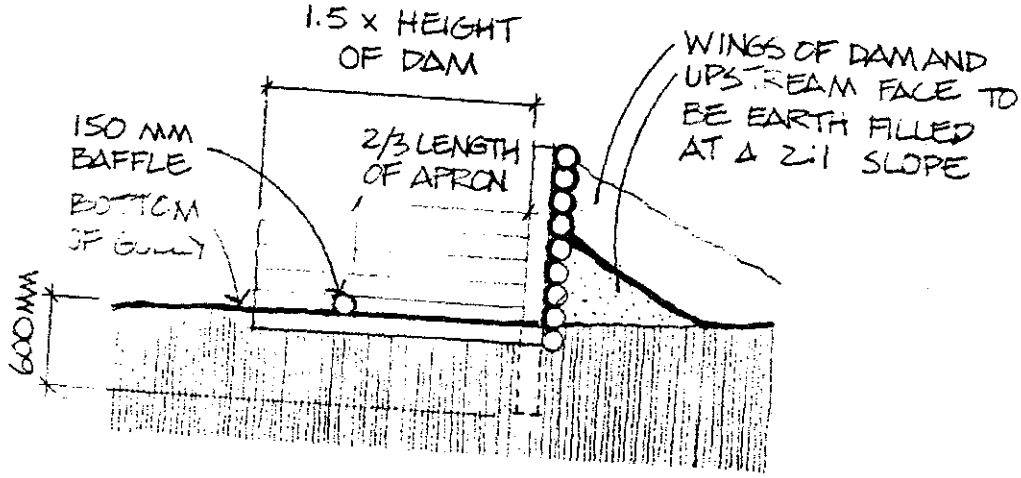
12. Construct a stilling basin not less than 150 mm deep by excavating between the toe wall (log) and the base of the dam sufficiently to permit the apron to be 150 mm below the top of the toe log or wall or build a 150 mm baffle across the apron. Build the baffle at a distance from the dam equal to two-thirds of the length of the apron.

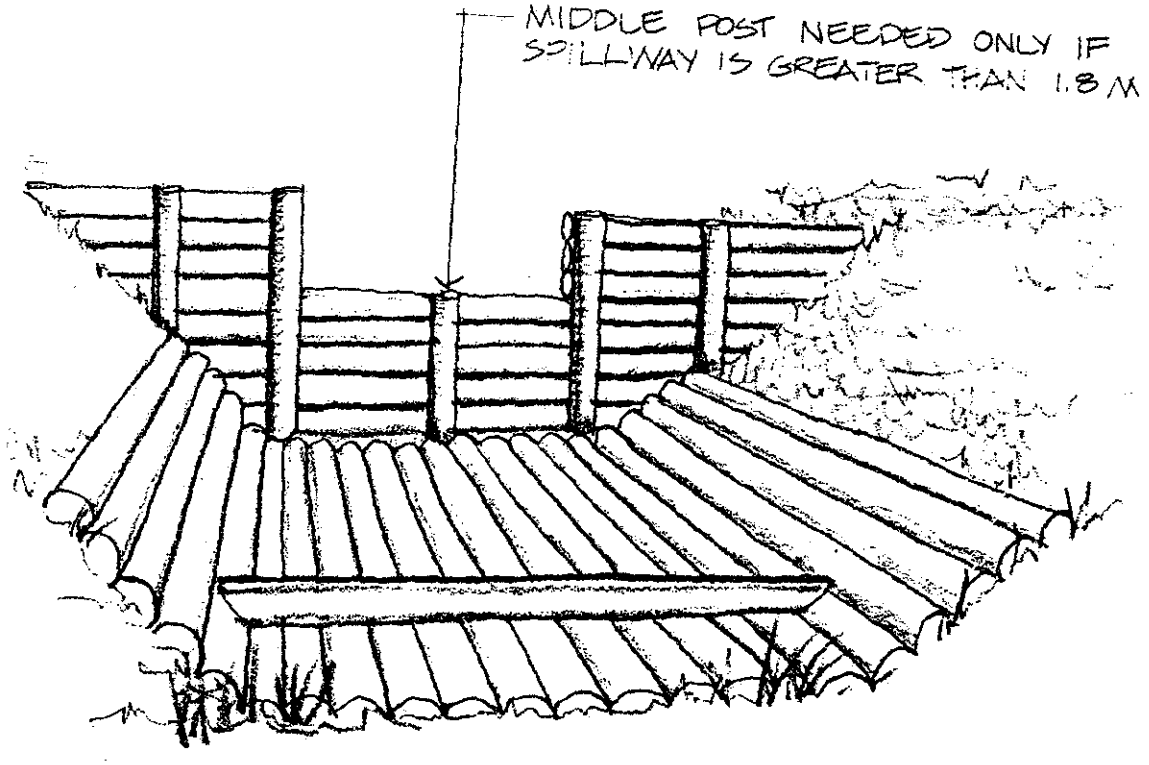
13. Prepare areas between check dams for planting (see 4.9) and establish new vegetation and/or seed the prepared areas (see 4.11).





PLANK DAM WITH ROCK APRON (after Conover, 1977)





LOG DAM AND APRON (after Conover, 1977)

4.2.7 GULLY EROSION CONTROL: METHOD 2 - SINGLE POST BRUSH DAMS

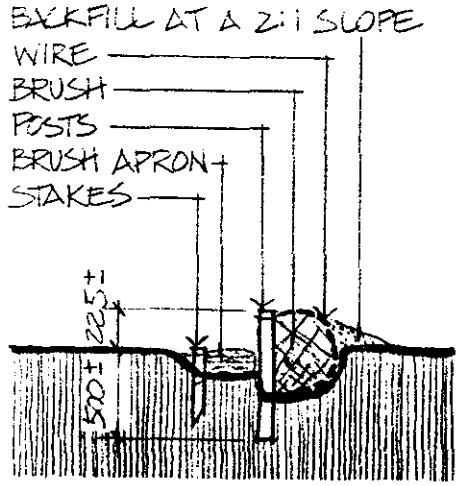
APPLICATIONS:

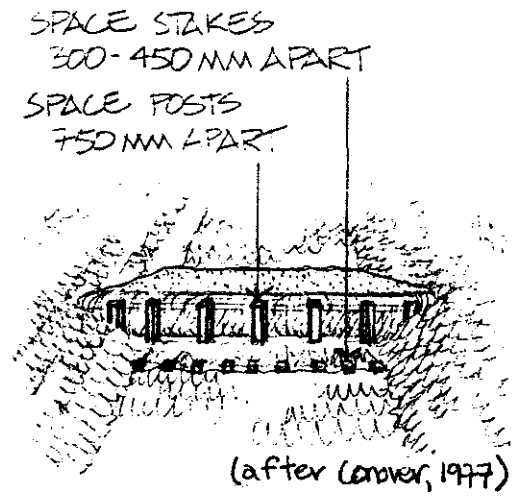
- gullies that require temporary 'structures' to provide sufficient time for establishment of vegetation which will provide long term erosion control.

- brush check dams act to collect and hold sediments and moisture and gully bottoms, thereby providing more favourable growing conditions for vegetation.

INSTRUCTIONS:

1. Slope the gully banks for the entire length of the dam and apron on a 1:1 slope, and extend these slopes up the sides of the gully to the full height of the dam (see sketches below).





2. The base of the dam should usually be excavated 300-450 mm wide and never less than 150 mm. The excavation should extend into the gully banks from 150-450 mm at right angles to the slope. The bottom of the excavation should be rounded to the curve desired in the finished dam, so that the finished structure will have a weir depth of 225 mm ±.

3. Space posts 750 mm apart and set 450-600 mm deep in the downstream face of the excavation. A single wire should be fastened to each post near the base before it is set in the ground. This wire will be used in tightening the brush.

4. Cover the bottom of the excavation with a layer of straw, grass or leaves 50-75 mm thick.

5. Place the brush lengthwise in the excavation, placing the smaller branches near the bottom. Keep the brush at a uniform height for the full length of the dam, tamping each layer for compactness.

6. After all the brush is in place, draw the wires attached to the base of the posts across the top of the dam as tightly as possible and secure near the top of each post. Set or cut the posts so that they will not extend above the top of the dam.

7. Backfill on the upstream face and wings of the dam (to full height at a 2:1 slope) as shown in sketches.

8. For apron construction, excavate the gully bottom to the approximate shape of the dam. Extend the excavation up on the banks to the full height of the dam. The excavation should equal in length 1.5 times the height of the dam.

9. Construct the apron by placing a layer of brush 100-150 mm thick in the excavation below the dam. Lay the brush parallel to the gully with the butt ends extending into the base of the dam. Secure the brush by means of a wire to stakes set 300-450 mm apart in rows across the apron.

10. Set the stakes and drive them partially into the ground before the wire is attached. After the wire is fastened and the brush is in place, the stakes should be driven fully, drawing the wire tight across the brush.

11. Prepare areas in the gully between the brush dams for planting (see 4.9) and establish new vegetation and/or seed the prepared areas (see 4.11).

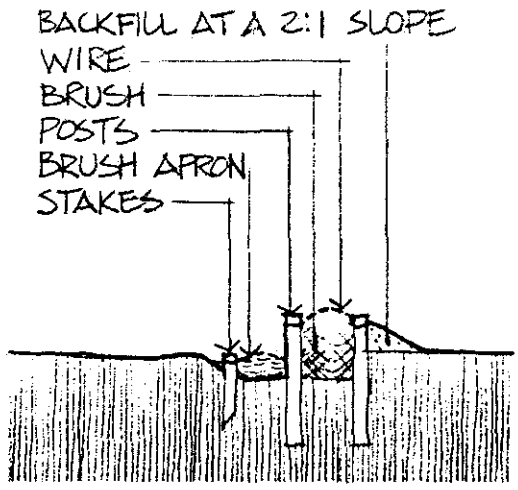
4.2.8 GULLY EROSION CONTROL: METHOD 3 - DOUBLE POST BRUSH DAMS

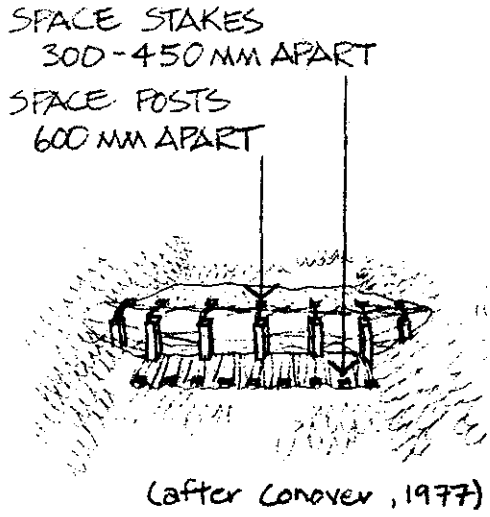
APPLICATIONS:

- gullies that require temporary 'structures' to provide sufficient time for establishment of vegetation which will provide long term erosion control, and where the severity of the problem and energy levels are such that single post brush dams would not be sufficient to withstand erosion forces.

INSTRUCTIONS:

1. Double post brush dams require the same excavation as single post brush dams (see 4.2.7), with a minimum weir depth of 225 mm ± (see sketches below).





(after Conover, 1977)

2. Place a layer of hay, straw or leaves, 50-75 mm thick, in the trench.

3. Drive posts partially into the ground at intervals of 600 mm, set opposite each other in two rows for the entire length of the dam.

4. Place brush as for single post dams (see 4.2.7). After all the brush is in place, fasten a wire securely to the top of the posts and drive them to their final depth.

5. Backfill as for single post brush dams (see 4.2.7).

6. Construct apron as for single post brush dams.

7. Prepare areas in the gully between the dams for planting (see 4.9) and establish new vegetation and/or seed the prepared areas (see 4.11).

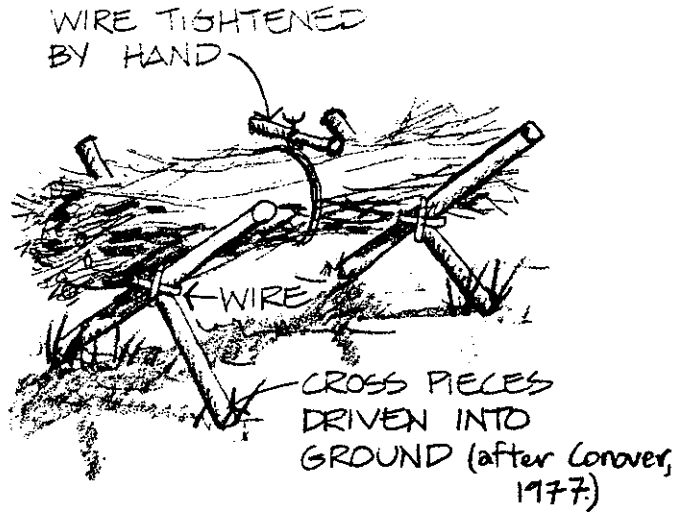
4.2.9 GULLY EROSION CONTROL: METHOD 4 - BRUSH CHECKS

APPLICATIONS:

- gullies carrying a very small amount of runoff
- it is seldom necessary to do any excavation, and brush checks serve as planting sites.
- the principal features of brush check construction are maximum height of construction (300 mm), little or no excavation in the gully bottom, and simple devices for holding brush in place.

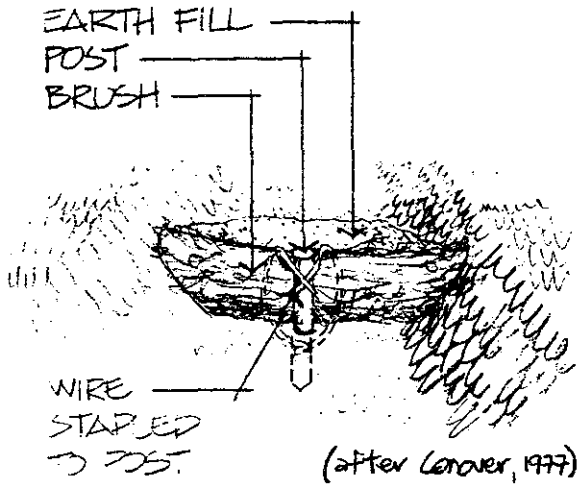
INSTRUCTIONS:

1. Using a brush bundler as shown below, prepare a well-tightened bundle of brush sufficiently long to span the bottom of the gully and no larger in diameter than 300 mm ±.



2. Drive a single post partially into the centre of the gully bottom.
3. Secure the brush bundle to the top and lower portion of the post, using wire and heavy staples.
4. Drive the post to its final depth.

5. Backfill the upstream face of the check (to the full height of the brush bundle) on a 2:1 slope, using clay or topsoil well compacted (see sketches below).



6. Prepare areas in the gully between the brush checks for planting (see 4.9) and establish new vegetation and/or seed the prepared areas (see 4.11).

4.2.10 GULLY EROSION CONTROL: METHOD 5 - BRUSH PAVING

APPLICATIONS:

- surface stabilization of gully channels to permit growth of vegetation

- especially good for use on steep slopes in gullies carrying considerable runoff

- as the effective life of brush paving is relatively short (up to 3 years ±), vegetation must be established quickly.

INSTRUCTIONS:

1. The gully bottom should be rounded or flattened and the gully banks sloped to a minimum of 1:1 above the expected height of water in the channel during peak flow periods. All loose earth in the channel should be removed or well compacted by tamping.

2. The materials used for brush paving are: branches 25 mm diameter maximum; durable stakes 450-600 mm long; straw, grass or leaves; and 9 to 14 gauge wire.

3. Place a 25 mm thick layer of straw, grass or leaves in the gully for the full width of the paving.

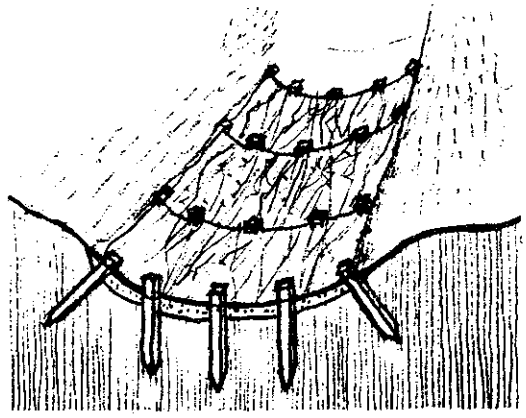
4. Place brush (with butt ends downstream), using smaller branches in the bottom layer. Brush should be placed to provide a finished thickness of 35-50 mm after the paving has been wired down.

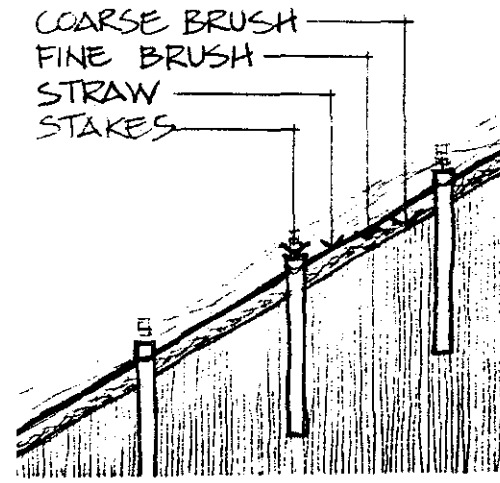
5. Set and partially drive the stakes in rows across the channel, with the rows and stakes at intervals of 450-600 mm.

6. Fasten wire securely around each stake and drive stakes to their final depth to draw the wire down tight across the brush (see sketches on next page).

7. Prepare areas adjacent to the brush paving for planting (see 4.9) and establish new vegetation and/or seed the prepared areas (see 4.11).

(after Conover, 1977)





4.2.11 GULLY HEAD EROSION CONTROL: METHOD 1

APPLICATIONS:

- gully heads less than 2 m high

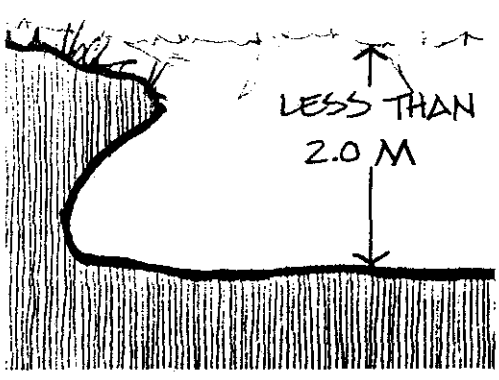
INSTRUCTIONS:

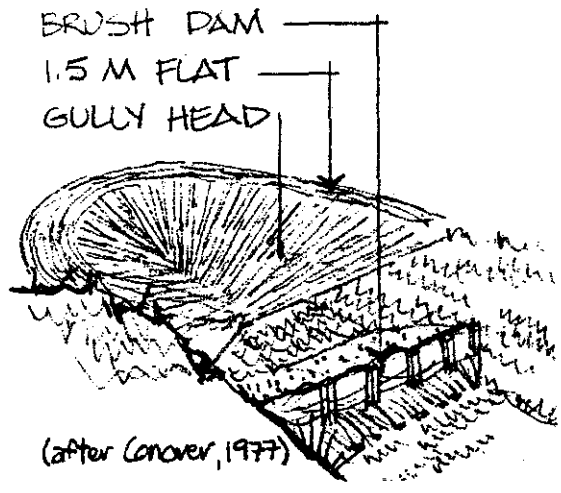
1. Grade the gully head to a 1.5:1 slope.

2. Break the ground (to a minimum depth of 150 mm) for a distance of at least 1.5 m back from the head and completely encircle it (see sketch below).

3. Mulch the gully head with straw and a light covering of hard-wood brush. (In exposed areas, this mulch may need to be 'anchored' with stakes and wire - see 4.2.10).

4. Mulch the 1.5 m flat with straw or wood chips (an anchoring mesh, staked down, may be needed in exposed areas).



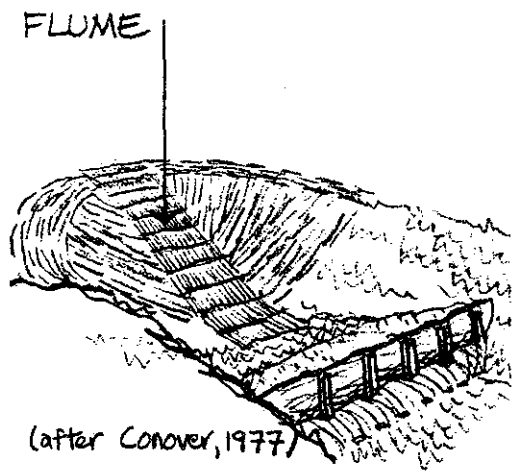


5. For gullies draining relatively large areas, a flume may also be required (see sketch on next page).

6. Excavation for the flume should be made on a 2:1 slope, with the sides on a 1.5:1 slope. Excavation should be in hard soil.

7. Break the ground in the bottom of the excavation to a depth of 50-75 mm, and mix in natural mulch materials (leaves, peat moss, etc.) and fertilizer (as required) with the loose earth. Treat the sides in the same manner and seed the sides and bottom with drought resistant bunch grasses. Mulch lightly and cover with an anchored mesh or light brush cover (see 4.2.10).

8. A brush dam should be placed 2 m from the bottom of the flume to form a 2 m stilling basin 300 mm deep (see 4.2.7 or 4.2.8).



NOTE: Gullies related to piping action require a permeable layer built in to prevent obstruction of sub-surface drainage.

4.2.12 GULLY HEAD EROSION CONTROL: METHOD 2

APPLICATIONS:

- gully heads more than 2 m high

INSTRUCTIONS:

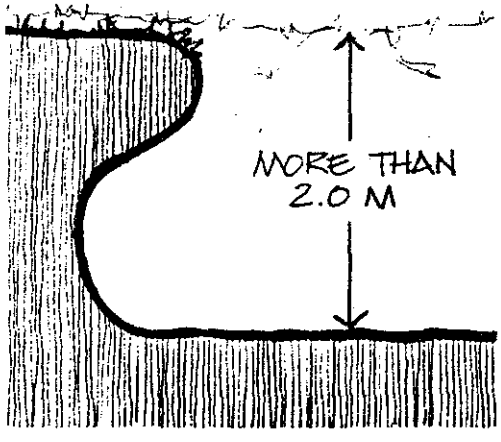
1. Grade the gully head to a 1.5:1 slope.

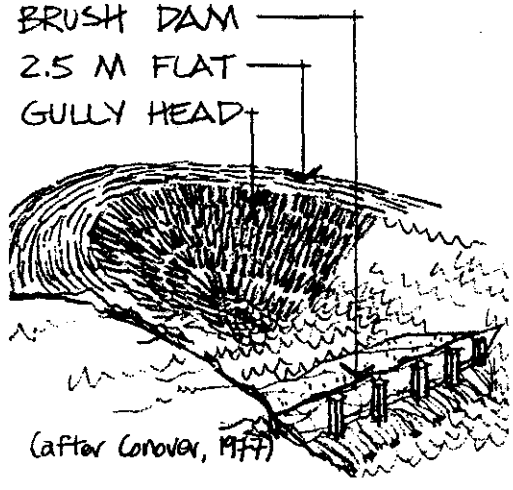
2. Break the ground (to a minimum depth of 150 mm) for a distance of at least 2.5 m back from the head and completely encircling it (see sketch below).

3. Mulch the gully head with straw and brush.

4. Tie the covering down by driving into it stakes 1.5 m apart in rows 1.5 m apart; wires fastened to the stakes should run both vertically and horizontally so that 1.5 m squares are formed. The stakes should be long enough to be securely driven into undisturbed earth.

5. The mulch on the 2.5 m flat above the head need not be fastened down, except in exposed areas (see 4.2.11). Mulch materials on the flat area may be straw or wood chips.





NOTE: Gullies related to piping action require a permeable layer built in to prevent obstruction of sub-surface drainage.

6. For gullies draining relatively large areas, a flume may also be required (see 4.2.11).

7. A brush dam should be placed 2 m from the bottom of the flume to form a 2 m stilling basin 300 mm deep (see 4.2.7 or 4.2.8).

4.2.13 CHANNEL BANK EROSION CONTROL: METHOD 1 - RIP RAP

APPLICATIONS:

- river channel banks subject to undercutting and/or sloughing as a result of fluvial (current) erosion.

INSTRUCTIONS:

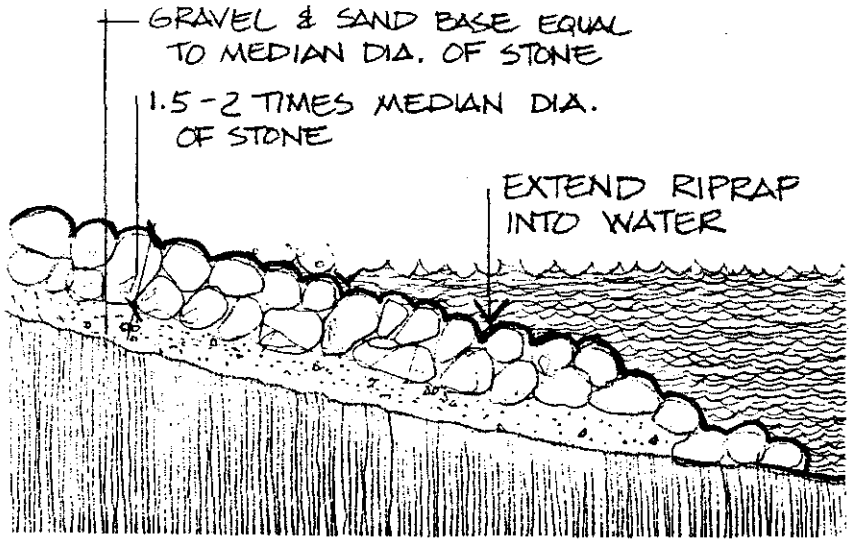
1. Grade the affected slope to a 4:1 gradient.

2. Calculate the median diameter of stone required to protect the slope, using the following table. Use of this table will require knowing the mean velocity of the river current along the bank.

CURRENT VELOCITY (m/sec)	MEDIAN STONE DIAMETER (mm)
1.0	24
1.5	55
2.0	97
2.5	152
3.0	219
3.5	298
4.0	389

3. Place a granular backing layer on the slope. This layer should be approximately equal in thickness to the required median stone diameter, and should consist of a gravel-sand mixture. No more than 25% of the mixture should be sand and the remainder of the mixture should be gravel, 10 mm - 50 mm diameter. This backing mixture should be placed across the full height of the bank being rip-rapped (under and above the water). The portion being placed under water should be pushed into the water from the bank.

4. Place the stone rip-rap (to a thickness equivalent to 1.5-2.0 times the required median diameter of the stone) across the full height of the bank being rip-rapped (under and above the water). The portion being placed under water should be pushed into the water from the bank. Above water level, the stone should be hand placed.


GRAVEL & SAND BASE EQUAL TO MEDIAN DIA. OF STONE
1.5 - 2 TIMES MEDIAN DIA. OF STONE
EXTEND RIPRAP INTO WATER

4.2.14 CHANNEL BANK EROSION CONTROL: METHOD 2 - VEGETATIVE CONTROL

APPLICATIONS:

- river channel banks subject to undercutting and/or sloughing as a result of fluvial (current) erosion and where expected river current velocities will remain below approximately 2 m/sec.

INSTRUCTIONS:

1. Grade the affected bank to a 4:1 slope.

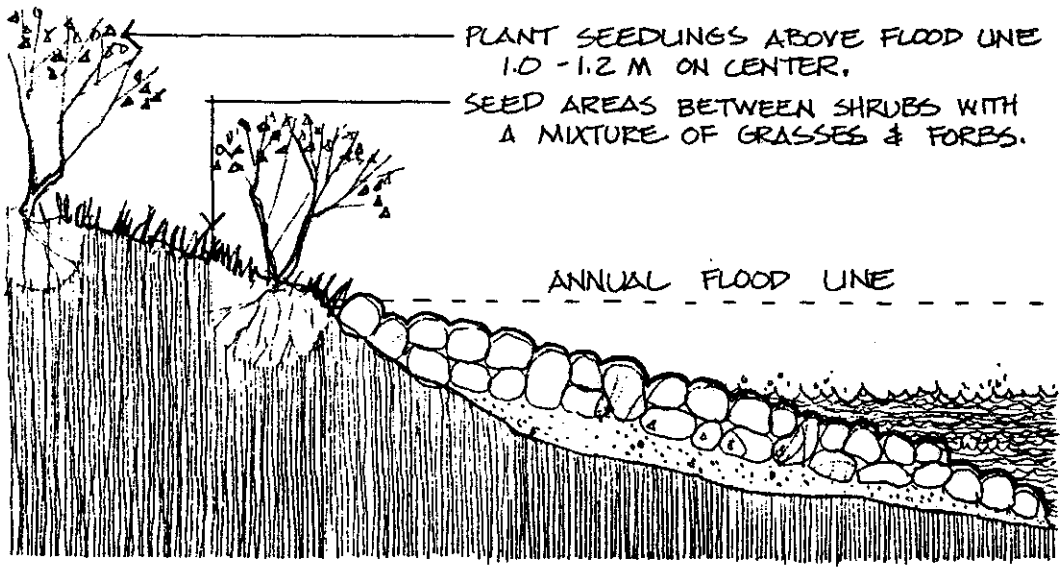
2. Place backing layer and stone rip rap (as required by current velocity - see 4.2.13) below the annual flood line.

3. Above the annual flood line, plant seedlings of shrub species that thrive in moist to wet soils (e.g. willow spp., red osier dogwood) on 1.0 m - 1.2 m centres (see 4.9 and 4.11.1). Planting area should extend to the full height of the bank being protected.

4. Seed all areas between established shrubs with an appropriate mixture of grasses or grasses and forbs (see 4.11.5 or 4.11.6).

5. In areas where current velocity will not exceed 1.0 m/sec. ±, seeding to bunch grasses should afford sufficient protection (see 4.11.4 or 4.11.5).

6. In areas where current velocity will not exceed 1.6 m/sec. ±, sodding of uniform turf should afford sufficient protection (see 4.11.8).



4.2.15 WIND EROSION CONTROL: METHOD 1 - RECLAIMING LARGE DUNE AREAS

APPLICATIONS:

- extensive areas of unstable dunes or wind erosion of sandy soils.

INSTRUCTIONS:

1. The ultimate success of restoration measures intended to stabilize sand dunes or to control wind erosion of light soils is contingent upon the establishment of permanent vegetation in the area. In large areas, this process must be considered an incremental one, with the restoration progressing from one portion of the site to the next each year. The fundamental principle on such an approach is to proceed in a downwind direction (based on the direction of the prevailing or most destructive winds). The first step in the process is therefore to identify the upwind portion of the site being restored.

2. Take steps to reduce wind exposure of the site being treated (see 4.9.2). Depending on the severity of the erosion, spacing between the windbreaks may need to be as little as 1-2 m.

3. Depending on the spacing between the windbreaks, it may be desirable to seed the area to a mixture of drought tolerant grass species and a quickly-germinating nurse crop prior to placing the windbreaks (see 4.11.4 or 4.11.9). NOTE: Any cultivation of the site should be carried out perpendicular to the prevailing wind, with less emphasis on cultivating across slopes (i.e. emphasize protection against wind, rather than water erosion). If seeding precedes installation of windbreaks, windbreaks must be installed as soon as possible following seeding. Regardless of the approach taken, seeding should be timed to take advantage of the optimum moisture conditions (autumn seeding is generally preferable) (see also 4.2.16).

4. Once the grass has become well established (usually the following year), install seedlings of drought tolerant shrubs (at a density that will, over time, provide 'natural' windbreak effects or soil stabilization. Species well suited to such an environment would include common juniper, creeping juniper, snowberry, saskatoon, chokecherry). Autumn planting of shrubs is recommended.

5. Do not remove artificial windbreaks until shrub material is well established.

6. In the second year, start again at step 2 for the portion of the site immediately downwind. Repeat the process each year until the entire site is supporting a well established vegetative cover.

4.2.16 WIND EROSION CONTROL: METHOD 2 - RECLAIMING SMALL DUNE AREAS

APPLICATIONS:

- small areas of wind erosion.

INSTRUCTIONS:

1. Grade site to desired grades.

2. Provide adequate artificial windbreaks (see 4.2.15). It may be desirable to provide windbreaks completely around the site, and some windbreaks may also be needed within the site.

3. Follow steps 3-5 in 4.2.15, although seeding technique 4.11.5 may be more appropriate.

4. Alternatively, and providing that pedestrians and vehicles can be excluded from the site, a dilutable plastics dispersion product, such as 'Curasol' AH or AK (as manufactured by Hoechst Canada) may be used in the following manner:

   a. Grade site to desired grades and seed with desired mixture of grasses or grasses and forbs (see 4.11.5 or 4.11.6). No windbreak protection is needed; however, if pedestrian or vehicle traffic could cross the site, temporary barriers will be required.

   b. Dilute Curasol with water at a ratio of 50 gm Curasol: 1 litre water ± (depending on slopes and soil permeability) and pour into a standard agricultural weed sprayer. NOTE: if services are available, a simple domestic garden sprayer may also be used.

   c. Spray solution over the seed bed at a rate of 1 litre/m^2 ±. NOTE: air and soil temperatures should be above 5°C when applying, and 2-6 hours are generally required for drying, so apply only when rain is not anticipated for at least a few hours.

   d. As the product cannot withstand traffic, do not install shrub material until grasses or grass/forb mixtures are well established.

5. As a third alternative, Curasol is also recommended for use in hydroseeding mixtures (see 4.11.9).

4.3 PEDESTRIAN AND VEHICLE TRAFFIC PROBLEM CONTROL

INTRODUCTION

As noted in Section 3, pedestrian and vehicle traffic can cause problems of vegetation trampling and soil compaction, which can in turn result in reduced vigour of vegetation along and adjacent to these corridors, or (with relatively intense or continuous traffic) in denudation of these areas. Where denudation occurs, the soil stabilization effect of the vegetation is lost and soil erosion problems can quickly follow.

Control of pedestrian and vehicle traffic problems may be achieved through two general strategies: prevention or redirection of traffic through a site; or development of alternate, hardened surfaces that can better withstand existing and anticipated traffic levels.

The prevention or redirection of traffic is best accomplished with the use of barriers (see 4.1).

The development of alternate surfaces along traffic corridors could employ a variety of techniques, depending upon specific site conditions. These techniques could range from the construction of sophisticated structures (e.g. boardwalks, bridges), through installation of concrete, asphalt, unit paving or gravel surface roads and pathways, to the use of 'low-tech' designs and materials. The design of structures is highly site-specific and is not considered in this section of the manual. The construction of standard concrete, asphalt, unit paving and gravel surface roads and pathways would usually employ typical M.V.A., City of Saskatoon or University of Saskatchewan designs for such facilities and are similarly excluded from consideration here. However, a number of techniques, applicable in a variety of situations, that utilize relatively simple technology and 'natural' materials are described in this Section of the manual (see also 4.2.3 and 4.2.4).

4.3.1 ALTERNATE TRAIL SURFACES: METHOD 1 - WOOD CHIP SURFACING

APPLICATIONS:

- trails where traffic is sufficiently heavy to cause soil compaction and denudation problems and where a relatively 'natural' or low key image is desired.

INSTRUCTIONS:

1. Grade trail to ensure positive drainage.

2. In any areas where the trail obstructs drainage and where ponding occurs upslope, cut the trail grade down sufficiently to allow drainage of upslope areas. The depth of the cut should be sufficient to permit the placement of brush paving (60-75 mm) (see 4.2.10). If necessary, cover brush with earth to bring grade back flush to adjacent grades on the trail. Brush paving should extend at least the full width of the trail. Corduroy may be useful in some areas (see 4.3.2).

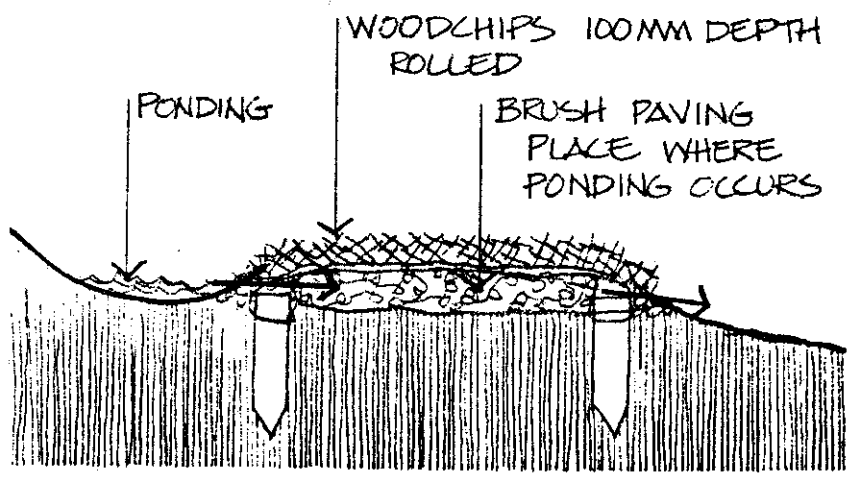
3. Scarify or otherwise loosen soil along the trail to a depth of 75-100 mm.

4. Place wood chips across the full width of the trail to a depth of 75-100 mm. (NOTE: do not use elm wood chips)

5. If water is available, water the trail to help the wood chips settle.

6. Whether or not water is available, roll the wood chip surface, using a standard lawn roller, to help the wood chips to settle and form a more consolidated walking surface.

7. On slopes where the wood chips may tend to 'slide' downslope, log cribs may be required to terrace the slope (see 4.2.4).



4.3.2 ALTERNATE TRAIL SURFACES: METHOD 2 - CORDUROY

APPLICATIONS:

- persistently wet areas and seepage zones along trails.

INSTRUCTIONS:

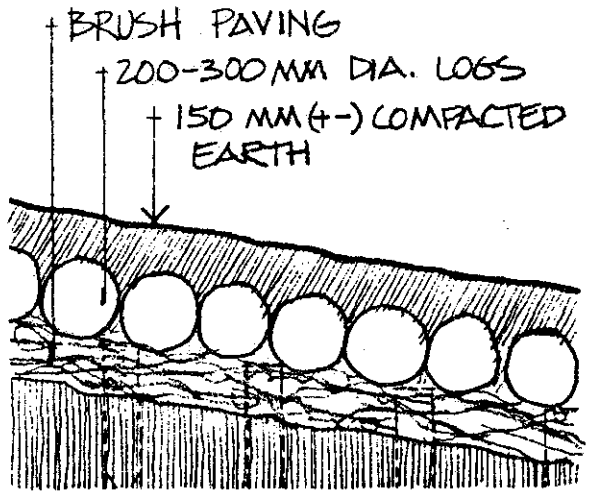
1. To prevent ponding or obstructed drainage upslope from the trail, cut the trail grade down sufficiently to allow proper drainage. In any case, grade should be lowered 300-400 mm below finished trail grade to permit installation of corduroy trail.

2. Install brush paving across the portion of the trail to be restored (see 4.2.10). Brush paving should extend at least 300 mm beyond each side of the trail.

3. Lay logs (200-300 mm diameter) across the trail on top of the brush paving. Logs should be long enough to extend at least 300 mm beyond each side of the trail. Actual diameter of the logs will depend on availability and site conditions; relative uniformity of log size is important. Logs should be placed tightly together.

4. Cover logs with 75 mm ± of earth, lightly compacted, if wood chip surface is to be used. If wood chip surfacing is not to be employed, depth of earth should be 150 mm ± and it should be compacted.

5. If wood chips are used for final surface, finish as per 4.3.1.



4.3.3 ALTERNATE TRAIL SURFACES: METHOD 3 - FLEXIBLE DUTCH SAND LADDER

APPLICATIONS:

- trails running up and down slopes in sandy areas to prevent the 'conveyor belt' effect of people pushing sand downslope when walking; also makes walking much easier.

INSTRUCTIONS:

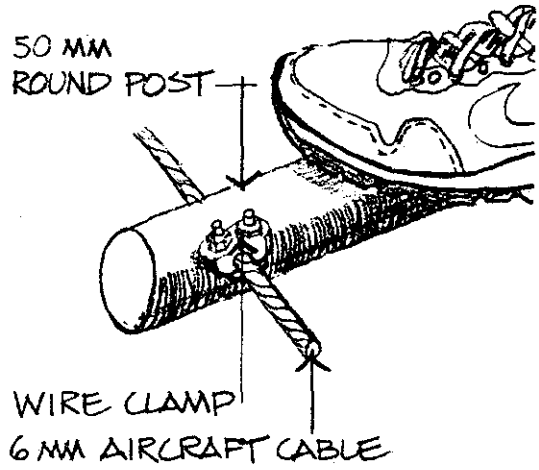
1. Lay out preferred 'trail' alignment.

2. Sand ladder is to be built in 8 m lengths. Locate and partially drive or set 2 posts (100 x 100 mm, 1 m long) at 8 m intervals on the slope. Posts should be 1.2 m apart, equidistant from the centre line of the 'trail'.

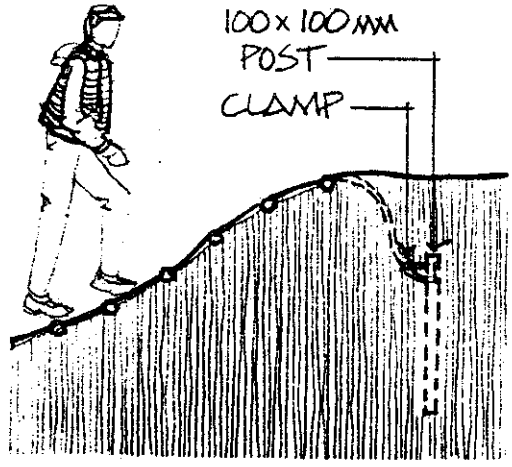
3. For each length of the ladder, cut 20 lengths (1.2 m) of 50 mm round posts. Drill 10 mm holes 100 mm from each end of the round posts.

4. Cut two lengths (10 m) of 6 mm galvanized steel cable. Securely attach the cables to the partially set posts. String the round posts to the cables and secure them (using wire clamps) at 400 mm intervals to form the rungs of the sand ladder.

5. Drive or set the anchoring posts to their full depth (so they are fully buried).






100 x 100 MM
POST
CLAMP

4.4 SEWER OUTFALL PROBLEM CONTROL

INTRODUCTION

In many instances, the site degradation problems caused by sewer outfalls and culverts may (and in some cases must) be remedied through wholesale reconstruction of the entire outfall structure, sometimes including adjusting the height of the outfall. In a few instances, erosion problems have also been caused by leakage of the storm sewer upstream of the outfall or some type of failure in the backfill of the sewer pipe. Rectification of such problems will require significant municipal engineering input and is best undertaken by others qualified to do so. This type of site restoration is therefore not incorporated into the manual.

However, where outfall or culvert reconstruction is not necessary, and where flows from the outfall are relatively low, site degradation problems can still occur; this Section of the manual describes techniques that may be suitable to rectify three of the more common problems - scouring, gully erosion and headward erosion.

4.4.1 TREATING SCOURING PROBLEMS AT SEWER OUTFALLS/CULVERTS

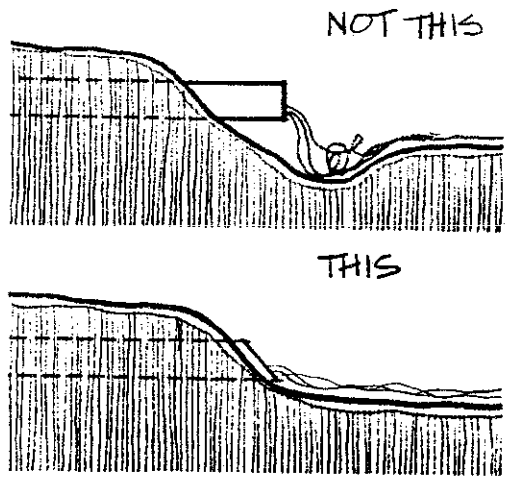
APPLICATIONS:

- outfalls (or culverts) where the pipe is cantilevered out beyond the slope.

INSTRUCTIONS:

1. Cut the pipe at the same angle as the slope from which it projects, nearly flush with the slope.

2. Install appropriate apron immediately below the end of the pipe, to protect from scouring action of the water (see 4.2.5b, 4.2.6 or 4.2.13, or for very small outfalls/culverts see 4.2.10).





4.4.2 TREATING GULLY EROSION AT SEWER OUTFALLS

APPLICATIONS:

- outfalls/culverts where gully erosion is occurring downstream, and where the pipe cannot be extended to the edge of the receiving water course or water body.

INSTRUCTIONS:

- see 4.2.5, 4.2.6, 4.2.7, 4.2.8, 4.2.9, 4.2.10

- see 4.2.11 or 4.2.12

- see 4.2.13

NOTE: Whatever gully restoration technique is utilized, ensure that protective measures extend at least to the low water level of the receiving water course or water body.

4.4.3 TREATING HEADWARD EROSION PROBLEMS AT SEWER OUTFALLS

APPLICATIONS:

- outfalls which are set too high and because of their height, scouring and gullying have resulted in failure of the slope from which the pipe projects, and where the outfall cannot be lowered.

INSTRUCTIONS:

1. Clean all fallen vegetation out of the area affected.

2. Backfill failed area with clean fill (ideally a competent clay till) in 150 mm lifts; compact each lift; backfill to match adjacent grades on the slope and to establish desired grades on restored slope.

3. Provide surface slope protection as outlined in 4.2.1, 4.2.2 and/or 4.2.5.

4.5 RODENT CONTROL

INTRODUCTION

This section includes techniques designed to control populations of common rodent pests in the Meewasin Valley and techniques intended to reduce the damage done by these pests. For some pests, population control appears to be the only feasible means of reducing damage; for other species (e.g. beaver) a co-ordinated program of population management techniques and direct damage control techniques will probably be desirable.

4.5.1 BEAVER CONTROL: METHOD 1 - REPELLENTS

APPLICATIONS:

- protection of trees, in relatively 'natural' situations, from beaver damage.

INSTRUCTIONS:

1. Prepare a mixture of lard, crushed hot pepper and moth crystals (naphthalene or paradichlorobenzene). Proportions of each in the mixture should be determined through experimentation. Tobasco sauce may be substituted for the crushed hot pepper.

2. Apply the mixture (with a paint brush) to the trunks of trees to be protected. The repellent should be applied from a height of at least 100 mm above ground to a height of 1 metre or so.

3. The repellent should be applied early in the spring and should last for the entire growing season. However, periodic checks should be made during the summer and if the repellent is losing its effectiveness, it may be necessary to re-apply it.

NOTE: This repellent mixture has been used relatively successfully on poplar species. Before carrying out widespread applications to other species, test the repellent to ensure that it does not negatively affect their health or vigour.

Also, moth crystals are toxic to humans if ingested. Decisions to use this repellent in areas subject to heavy human activity (especially unattended children) should take this factor into account.

4.5.2 BEAVER CONTROL: METHOD 2 - PHYSICAL PROTECTION OF VEGETATION

APPLICATIONS:

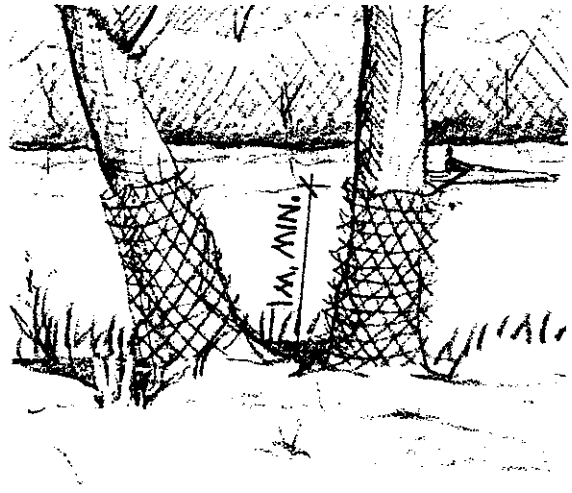
- protection of individual tree specimens from beaver damage.

INSTRUCTIONS:

1. Identify the individual specimens at risk in the area inhabited by beaver and those considered of sufficient value to protect.

2. Secure chicken wire mesh around the bottom metre or so of the tree trunk.

NOTE: If the chicken wire is secured up against the tree trunk, it will, from time to time, have to be loosened and re-secured to allow for growth of the trunk.



4.5.3 BEAVER CONTROL: METHOD 3 - TRAPPING

APPLICATIONS:

- controlling beaver populations during the winter season.

INSTRUCTIONS:

NOTE: Beaver trapping should be undertaken only by, or under the direction of, someone experienced in same. Ensure that all required licenses, permits and approvals have been obtained before beginning trapping program.

1. Required equipment includes ice chisel, scoop shovel, axe, hay wire, Swede saw and large Conibear trap (No. 330).

2. Locate the underwater entrances or runs leading into the lodge or den. The presence of strings of bubbles and freshly-peeled sticks in the ice is a good indicator of the location of a live run.

3. With the ice chisel, cut a hole, about 1 metre long and 0.5 m wide, directly above the run, and as near to the lodge or den as possible.

4. After clearing the broken ice out of the hole with the shovel, cut a bow-shaped stem about 1.5 - 2 m long. Using the stem as a probe, determine the exact location of the run. There may be sticks and twigs at the entrance of the run. These must all be cleared away, or cut off (using the chisel or Swede saw), before the trap may be set.

5. Cut two stakes just thick enough to fit snugly into the coiled springs on each side of the Conibear trap. Leave the stub of a branch on each of these stakes so that the trap may slip down to them, but no further.

6. Test the water bottom to determine whether it is hard sand or soft mud. If it is a hard bottom, only a few centimetres of stake will be needed below the branch stub; if it is a soft bottom, more length will be required.

7. Insert the two stakes into the coiled ends of the springs on the Conibear trap. Fasten a piece of wire to the ring of the trap chain and wrap the wire around the same stake that is inserted through the coil at the end of the trap.

8. Release the safety hooks; the trap is now in a 'set' position.

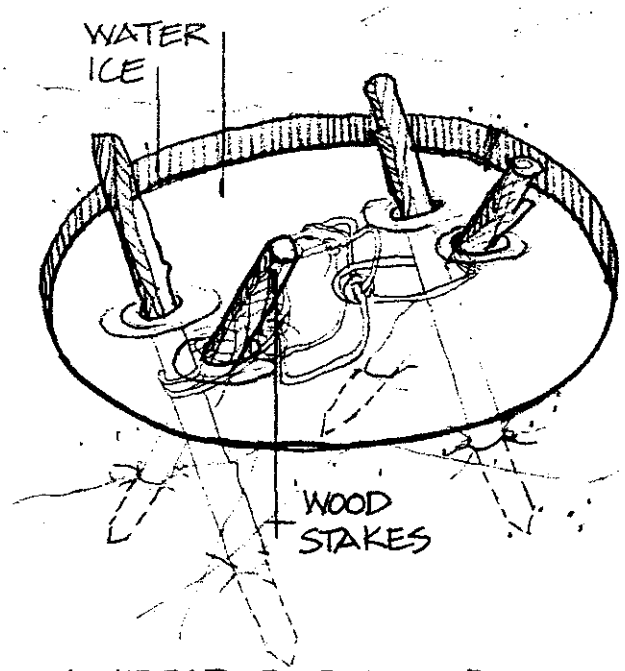
9. Lower the trap directly in front of the run and push the stakes into the mud bottom firmly enough so that they will support the trap in an upright position. The lower jaws of the trap should almost touch the mud bottom.

10. Cut more stakes and place at least two in an upright position on each side of the trap. These must be placed inside the doubled-up springs and not alongside the springs (see sketch below).

11. Stick in enough stakes on either side of the run so that the only place the beaver may enter the run is through the opening of the trap.

12. When all stakes are in place, loosen the wire from the stake and fasten it to a stick or pole on the den.

13. For best results, a trap should be set at each entrance.



CONIBEAR TRAP SET AT ENTRANCE OF BEAVER LODGE (after ST.R.R. no date)

4.5.4 BEAVER CONTROL: METHOD 4 - LIVE TRAPPING/RELOCATION

APPLICATIONS:

- control of beaver populations where other control measures are undesirable or inappropriate.

INSTRUCTIONS:

1. Swing cross bar at right angles to base bar. Tighten the nut which has been loosened to allow folding (see (1) below).

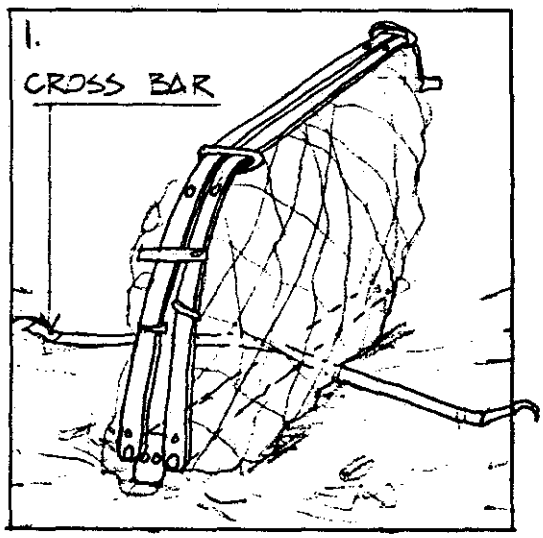
2. Draw one jaw down to the cross bar and place the short safety hook over the edge. Do the same with the other jaw (see (2) below).

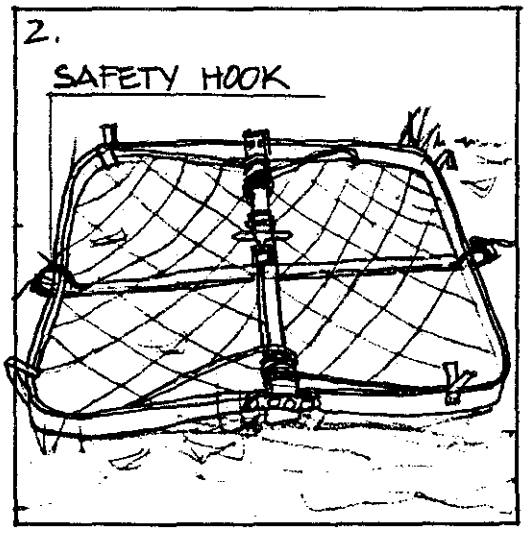
3. Compress trigger spring in the centre of the trap and place the trigger over it, as close to the end of the spring as possible (see (3) below).

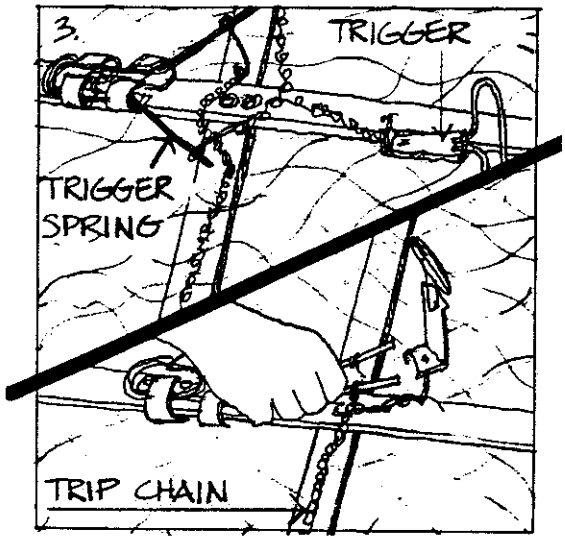
4. Pull all slack from the trip chains and pull the two sliding hinges toward the ends of the cross bar.

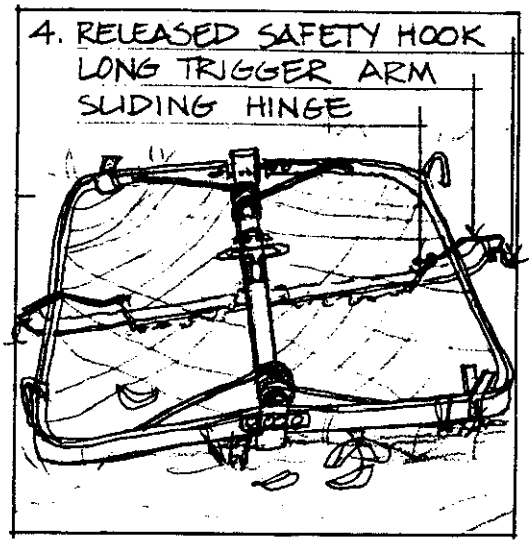
5. Bring the longer trigger arm over the edge of each jaw and pass the sliding hinge over the end of it (see (4) below). Adjust the mesh around the sliding hinge so it does not press too hard against it one way or the other. Be sure there are no mesh strands over the ends of the trigger arms.

NOTE: Do not release the safety hooks until the trap is fully set in its final position and baited.









6. To set the trap, select small channels where beaver come to shore for feeding or dryland runs. If setting in the water, the water should be 250-300 mm deep (deep enough to cover every part of the trap, but shallow enough to prevent the trapped beaver from drowning).

7. The trap should be set with the cross bar at right angles to the run with the trigger directly in line with the probable approach. If there is a chance that the beaver will not pass over the centre of the trap, place heavy sticks or small logs out from the trap at an angle, leaving an opening of 350-400 mm in the centre through which the beaver must walk or swim.

8. If the beaver may be trap-shy, splash water over everything you handle and where you walk. Do not disturb the surroundings more than necessary.

9. Before leaving the set, make sure that none of the mesh strands are over the ends of the trigger arms at the hinges. Place green aspen, poplar or other choice beaver foods behind the trap as bait.

10. Carefully release the safety hooks and be sure they hang straight down, out of the way.

11. Check the sets every morning, as exposure may cause death if the trapped beaver is left too long.

12. To remove the beaver from the trap, simply unhook the inside arm of the large springs and allow them to rest against the opposite side, thus freeing the tension from the jaws. Tip the trap down toward the corner in which the beaver is facing. Open the safety catches and reach in, taking hold of the tail, at which time the trap may be allowed to fall open. Lift the beaver out and place in a carrier.

13. The trap can be reset immediately, if desired, after replacing the spring arms.

NOTES: a) In testing the trap, do not push the trigger off with your hands. Use a stick or throw something onto the trigger.

b) To prevent recurrence of problems from trapped beavers, they should be relocated to another watershed, preferably at least 40 km away. Ensure that permission has been received to release beaver at intended locations. Alternatively, if no acceptable release area can be found, the trapped animal can be shot (using a .22 caliber pistol) behind the ear. This method is humane and results in minimal pelt damage.

4.5.5 GROUND SQUIRREL CONTROL: METHOD 1 - TOXIC GRAIN BAIT

APPLICATIONS:

- control of Richardson's Ground Squirrel populations.

INSTRUCTIONS:

1. Be sure the entire ground squirrel population is active. Do not bait at the first sign of activity in the spring or when the squirrels start to disappear into their burrows late in the summer. Baiting is also ineffective late in the gestation period or shortly after the young are born (usually 4-8 weeks after emergence from hibernation). The activity level of the femals can be checked by shooting or trapping about 10 squirrels (see 4.5.6) and checking the ratio of males to females. If the ratio is about 1:1, the females are probably active and baiting should be effective.

2. Be sure that the ground squirrels are readily accepting the bait. Use untreated bait around several burrows. If the untreated bait is not taken, treated bait would also not be eaten.

3. Prebait the burrows with untreated bait; by accustoming the squirrels to this new food, the chances of them eating a lethal dose of toxic bait will be improved and control will then be increased.

4. Purchase or prepare toxic bait. Fresh toxic bait should always be used. Potency does not decrease with age, but palatability does. If preparing the bait, apply zinc phosphide (at 2.0% active ingredient by weight) to steam-rolled whole oats. Mix with lecithin and white mineral oil (at 0.5% each), which act as adhesives. Also mix in monastrol green-B (at 0.2%) as a bird repellent.

5. Two to four days after pre-baiting, set out the toxic bait. Scatter 5 g ± of the treated oats adjacent to each active burrow. Do not place in the burrow, as squirrels are highly suspicious of food there.

6. Bait any site only once a year.

NOTE: Because of the way in which zinc phosphide affects animals, primary poisoning of many non-target animals is not usually a problem. However, a potential for secondary poisoning does exist, depending on the quantity of zinc phosphide residue in the primary animal, food habits of the secondary species and the susceptibility of the secondary species to zinc phosphide.

4.5.6 GROUND SQUIRREL CONTROL: METHOD 2 - JAW TRAPS

APPLICATIONS:

- control of small ground squirrel populations where other control methods are unsatisfactory or undesirable.

INSTRUCTIONS:

1. Place jaw traps (No. 1 and No. 0) where squirrels will travel over them entering and leaving the burrows.

2. Conceal the trap by placing it in a shallow excavation and covering it with 3-6 mm of soil. Ensure that there is no soil or small pebbles beneath the trap pan to impede its action. No bait is necessary.

3. Check the traps regularly to remove dead animals and re-set the traps.

4.5.7 GROUND SQUIRREL CONTROL: METHOD 3 - BOX TRAPS

APPLICATIONS:

- control of small ground squirrel populations where other control methods are unsatisfactory or undesirable.

INSTRUCTIONS:

1. Set the box trap in any areas frequented by ground squirrels.

2. Place the trap solidly on the ground so it will not tip or rock when the squirrel enters.

3. Cover the floor of the trap with dirt and bait it with fresh fruit, vegetables, greens, peanut butter or grain. It may be necessary to experiment with baits to find the best one or combination.

4. Wire the top door open and replenish the bait daily to help overcome trap shyness.

5. Once the traps are in operation, check them at least daily to remove and relocate trapped animals, to replenish bait and to re-set the traps.

4.5.8 GROUND SQUIRREL CONTROL: METHOD 4 - FUMIGATION

APPLICATIONS:

- relatively small areas of light ground squirrel infestation.

INSTRUCTIONS:

1. Ensure that all burrow entrances are tightly sealed with tamped earth.

2. Inject fumigant into the burrow system as per manufacturer's instructions. Fumigants suitable for ground squirrel control include aluminum phosphide (Phostoxin, Rotoz, Fumitoxin), carbon disulfide and magnesium phosphide (Magtoxin).

NOTE: Gas fumigants work most effectively when soil moisture is sufficiently high to prevent gas seepage into the earth.

4.5.9 POCKET GOPHER CONTROL: METHOD 1 - POISON BAITS

APPLICATIONS:

- control of pocket gopher populations.

INSTRUCTIONS:

1. Locate the main burrow (usually 300-450 mm away from the 'plug' on the fan-shaped surface soil mounds). The main burrow can be located either by digging with a shovel or trowel or by using a hand probe as manufactured by Elston Co. Inc., Minneapolis, Minnesota (Gopher Getter Junior). If using a hand probe, you will know you have located a burrow by the decreased frictional resistance to the probe.

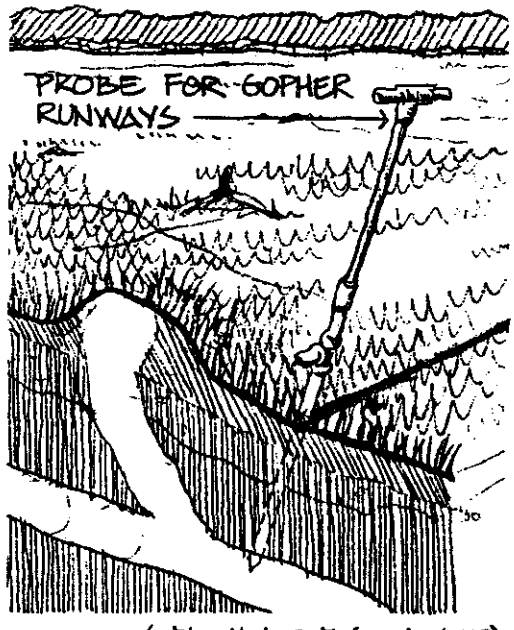
2. Place the bait in the burrow (either with a long-handled spoon or with a hand probe dispenser). About 15 ml of poisoned grain is sufficient. Suitable poisons include strychnine, zinc phosphide and chlorophacinone (Rozol). NOTE: Strychnine may only be handled by a trained pest control officer.

3. If a hole is dug to place the bait in the burrow, cover the hole well with sod and dirt. Probe holes should also be covered.

4. Each burrow system should be baited in 2 or 3 places for best control, but it is not necessary to bait around every mound.

5. Spring and fall are the best times for effective control of pocket gophers with poison baits.

6. Since some poisoned gophers may die above ground, baited areas should be checked periodically for 10-14 days after treatment. Dead gophers should be buried or incinerated. In heavy use or urban areas, checks must be made daily.



(after Nat. Def. Canada (1983))

4.5.10 POCKET GOPHER CONTROL: METHOD 2 - TRAPPING

APPLICATIONS:

- control of pocket gopher populations in small areas or to remove remaining animals after a poison control program.

INSTRUCTIONS:

1. For trapping in main tunnels, locate the tunnel as set out in 4.5.9 (step 1). To locate lateral tunnels, find a fresh mound and with a trowel or shovel, dig several centimetres away from the mound on the plug side. On fresh mounds, the lateral tunnel may be plugged with soil for a few centimetres.

2. There may be a need to experiment with trap type and placement. Suitable traps include the Macabee Gopher Trap (or Victor M0610), Guardian Gopher Trap (or California Gopher Trap M0262) and the Victor Gopher Getter M00602. Some trappers have more success when they leave tunnels, in which the traps are set, completely open. Others close off the tunnel completely when placing traps in the main and close most of the tunnel with sod when trapping the lateral.

3. Traps should be marked above ground with surveyor's flagging tape and should be anchored with a stake and wire or chain so a predator does not carry off the catch and the trap.

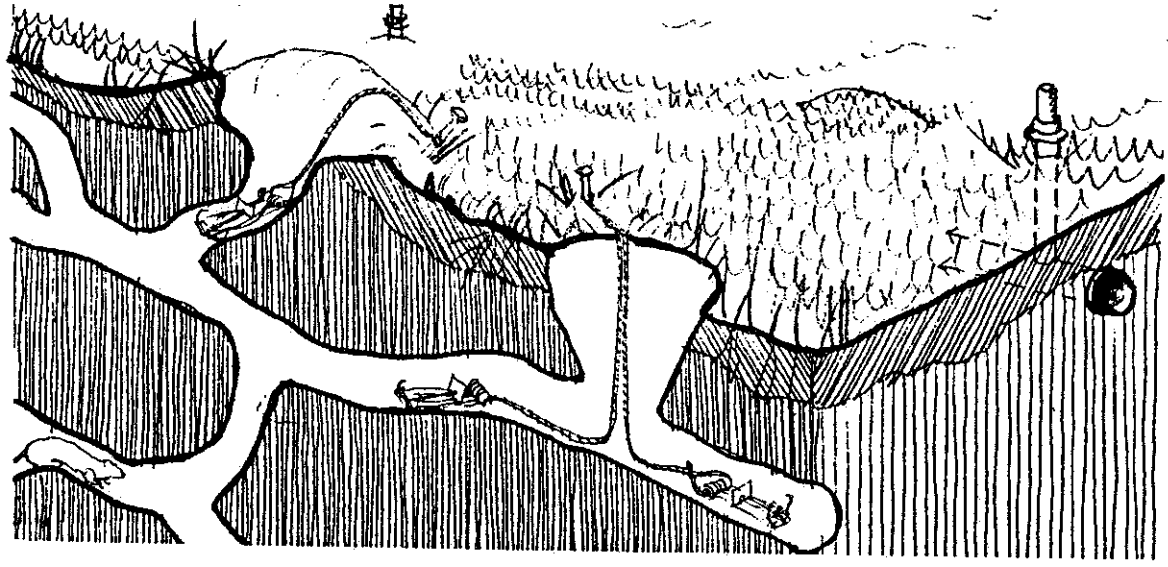
4. Trapping can be carried out at any time during the year, but is generally most effective when gophers are pushing up new mounds in the spring and fall.

5. If a trap has not been tripped within 48 hours, it should be moved to a new location.

6. In spring and early summer, when gophers often share burrows, leave traps in a tunnel system even if a gopher has already been trapped.

7. Traps should be checked at least twice daily.

-MACABEE TRAP SETS FOR POCKET GOPHERS (after Nat. Def. Canada, 1983) -



4.5.11 POCKET GOPHER CONTROL: METHOD 3 - FUMIGATION

APPLICATIONS:

- control of pocket gopher populations in relatively small areas of light infestation.

INSTRUCTIONS:

1. This technique should only be used when soil moisture levels are high to minimize diffusion of the gas into the soil.

2. Ensure that all burrow entrances are tightly sealed with tamped earth.

3. Inject fumigant into the burrow system as per manufacturer's instructions. Fumigants suitable for pocket gopher control include sulphur oxide (Giant Destroyer, Dexol) and carbon monoxide. Car exhaust is a practical source of carbon monoside, especially from vehicles built prior to 1972.

4.5.12 PORCUPINE CONTROL: METHOD 1 - LIVE TRAPPING/RELOCATION

APPLICATIONS:

- porcupine population control in urban areas.

INSTRUCTIONS:

1. Place a large cage or box trap in the vicinity of porcupine damage. If the location of the porcupine den is known, a trap at that location will also be effective.

2. Bait the trap with a salt-soaked cloth, sponge or piece of wood.

3. Check the trap regularly.

4. If re-locating a trapped porcupine, be sure to take it at least 40 km away.

4.5.13 PORCUPINE CONTROL: METHOD 2 - SHOOTING

APPLICATIONS:

- porcupine population control in rural areas where damage is severe and live trapping/relocation is not feasible.

INSTRUCTIONS:

1. Porcupines are active in winter and thus easy to track. Further they will often congregate around good denning sites, and large numbers may be taken by shooting with minimal expenditure of cost and effort.

2. Do not use high-powered rifles. Ideally, small shotguns should be used (e.g. .410 calibre or 20 gauge) as they are effective and relatively safe.

3. Bury, burn or otherwise dispose of porcupine carcasses.

4.6 WEED CONTROL

4.6.1 MOWING GRASSLANDS FOR WEED CONTROL

APPLICATIONS:

- open grassland areas (either recently-established or fully established).

INSTRUCTIONS:

1. In recently-established areas, when weeds have grown to the point where they are shading more than 50% of the ground surface, mow the area to a height just above that of the desirable grasses and forbs.

2. Mowing can be undertaken either early or later in the growing season. Early, it can control the development of weeds. Late, it can be used to control undesirable tree and shrub seedlings. Although fall mowing will not compact the soil as much, it does destroy wildlife food and cover, and can reduce snow trap effects.

3. If prescribed burning is not a part of the grassland management program, thatch from the mowing operation should be removed as it can be detrimental to some desirable species.

4.6.2 PRESCRIBED BURNING OF GRASSLANDS FOR WEED CONTROL

APPLICATIONS:

- open grassland areas where prescribed burning is permitted and where burns may be easily controlled.

INSTRUCTIONS:

1. The day selected for a prescribed burn should be relatively calm, but not perfectly still. A light, steady breeze of 2-5 km/h is ideal, as it will produce a sustained fire in one direction. Turbulent winds must be avoided, as they produce erratic, unpredictable fires that are difficult to control. Turbulence is at a minimum at night and early in the morning.

2. Notify neighbours, the fire department and any other parties who may be affected by, or involved in, the prescribed burn. Obtain any required permits.

3. Create a firebreak and assemble fire control equipment, including pump and hose, backpack sprayers, fire slappers and rakes. Suitable firebreaks include paved or gravel surfaces and mown areas. Clear the firebreak of litter and thoroughly soak it. Remember, the firebreak should surround the prescribed burn area, and the greatest care should be taken in the portion of the firebreak on the downwind side of the burn.

4. The burn should be limited to small areas at a time, to ensure control.

5. Burn alternate areas in alternate years, always leaving unburned areas as refuges for wildlife.

6. Ensure that all evidence of fire is out before leaving the site.

NOTE: In recently established grasslands, fire should not be used for weed control until after the end of the second growing season.

: Early spring (late March - mid April) is the most effective time for a prescribed burn to control weeds and stimulate growth of desired species.

4.6.3 CHEMICAL WEED CONTROL

APPLICATIONS:

- control of annual, biennial or perennial weeds in grass areas
- control of weeds around newly-established trees and shrubs where cultivation is not feasible.

INSTRUCTIONS:

NOTE: Herbicides vary widely in their selectivity and recommended methods and rates of application. They are also potentially poisonous to desirable plant species, animals, soil bacteria and humans. Extreme caution must be exercised when using herbicides for weed control.

1. Always apply herbicides according to manufacturer's instructions and observe all precautions noted by the manufacturer.

2. Do not overdose; overdoses are costly and may damage desirable plants.

3. Use appropriate application equipment, to ensure proper spray pressures and coarseness of spray.

4. For best results, apply herbicidal sprays only when:

   a. Temperature is between 20° and 30° C.
   b. Little or no wind is blowing.
   c. No rain is expected for several hours.

4.7 CONTROLLING VEGETATION DISEASES, INSECTS AND ENVIRONMENTAL PROBLEMS

INTRODUCTION

Techniques in this section are intended for control of some of the more common diseases, insects and environmental problems that affect vegetation in the Meewasin Valley. Techniques include chemical and biological control methods (to control the causative agents) as well as measures intended to increase the level of tolerance or resistance to the agents causing the problems.

4.7.1 CANKER DISEASE CONTROL

APPLICATIONS:

- trees infected with canker diseases

INSTRUCTIONS:

1. If cankers are found on branches only, prune away infected branches (see 4.8.1); remove and burn all pruned wood.

2. If trunk shows evidence of infection, fell the tree (see 4.8.2); remove and burn.

3. Take care to avoid injury to nearby healthy trees.

4.7.2 DWARF MISTLETOE

APPLICATIONS:

- trees and shrubs infected with dwarf mistletoe (witches broom)

INSTRUCTIONS:

1. Prune back all infected branches to sound wood (see 4.8.1); remove and burn all pruned material.

2. In severe cases, felling of the infected tree may be necessary (see 4.8.2); remove and burn the felled tree.

4.7.3 FIRE BLIGHT CONTROL

APPLICATIONS:

- treatment of trees and shrubs infected with fire blight.

INSTRUCTIONS:

1. As there is no chemical that can cure fire blight, pruning of diseased twigs and branches is the only effective method of control. During the dormant season (late fall to early spring), prune out and burn all diseased branches.

2. Follow the recommendations for pruning practices in 4.8. Ensure that all cuts are at least 250-450 mm below diseased areas, as bacteria may extend beyond the blighted portion.

   NOTE: In order to prevent the infection of healthy tissue, pruning tools should be dipped, after each cut, into a disinfectant (e.g. Lysol) diluted in water at a rate of 1:20 or household bleach diluted in water at a rate of 1:10.

3. During the growing season, prune and burn any infected twigs or branches, again cutting 250-450 mm below the infected area. Make regular inspections during the summer to detect and remove new infections, but avoid excessive pruning.

4. Trees or shrubs that are severely infected, with large cankers in the trunk or main stems, should be removed and burned immediately.

5. Remove root suckers and succulent sprouts on the body of the tree or shrub as these are very susceptible to fire blight.

6. Avoid using high nitrogen fertilizer which will promote susceptible growth.

4.7.4 POWDERY MILDEW CONTROL

APPLICATIONS:

- valuable larger deciduous trees and shrubs infected with powdery mildew.

INSTRUCTIONS:

1. Spray 'Karathane' (also known as dinocap), as per manufacturer's instructions. Note that certain precautions listed on the package must be followed.

4.7.5 BLACK KNOT CONTROL

APPLICATIONS:

- trees and shrubs infected with black knot

INSTRUCTIONS:

1. Prune away all infected branches (see 4.8.1); remove and burn all pruned material.

2. Spray plant with dormant strength lime sulphur (1 part lime sulphur to 8-10 parts water) just as the buds break in spring.

3. Spray summer strength lime sulphur (1:50) at full bloom and shuck fall stages.

   NOTE: Do not spray lime sulphur near buildings, walls or trellises as it will stain them. Do not spray when air temperature is above 30°C.

4.7.6 APHID CONTROL

APPLICATIONS:

- trees and shrubs infested with aphids (plant lice)

INSTRUCTIONS:

1. If natural controls of aphid populations have been unable to keep them within acceptable numbers, chemical control may be necessary.

2. For spruce trees, spray the tips of twigs and bases of buds with malathion or carbaryl ('Sevin') in spring before new growth emerges. Follow manufacturer's instructions and precautions carefully. Note: malathion should not be applied when the temperature is below 20°C.

3. For other species, dimethoate, diazinon or malathion 50% emulsifiable concentrates may be applied to the drip stage when diluted with water at a rate of 1:150 ±. Dutox is also recommended at a dilution rate of 1:75 ±. Spray should be applied in the spring after bud break or when the infestation is first noticed. A second application may be necessary 2 or 3 weeks later if aphids are still present.

4. Aphids may also be controlled by sprays containing nicotine, soap, rotenone, pyrethrum, benzene hexachloride, or Summer oils. Again, spraying should occur in spring when the young aphids are just crawling out in the open.

4.7.7 GALL INSECT CONTROL

APPLICATIONS:

- trees and shrubs infested with midges, mites, aphids or wasps which cause gall formation on the host plants.

INSTRUCTIONS:

1. In early stages of infestation, pruning and burning of galled twigs or stems may provide control (see 4.8).

2. Spraying insecticides as outlined in 4.7.6 is an effective means of control.

4.7.8 FOREST TENT CATERPILLAR CONTROL

APPLICATIONS:

- deciduous trees and shrubs being defoliated by forest tent caterpillars.

INSTRUCTIONS:

1. On shrubs and small trees (up to 3 m height), non-chemical control can be effective. In late fall or early spring when vegetation is bare, branches containing the grayish egg bands (5-15 mm long and usually covered with a brownish foam) can be pruned off (see 4.8). Egg bands located on the main stem or other branches which should not be pruned can be easily scraped off, with a dull knife. Or, once the eggs have hatched, the larvae can be picked off and destroyed when they cluster together in the evening or on cool days.

2. The recommended spraying control method is also non-chemical, and utilizes Bacillus thuringiensis, diluted with water at a rate of 1:500. One application as a foliar spray in early June while the larvae are still feeding actively in groups will provide adequate protection. Hand-operated low-pressure sprayers are suitable for spraying shrubs and small trees; for large individual trees or large stands of trees, high pressure spray equipment is necessary.

3. Chemical sprays that are effective in controlling forest tent caterpillars include malathion 50% emulsifiable concentrate diluted in water at a rate of 1:500, methoxyclor 25% emulsifiable concentrate (1:250) and carbaryl wettable powder (16 g: 5 l). Application times and equipment for these sprays are as for Bacillus thuringiensis. Malathion should not be applied when the air temperature is below 20°C.

4.7.9 CANKERWORM CONTROL

APPLICATIONS:

- deciduous trees and shrubs infested with the fall cankerworm

INSTRUCTIONS:

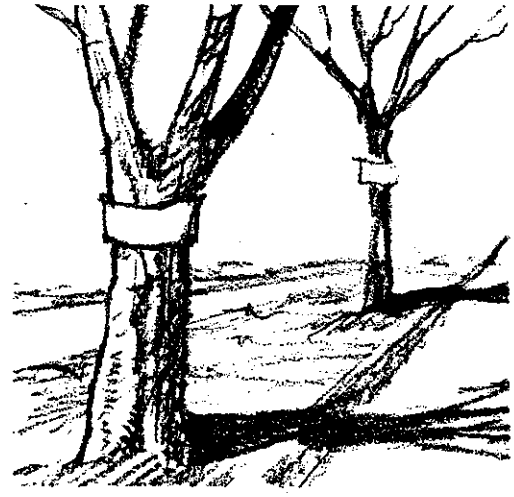
1. Tree banding with a sticky substance will prevent adult females from climbing up the host plant to lay their eggs. In mid-September a 100 mm wide band of fibreglass insulation with paper backing or similar material should be secured around the tree trunk about 1.5 m above ground, paper side out. On older trees, loose bark should be carefully removed to facilitate proper installation.

2. Smear a thin layer of sticky adhesive (e.g. 'Tree Tanglefoot') over the paper.

3. Clean the sticky surface of accumulated debris at regular 2-3 day intervals until mid-November.

NOTE: Banding is most effective if trees are sufficiently isolated so that they will not become infested with wind-dispersed larvae.





4. Spraying of Bacillus thuringiensis and chemical insecticides as outlined in 4.7.8 is also an effective method of control, except that dilution rates are different for carbaryl wettable powder (18 g:5 l)and methoxyclor (1:1000).

5. Dusts and pressurized sprays of carbaryl mixed with malathion, rotenone or pyrethrins are also suitable for small-scale treatment.

4.7.10 BRONZE BIRCH BORER CONTROL

APPLICATIONS:

- birch trees infested by the bronze birch borer

INSTRUCTIONS:

1. Spray the trunk and branches thoroughly and the leaves lightly in early June and twice more at 2-week intervals with methoxychlor as directed by the manufacturer.

2. Prune away dead branches (see 4.8.1); remove and burn.

3. Keep trees healthy by feeding and watering as required.

4. Severely infested trees should be felled (see 4.8.2) and removed.

4.7.11 BIRCH LEAF MINER CONTROL

APPLICATIONS:

- ornamental or native birch trees infested with birch leaf miner.

INSTRUCTIONS:

1. Because the insects feed inside the leaves, systemic insecticides are required for control. The first application should occur as soon as damage is noticed, unless the tree was infested the year before (in which case the application should occur as soon as the leaves are open).

2. The three recommended treatments (in order of effectiveness) are as follows:

   a. Soil Drench

   - the most effective method of control, with the added advantage of eliminating spray drift and contamination of nearby areas.
   - in May, after the leaves are fully open, apply undiluted dimethoate ('Cygon 2E') 23.4% emulsifiable concentrate at the rate of 50 ml for each 25 mm of tree trunk diameter (measured at 1.2 m above ground).
   - dig four small, shallow holes around the base of the tree inside the drip line.
   - apply the chemical in roughly equal parts into the holes.
   - fill the holes with soil, and water until saturated to ensure uptake of the insecticide.
   - one soil treatment should give control for the full season; do not make more than one treatment per year or apply more insecticide than required.
   - soil drenches on newly transplanted birches may not be effective or may cause injury.

   b. Banding

   - paint, with an applicator or brush, a band of undiluted dimethoate ('Cygon 2E') around the trunk below the lowest branch when the leaves are fully open.
   - the band should be 25 mm in width for every 25 mm of tree diameter (measured 1.2 m above ground).
   - do not use this treatment on trees less than 25 mm or more than 150 mm in diameter.
   - repeat the application in early July, but avoid painting the insecticide on the same spot.

   c. Foliage Spray

   - when leaves are open in May, spray with carbaryl 50% wettable powder (18 g: 5 l) or dimethoate (1:500) or malathion or diazinon 50% emulsifiable concentrate (1:500).
   - a second application should be made in mid-July.

4.7.12 ROAD SALT DAMAGE CONTROL

INTRODUCTION:

Road salt damage is usually most severe within 1 m ± of roadways, beneath bridges and at snow dump sites. The techniques for correcting this damage could be applicable, to varying degrees, in any of these situations.

APPLICATIONS:

- sites where road salt has caused decreased vigour or death of vegetation.

a. USE OF LEAST TOXIC DE-ICING COMPOUNDS

INSTRUCTIONS:

1. Where possible, use substances such as urea pellets (40-0-0 fertilizer) for de-icing.

2. Where road salt is the only feasible de-icing compound, minimize the sodium chloride content and maximize the calcium chloride content, as calcium chloride is significantly less toxic to some vegetation.

b. NON-VEGETATED SURFACES

INSTRUCTIONS:

1. In severe problem areas, non-vegetated surfaces may be the only alternative. Such surfaces as concrete, asphalt, unit paving and gravel or rock mulch are possible alternatives.

c. USE OF SALT-TOLERANT SPECIES

INSTRUCTIONS:

1. Install trees, shrubs and ground covers that exhibit relatively high tolerances to road salt (see 4.11).

   Tolerant grasses include: slender wheatgrass
   crested wheatgrass
   tall wheatgrass
   altai wild ryegrass
   Russian wild ryegrass

Tolerant woody plants include: sea buckthorn
oak
elm
birch
aspen
colorado spruce
white spruce

d. REDUCING SALT CONTENT IN SOILS

INSTRUCTIONS:

1. Ensure that affected sites have very good internal drainage. Installation of drainage tiles might be considered for some sites.

2. As early as possible in spring, sweep the sand/salt residues off the site.

3. Once the frost is fully thawed in the ground, heavily irrigate the site to leach the salts out of the soil.

4.7.13 TREATING WINTER BROWNING OF EVERGREENS

APPLICATIONS:

- evergreen trees and shrubs (usually relatively small, recently-installed and/or in exposed sites) that exhibit browning of needles in the spring.

INSTRUCTIONS:

1. Affected trees and shrubs should be well watered. Do not remove immediately. Rather, wait and water for several weeks in the growing season to determine if they are really dead or, if not, the extent of winter browning.

4.8 REPAIRING DAMAGED VEGETATION

INTRODUCTION

This section includes techniques related to tree and shrub pruning (for vegetative health and public safety), wound and cavity treatment, tree felling, and the rectification of problems caused by grade changes around trees.

With reference to pruning, although this manual outlines the major principles and techniques, it is important that any field crew members with no previous pruning experience receive some 'in the field' orientation and training from an individual experienced in these techniques before attempting any pruning on their own.

4.8.1 PRUNING

a. INTRODUCTION (from Pirone, 1972)

The pruning of trees and the subsequent treatment of wounds are probably the most important of all tree maintenance practices. Proper and systematic pruning helps trees better to withstand adverse environmental conditions. In addition, properly pruned trees require less fertilizing, bracing, and spray materials to keep then healthy. Correct wound treatments reduce losses due to wood-decay fungi. Pruning trees and treating their wounds are so closely related that the two practices must be considered together.

Need for Pruning

Trees are pruned principally to preserve their health and appearance, and to prevent damage to human life and to property.

Pruning for Health

Broken, dead, or diseased branches are pruned to prevent decay-producing fungi from penetrating into the part of the tree to which these branches are attached. Live branches are removed to permit penetration of sunlight and circulation of air through the canopy or to compensate for loss of roots. Overlapping branches and those that interfere with utility wires are removed to prevent rubbing and eventual decay. Branch stubs are removed to promote proper healing.

Tops are sometimes cut back to revitalize the remaining parts of the tree. Such pruning, if properly done, increases the general vigor of the tree by supplying additional nourishment to the parts that remain. Drastic pruning involving the removal of much potential leaf surface may, however, seriously affect the food supply and weaken the trees. The removal of a large portion of the top may also favor fungus and insect attack, and increase the possibility of scalding of the bark by suddenly exposing tender tissues to the direct rays of the sun. The removal of many small branches rather than a few large ones not only reduces the amount of sun scald, but also makes the work less conspicuous and facilitates maintaining the desired shape. In addition, the many small wounds will heal more rapidly and completely than the few large ones.

Since the removal of dead or dying branches constitutes one of the major objectives of pruning, it is well to list some of the principal causes of dieback. These include: lack of adequate or proper plant food; damage to the root system; a deficient or overabundant moisture supply; poisonous elements in the atmosphere or soil; inadequate aeration of the root system owing to grade changes; excessively dense crown; fungus, bacterial, or insect attack; mechanical injury to the trunk and branches; and lightening injury. While it is imperative that all dead wood resulting from any of these causes be removed, it is extremely important that the causal factors be eliminated or corrected whenever feasible (see 4.3, 4.5, 4.6, 4.13.3).

Pruning for Safety

Dead, split and broken branches are a constant hazard to human life and to property. Danger from falling limbs is always greatest in trees along city streets and in public parks. Low-hanging live branches must be removed to a height of 10 to 12 feet when they interfere with pedestrian and vehicular traffic. This phase of pruning is probably the most important of all street tree maintenance practices.

Pruning Equipment

Adequate equipment is an essential of good pruning. Equipment must be maintained in first-class condition both for the safety of the operator and the good of the tree. The following chart lists the most essential pieces of pruning equipment and their use.

Equipment	Specifications	Use
Hand Saw	no more than 4.5 mm/tooth	normal pruning cuts
Crosscut Saw	1 m ± long	large cuts
Pole Pruner Pole Saw	3-3.5 m long	removing small limbs not reached by hand saw
Rope	50 m, 15 mm diameter	climbing
Rope	30 m, 20 mm diameter	lowering large limbs
Pruning Shears	hand operated	cutting back small trees and pruning roots
Mallet and Chisel	small size	point and shape final cuts
2 Belt Snaps		hold saw and paint cans
Wound Dressing		paint cuts
Safety Belt		fasten operator securely

b. GENERAL PRUNING PROCEDURES

1. In general, it is best to start pruning operations in the upper parts of the tree and work downward.

2. All dead, broken, fungus-infested, insect-infested and interfering branches should be removed. Small branches that may prove undesirable within a few years should be treated as interfering branches.

3. Clean cuts should be made as nearly flush as possible with the branch that is to remain.

4. Dead branches should be cut back to a healthy crotch, so that healthy tissue surrounds the final cut.

5. All dead bark areas should be cut to healthy tissue and old wounds not healing properly should be recut, and then a wound dressing applied.

c. SHAPING FINAL CUTS

1. All final cuts should be made as close as possible to the remaining part. Stubs or protruding 'lips' should never be left, since proper healing is inhibited and water pockets that promote root decay may develop.

2. Theoretically, all wounds, regardless of size, should be painted with a dressing. In practice, however, only wounds 50 mm or more in diameter are usually painted. It should be noted, nevertheless, that decay may readily develop in smaller untreated wounds, especially in trees low in vigour, in which healing progresses slowly.

d. REMOVING LARGE BRANCHES

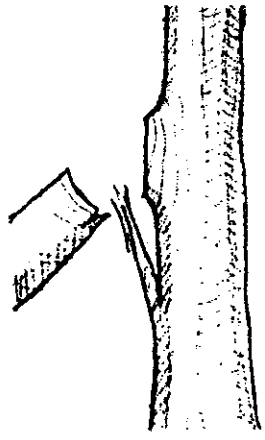
1. The procedure for removing large branches is the same as that followed in removing smaller branches, except that additional precautions must be taken to prevent injury to the tree. The tree will suffer considerable damage if a single pruning cut is made in a large limb, as shown on the left-hand sketch below. The proper way to remove a large branch is shown in the right hand sketch below. About 300 mm beyond the proposed final cut, make a preliminary undercut by sawing until the saw blade begins to bind.

2. On the upper side of the limb, 25 mm or so beyond the first cut, make a second cut to sever the branch.

3. Remove the remaining short stub by making the final cut as nearly flush with the remaining stem as possible. Hold the stub in place with your free hand on a rope, to prevent tearing of the bark.

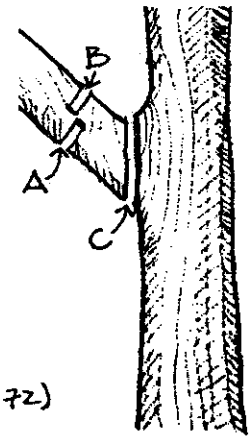
4. When an entire branch is small enough to be held firmly in place by ropes or by hand, the first and second cuts may be omitted.

5. Large final cuts cannot always be made as close to the remaining branch as necessary. In such cases, the cut surface must be smoothed over with a chisel.



THE WRONG WAY TO PRUNE A LARGE BRANCH. A SINGLE CUT CLOSE TO THE MAIN STEM MAY RESULT IN TEARING OF THE BARK

(after Pirone, 1972)



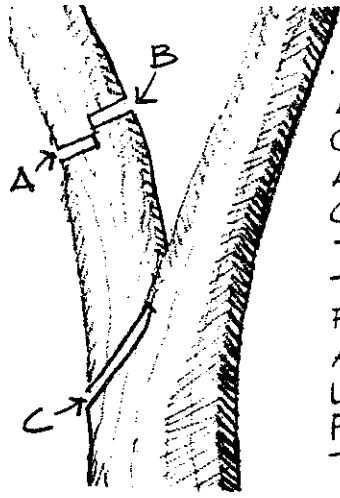
THE CORRECT WAY TO PRUNE A LARGE BRANCH. A PRELIMINARY UNDERCUT IS MADE AT A; A SECOND CUT IS MADE AT B, TO SEVER THE MAIN PART OF THE BRANCH. THE REMAINING STUB IS REMOVED BY CUTTING AT C.

e. REMOVAL OF V-CROTCHES

1. Make preliminary cuts, as described for removing large branches and as shown in the sketch below, 300 mm or so above the crotch, to remove the upper part of the limb.

2. A final cut, starting from the main trunk and slanting upward to the point of union of the two limbs completes the operation.

3. After this stub is removed, it may be necessary to finish the cut with a chisel, to form a pointed wound that will heal rapidly.



REMOVAL OF V-SHAPED CROTCH

A PRELIMINARY UNDER-CUT IS MADE AT A, AND THE SECOND CUT AT B TO REMOVE THE MAJOR PART OF THE BRANCH. THE FINAL CUT, STARTING AT POINT C, SLANTS UPWARD TO THE POINT OF UNION OF TWO LIMBS.

(after Pirone, 1972)

f. BARK TRACINGS

APPLICATIONS:

- to speed healing of bark abrasions on tree trunks.

INSTRUCTIONS:

1. Bark abrasions should be treated promptly to permit rapid healing of the wound and to prevent decay.

2. Assemble tools and materials, which include a sharp curved-blade pruning knife, a 10-15 mm paint brush and small quantities of shellac and tree-wound paint. If the bark is thick, a sharp wood chisel and light mallet may be needed to cut it.

3. Determine the extent of injury and carefully remove all loose bark.

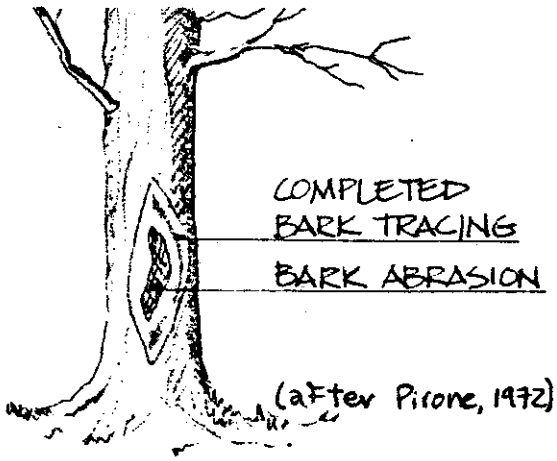
4. Start the bark tracing in sound bark above the injury and work a knife or chisel down on a slight curve to one side of it, removing all sprung bark. Hold the chisel at a slight angle away from the injury, with beveled edge toward the sound bark.

5. Shellac the exposed edge of bark as tracing progresses to prevent drying.

6. Continue tracing downward until distances above and below the centre of the injury are about equal, and then repeat the procedure on the opposite side of the injury.

7. Apply a second coat of shellac to the exposed bark edge and paint the exposed wood with a tree-wound compound.

8. The top and bottom points of the tracing must be established on the centreline of the injury to permit uniform healing (see sketch below). The healing callus does not develop on the lower side of a bark tracing made on an angle.



9. When two small injuries are close together (see sketch below) make one bark tracing, because the thin strip of bark between two abrasions dries out and tracing must be repeated.



g. PRUNING SHRUBS

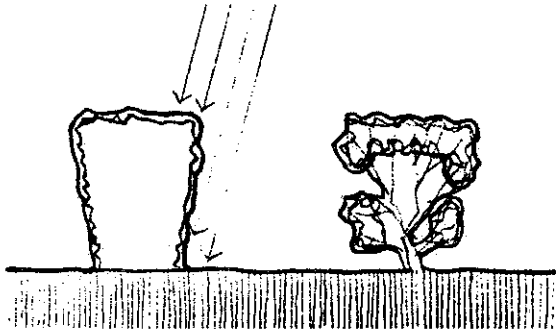
1. When deciduous shrubs are transplanted, there may be a partial loss of the root system. If this happens, about one-third of the top growth should be pruned away to compensate for this and to promote rapid recovery from transplant shock.

2. Newly planted shrubs should be pruned according to their natural growth habit. Heavier canes should be pruned at a greater height from the ground than smaller canes.

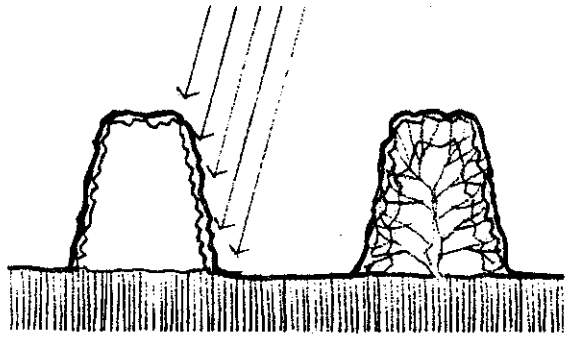
3. Old, oversized shrubs can often be pruned by cutting the heavy canes back to the ground so that new shoots grow from the base of the plant (see 4.11.10). When a shrub consists entirely of old, heavy canes, remove only half of the canes the first year if it is desirable to avoid the brushlike effect of a mass of stiff stalks.

h. PRUNING HEDGES

1. Hedges should be pruned to keep the top somewhat narrower than the base (see sketch below). This method takes advantage of full sunlight from top to bottom, thereby maintaining the whole hedge compact and dense.



WRONG METHOD OF HEDGE PRUNING. LITTLE LIGHT REACHES THE SIDE OF THE HEDGE.



RIGHT METHOD OF HEDGE PRUNING. LIGHT REACHES THE ENTIRE SIDE OF THE HEDGE.

(after Pirone, 1972)

4.8.2 TREE FELLING

APPLICATIONS:

- dead trees or trees that, because of their poor health, pose a threat to public safety or a threat to the health of other nearby vegetation.

INSTRUCTIONS:

NOTE: Felling of large trees should be undertaken only by skilled crews with experience in this complex and potentially hazardous task.

1. Clear all brush in the area immediately around the tree being felled.

2. Before felling, a tree should be carefully assessed in terms of its height, soundness and direction of lean, slope of the ground, species of tree, top-heaviness, wind direction and strength, proximity to other trees, structures and wires, and dead limbs or stubs which may break off and fall.

3. Guidelines and/or block and tackle may be required. Guidelines should be tied and snubbed around other trees before any cutting is done at the base of the tree. Winch line, block and tackle, or pull lines assist in controlling the direction of the fall.

4. It may sometimes be necessary to fell a tree by lowering it in sections instead of simply cutting it off at the ground. Great care is required to ensure that such topping is completed safely.

5. Once the base cut has been started, felling operations should be finished before the crew leaves the job for lunch or at the end of the working day.

6. Additional precautions are necessary in felling trees with a chain saw. If there is loose bark on the trunk where the cut is to be made, it is best to remove it with an axe; otherwise the saw may throw it into the face of the operator.

7. Make an undercut to the proper depth on the side of the desired direction of fall and notched out with an axe. All but small trees should be undercut.

8. When a tree is to be cut flush to the ground, it is safer to make the first cut at a height above the swell of the roots and a second cut flush with the ground after the tree is down.

9. If binding occurs as the felling cut proceeds, wedges may be used or a pull rope may be sufficient to prevent binding.

10. When the felling cut is to the proper depth, the tree should be pulled or wedged over. Do not make the felling cut too deep and beyond the wood controlling the direction of fall.

11. When the tree begins to fall, keep well back from the base of the tree.

12. The removal of brush and wood after a tree has been felled will depend upon the possibility of the presence of tree disease or insect infestation and the intended use or role of the site. In any case, debris should be kept clear of the base of the tree being felled so it will not interfere with the felling operation.

4.8.3 RECTIFYING PROBLEMS OF RAISED GRADES AROUND TREES: Method 1

APPLICATIONS:

- trees where grades have been raised sufficiently to affect tree vigour

- only recent fills are treatable; little can be done for trees that have been suffering from grade fills over a long period.

INSTRUCTIONS:

a. SHALLOW FILLS

1. Where a relatively shallow layer of soil has raised the grade, periodically cultivate or otherwise break the soil up.

2. Inject compressed air into the soil after cultivation.

3. Fertilize and water.

b. MODERATE FILLS

1. Remove fill immediately around the trunk (600 mm ±) to original grade and construct a dry well with loosely placed stones around the perimeter of the excavation.

2. Carefully place coarse granular material (10-20 mm diameter) in the dry well.

3. Dig holes every metre or two, inside the drip line and slightly beyond, down to the original grade.

4. Install 150 mm drainage tiles vertically in these holes and backfill around the tiles with soil.

5. Apply fertilizer, in appropriate quantities in the bottom of the vertical tiles and water in well.

6. Fill the tiles with coarse granular material (10-20 mm diameter), and cover them with a secured screen.

c. DEEP FILLS

1. Excavate to the original grades immediately around the trunk (600 mm ±).

2. Dig trenches (deep enough to reach original grades) radiating from the excavation around the trunk out to or slightly beyond the drip line of the tree. The bottoms of these radial trenches should slope gently downward (minimum 2%) from the trunk to the drip line to facilitate drainage away from the trunk.

3. Connect the ends of the radial trenches by digging a circular trench to the same level.

4. Apply fertilizer, in appropriate quantities in the bottom of the radial and perimeter trenches, but not around the trunk.

5. Build a dry well with loosely placed stones around the outside of the trunk excavation and carefully backfill the dry well with coarse granular material (10-20 mm diameter).

6. Place 100 mm agricultural drainage tile on 50 mm of granular material in the radial and perimeter trenches. Loosely wrap tile with a filter fabric to prevent soil particles from entering the tiles.

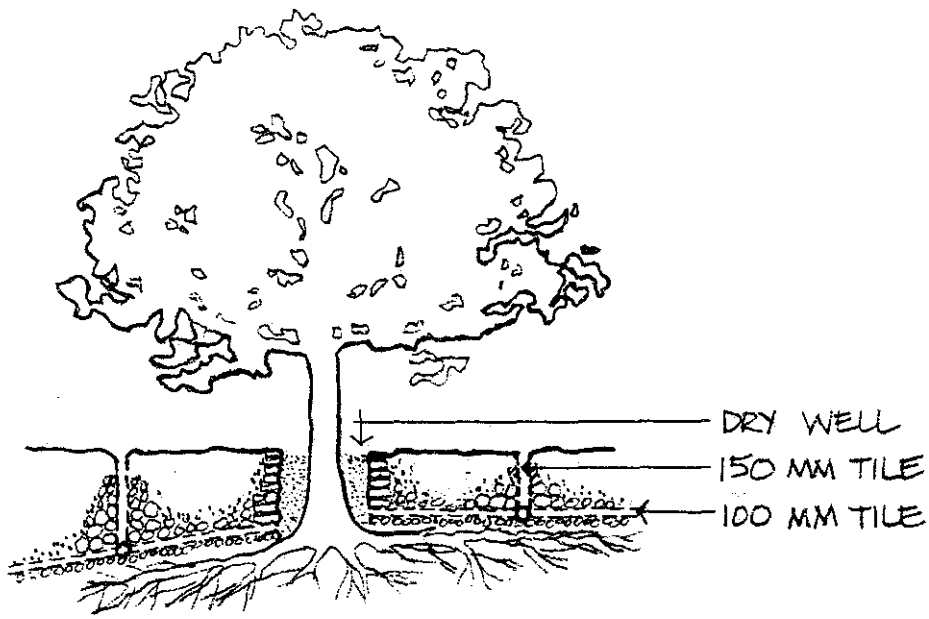
7. Place 150 mm drainage tiles vertically over the junctions of the perimeter and radial tile lines, and pile stones around them to hold them in place (do not crush tile in trenches).

8. Backfill trenches (to within 300 mm ± of finished grade, but in no case less than 150 mm thick) with coarse granular material (10-20 mm diameter).

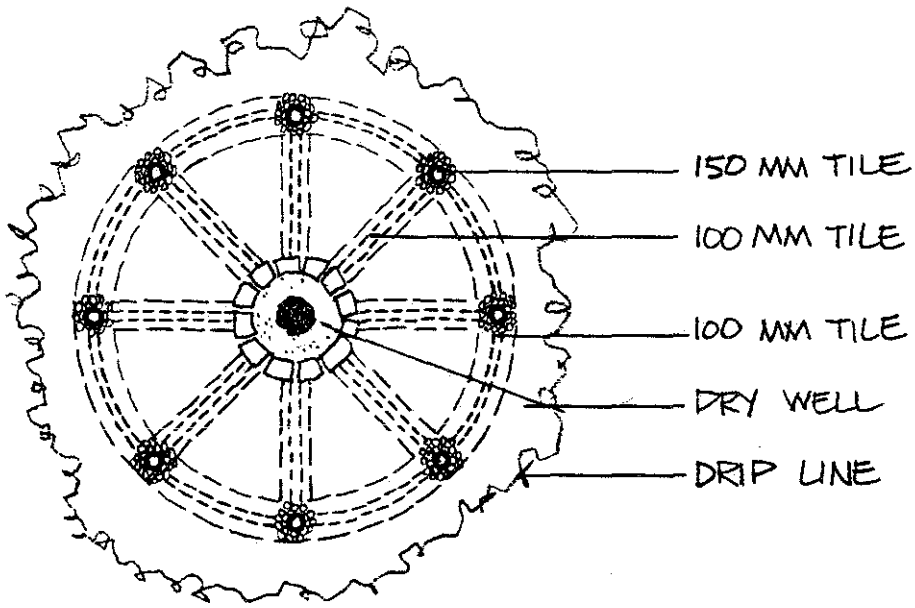
9. Cover granular material with a thin layer of straw or hay (50 mm ±) and then complete trench backfilling with topsoil.

10. Fill vertical drainage tiles with coarse granular material (10 - 20 mm diameter) and cover them with a secured screen.

NOTE: Where water drainage is not a serious problem, coarse granular material can be substituted for the drainage tile, both in the trenches and the vertical tiles.



SECTION



PLAN

4.8.4 RECTIFYING PROBLEMS OF RAISED GRADES AROUND TREES: Method 2

APPLICATIONS:

- areas where filling around trees is imminent.

INSTRUCTIONS:

1. Immediately before the grade is raised, wound the bark on the lower trunk or major roots.

2. Where grades are to be raised 300 mm ± or more, make the wounds in the lower trunk. Where the fills are to be shallow, wounds made in the larger roots will result in the growth of roots up into the fill.

3. The wound in the trunk or larger roots should be deep enough to penetrate into the sapwood, and a pebble or some other object placed in the wound to keep it open and prevent healing at that point.

4.8.5 RECTIFYING PROBLEMS OF LOWERED GRADES AROUND TREES

APPLICATIONS:

- trees where grades have been lowered sufficiently to expose roots or otherwise affect tree vigour.

INSTRUCTIONS:

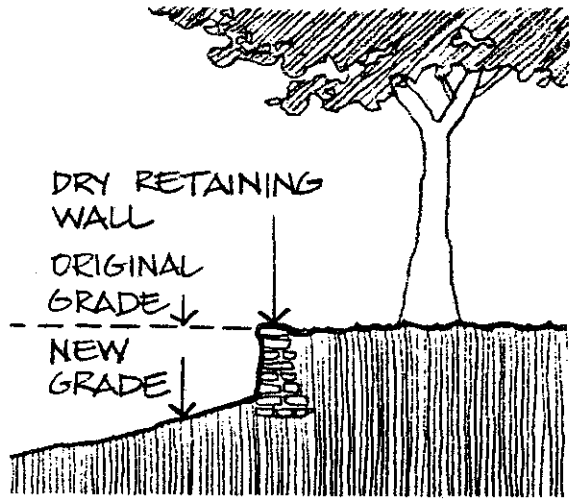
1. Exposed roots, if cut or broken, should be treated and covered with peat moss to prevent drying.

2. Incorporate peat moss, leaf mold or rotted manure into the remaining soil to increase the water holding capacity and compensate for possible lowering of the water table.

3. If large roots are cut or damaged, prune some of the branches to maintain a balance between above and below ground components (see 4.8.1).

4. Apply fertilizer, in appropriate quantities, in undisturbed areas around the tree.

5. If a deep cut has been made or is required, a dry stone retaining wall will reduce the impact of the cut (see sketch below).



4.9 SITE PREPARATION FOR PLANTING

INTRODUCTION

At sites where vegetation is to be re-established, planting areas should be treated to enhance the chances of plant material survival. It is important that competing vegetation be removed or controlled, that exposure to wind be minimized and that compacted soils be loosened.

4.9.1 CONTROLLING COMPETING VEGETATION

APPLICATIONS:

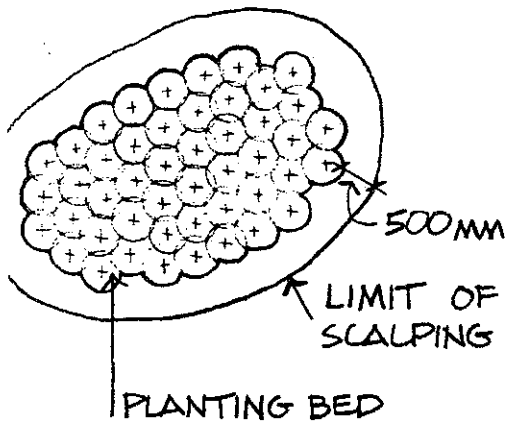
- On growing sites, existing vegetation may inhibit the establishment of desired vegetation through competition for light, moisture and nutrients.

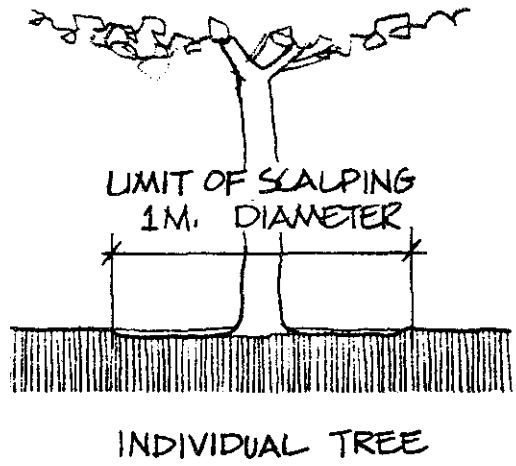
INSTRUCTIONS:

1. On large unwooded sites, mechanical discing or other forms of cultivation prior to planting is the most efficient means of controlling competition and preparing a seeding or planting bed.

2. On small sites, or sites where there is considerable woody plant cover existing, undesired competing vegetation should be cut or pulled out of the ground, and root masses should be 'scalped' away with a round-mouth shovel, mattock or other suitable implement.

3. Scalps should be made immediately prior to planting. They should be more or less continuous is areas which are to be densely planted and should extend in a 500 mm band around such planting beds. Individual trees which are planted at relatively low densities require scalps 1 metre in diameter (see also 4.6.3).





4.9.2 REDUCING WIND EXPOSURE

APPLICATIONS:

- At growing sites where natural windbreaks such as shrubs, shelterbelts, fallen trees or logs are absent, the establishment of vegetation may be inhibited by wind stress. Wind is a very effective drying agent and, where it is excessive, soils may be prematurely dried out in spring or after rainfalls, thus depriving newly-established or germinating vegetation of much-needed moisture. Moreover, a layer of leaf litter, which can act as a mulch preventing rapid evaporation, may not be allowed to accumulate in windswept areas. Further, wind action may cause excessive losses of moisture through the leaves of young plants (dessication). As a consequence, newly-established plants, which may have damaged or underdeveloped root systems, may not be able to absorb enough water from the soil to compensate and may become severely stressed or die.

INSTRUCTIONS:

1. In areas which are devoid of natural windbreaks and where wind stress is believed to be a problem, decadent logs (placed perpendicular to the direction of the prevailing or impacting wind), brush or other natural debris should be scattered throughout the growing site to break up continuous winds, to trap leaf litter and to generally encourage a more favourable microclimate for the successful establishment of vegetation.

2. Alternatively, if such 'natural' windbreak materials are unavailable, lengths of snow fencing can serve a similar function.

3. The selection of 'natural' or artificial windbreak techniques will be dependent upon the intended long term image of the site and the relative costs and benefits or removing such windbreaks once the desired vegetation is successfully established.

4.9.3 TREATING COMPACTED SOILS

APPLICATIONS:

- Compacted soils inhibit plant growth by limiting water movement and gaseous exchange in the soil and act as a physical barrier to root development and natural regeneration. In all areas where vegetation is to be established, compacted soils must be loosened.

INSTRUCTIONS:

1. In large areas, where existing vegetation will not limit the operation of mechanized equipment, scarification or cultivation with a tractor-pulled aerator, harrow or disc cultivator or a tractor-mounted roto-tiller would loosen compacted soils.

2. In small, wooded or relatively inaccessible sites, a hand-pushed roto-tiller or such hand implements as shovels, picks, mattocks or bars may be used to loosen such soils.

4.10 ACQUISITION OF PLANT MATERIAL

INTRODUCTION

Plant material to be used in a site restoration program may be acquiried as nursery-grown stock or commercially available seed, or it may be collected in the field in the form of wildlings, cuttings or seed. Encouragement of natural regeneration may also be feasible for vegetative restoration.

Nursery-grown stock is available locally from four principal sources:

i. City of Saskatoon Parks & Recreation Department Nursery
ii. University of Saskatchewan Nursery
iii. P.F.R.A. Tree Nursery at Indian Head, Saskatchewan
iv. Various commercial nurseries in and around Saskatoon.

i. Parks & Recreation Department Nursery

The Parks & Recreation Department Nursery contains a variety of sizes and species of deciduous and coniferous trees and shrubs (native and horticultural species). Shrub quantities are limited (especially seedlings). Material from the nursery could be made available for site restoration work in the Meewasin Valley.

ii. University of Saskatchewan Nursery

The University of Saskatchewan Nursery contains a wide variety of species and sizes of deciduous and coniferous trees and shrubs (native and horticultural, although the selection of native shrub species may be limited). Plant material from this nursery is available only for use on University Lands.

iii. P.F.R.A. Tree Nursery

The P.F.R.A. Nursery at Indian Head, Saskatchewan has available, at no charge, a variety of native and horticultural deciduous and coniferous trees and deciduous shrubs. All of this material is in seedling form and must generally be ordered 8-12 months before delivery. Plant material from the P.F.R.A. nursery is generally available for use only on public land and private farms (for shelterbelts on the farms), although there are certain other instances where it can be used on other private land.

iv. Commercial Nurseries

A wide variety of species and sizes of plant material is available from several local commercial nurseries. However, the quantities of certain species available may be limited, and if large quantities are required for site restoration purposes, local nurserymen should be contacted well in advance to ensure availability. Of critical importance is the need to ensure that the plant material acquired from commercial nurseries is hardy in the Meewasin Valley. Locally grown stock is preferable.

Although the emphasis in this manual for the restoration of herbaceous plant material is on the creation of conditions which will encourage natural regeneration of such species, there will most likely be instances where it will be desirable to 'install' native grasses and wildflowers. Seeding is the preferred technique for establishment of these species, and a partial list of commercial seed sources is to be found in Appendix I of this manual.

4.10.1 COLLECTING WILDLINGS

APPLICATIONS:

- Wildlings may be collected where they grow naturally, where their removal does not destroy the natural amenities or ecological relationships in an area, and where permission to collect has been given by the property owner or agency responsible for the source area.

INSTRUCTIONS:

1. Wildlings are simply dug up (when they are dormant - i.e. autumn or spring), in a manner that preserves as much of the root ball as possible and immediately transported to and planted in desired areas.

2. Also, for the purposes of producing additional wild stock for transplanting, existing stands of wildlings may often be increased in size by induced suckering and layering. Suckers should be at least one year old before transplanting and should be induced in spring so they may be transplanted the following spring (see 4.11.10).

4.10.2 CUTTINGS

APPLICATIONS:

- Cuttings may be obtained from some wild stock species found growing in or near the valley where cutting or digging will not destroy natural amenities or disturb sensitive ecological features and where permission to do so has been given by the property owner.

INSTRUCTIONS:

1. Cuttings should be taken from stock which is healthy and shows normal vigorous growth.

2. Cuttings should be taken when the plants are dormant (late fall to early spring) when there is a maximum of stored foods in the tissues of stems and roots.

3. Hardwood stem cuttings should be 6 to 25 mm in diameter and 150 to 200 mm long (length and diameter may vary according to species) and each should contain at least two nodes. The top of each cutting should be made square, 12 to 25 mm above a node and the bottom cut should be made just below a node. Bottom cuts should be made at a sharp angle to facilitate planting and to serve as a marking for reference in planting and storage.

4. Root cuttings should be taken from the fleshy roots of plants 2 to 3 years old and should be cut into lengths of 50 to 150 mm. Proximal ends should be marked for reference in planting and storage (see 4.11.3 for sketches).

5. The handling of cuttings is critical. Fresh cuttings should not be allowed to dry out; neither should they be exposed to direct sunlight.

6. Cuttings taken in advance of the planting date must be stored under cool, moist, dark conditions. They should be tied in bundles with bottoms and tops together and either:

   -stored, for periods of up to a few weeks, in a cool, moist, dark place; or

   -buried in well-drained sandy soil, either horizontally or vertically (with bottom ends up) and covered with 75 to 125 mm of loose soil if storage must continue for a few months.

7. Care must be taken at all times to prevent damage to bark tissues.

*NOTE: Species - specific requirements vary. Refer to U.S.D.A. Handbook No. 271 (1965): Silvics of Forest Trees in the United States (U.S.D.A. Forest Service).

4.10.3 SEED COLLECTION

APPLICATIONS:

- Seed may be collected from wild stock growing in or near the area without jeopardizing natural amenities or sensitive features, provided that permission to do so is granted by the property owner. A useful technique for obtaining seeds not commercially available.

INSTRUCTIONS:

1. Ripeness criteria and the frequency of abundant seed crops vary according to species and should be confirmed.

2. Seed plants should be located in advance of seed collection and observed periodically to assess available quantities and dates for collection.

3. Fruits containing seed may be collected from the ground and/or picked or knocked from branches onto ground sheets.

4. Fruit containing seed should be collected in well-ventilated containers and stored in a cool place until planted. Fleshy fruits should not be stored in containers for more than a few days as moulds and heat generation may cause serious damage to seeds. If stored for more than a few days, fleshy fruits should be spread out on a flat surface and allowed to dry. Drier fruits may be kept in containers for longer periods, but must be watched for the first signs of mould or heating.

5. At all times, fruits must be protected from rodents and other animals which may consume large quantities of seed.

*NOTE: Species - specific requirements vary. Refer to U.S.D.A. Handbook No. 450 (1974): Seeds of Woody Plants in the United States (U.S.D.A. Forest Service).

4.11 ESTABLISHING PLANT MATERIAL

INTRODUCTION:

A major key to the successful restoration of most degraded sites is the establishment or re-establishment of appropriate plant material, including ground cover, shrub material and trees. This section includes a variety of techniques for establishing plant material, using seeds, seedlings, cuttings, suckers, sprouts or larger individual plants.

4.11.1 ESTABLISHING SEEDLINGS

APPLICATIONS:

- small first year tree or shrub seedlings (e.g. P.F.R.A. nursery stock), for slope stabilization, gully stabilization or general vegetative restoration.

INSTRUCTIONS:

1. Ensure that the planting site is satisfactorily prepared (see 4.9).

2. Determine appropriate spacing between individual plants (dependent upon species).

3. On receipt of the plant material, keep moist and out of direct sun, to prevent roots from drying out.

4. As soon as possible in the spring, after receipt of plant material, begin installation as follows.

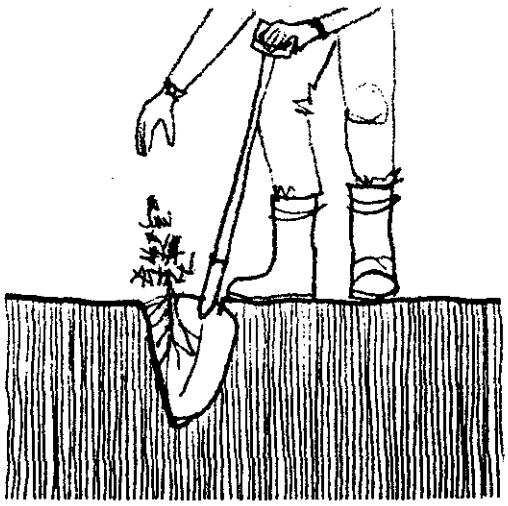
5. With a round-mouth shovel or mattock, cut a slit into the ground deep enough to accommodate the full length of the seedling's root system (see sketch below).

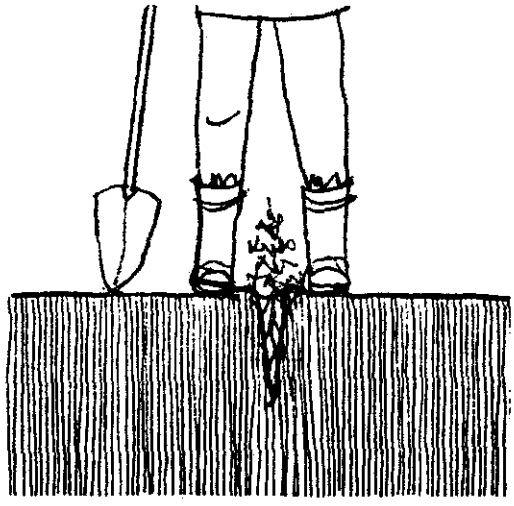
6. Push the shovel handle forward or lift the mattock handle to open the slit, and with your free hand, insert the seedling into the open slit, making sure that the roots do not double up.

7. Remove the shovel or mattock carefully and tamp the ground down around the seedling with your feet.

8. Carry out establishment maintenance measures as appropriate (see 4.12).

*NOTE: If roots are dipped in a product known as "Terra-Sorb" immediately prior to planting, plant vigour and survival rate should increase.





4.11.2 ESTABLISHING LARGER TREES AND SHRUBS

APPLICATIONS:

- installation of container-grown, B & B (balled and burlapped) or bare root trees and shrubs.

INSTRUCTIONS:

a. CONTAINER-GROWN OR B & B SHRUBS

1. Ensure that the planting site is properly prepared (4.9).

2. Dig planting pits in circular shape with vertical sides to a depth and width amounting to twice those of the root system, but in no case should the depth be less than 375 mm or the width less than 600 mm. Scarify sub-soil below pit to a minimum depth of 150 mm (see sketch on next page).

3. Plants should be handled with care so the root balls do not break. Prune back broken roots of deciduous stock prior to planting.

4. Set the plant into the pit, filling below the root ball as required (with topsoil) to achieve the correct finish level. Ensure that the plant is set plumb and centred, in the pit. With B & B plants, do not fold burlap back; but ensure that burlap is biodegradable.

5. Fill in around the root ball, compacting to stabilize the plant.

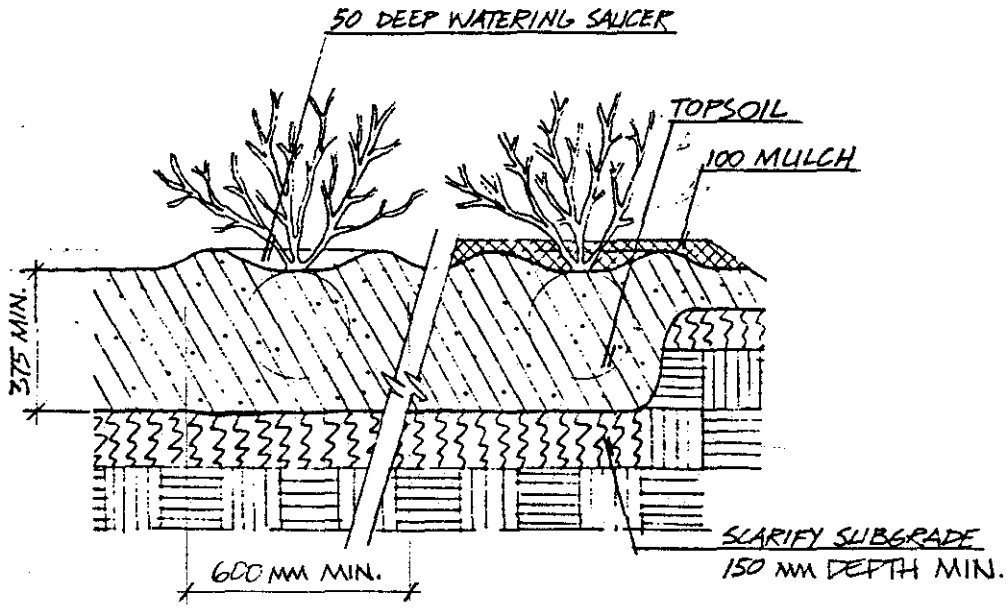
6. When the hole is half filled, apply fertilizer (as required) uniformly, soak thoroughly and allow to drain.

7. Complete filling and compacting of the planting pit, leaving a saucered depression for correct watering.

8. Prune as required (see 4.8.1).

9. Carry out establishment maintenance measures, as appropriate (see 4.12).

NOTE: Container-grown and B & B shrubs can usually be safely transplanted at any time during the growing season, provided that proper procedures are followed and care is taken.


50 DEEP WATERING SAUCER
TOPSOIL
100 MULCH
375 MIN.
600 MM MIN.
SCARIFY SUBGRADE
150 MM DEPTH MIN.

b. CONTAINER-GROWN OR B & B DECIDUOUS TREES

1. Ensure that the planting site is properly prepared (see 4.9).

2. Dig tree pits in circular shape with vertical sides to a depth and width amounting to twice those of the root system, but in no case should the depth be less than 600 mm or the width less than 750 mm. Scarify the sub-soil below the pit to a minimum depth of 150 mm (see sketch on next page).

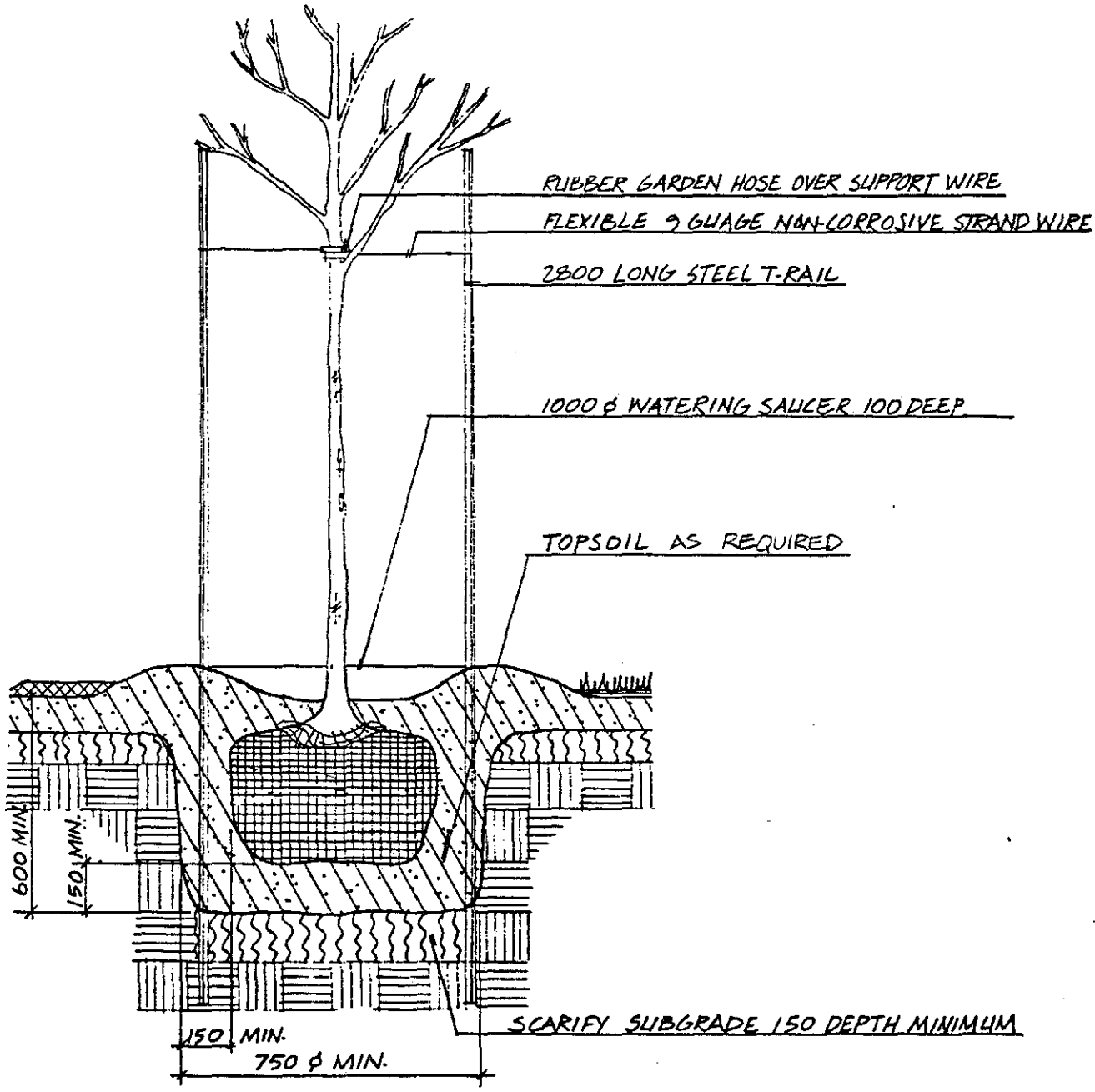
3. Follow steps 3 through 7, as outlined in (a) above for shrubs.

4. Stake the tree, as shown on the sketch, with 2 steel T-rails, 2800 mm long (or 38 x 38 mm wood stakes, 2800 mm long), and fastened to the stakes with flexible galvanized wire covered with rubber hose to protect the tree. Staking should effectively prevent movement of the tree, and stakes should be on the same sides of all trees installed on a site. Some larger trees may require guying rather than staking, as outlined for coniferous trees in (c) below.

5. Prune as required (see 4.9.1).

6. Carry out establishment maintenance measures, as appropriate (see 4.12).

NOTE: Container-grown and B & B deciduous trees can usually be safely transplanted at any time during the growing season, provided that proper procedures are followed and care is taken.



NOTE: ALL DIMENSIONS IN MILLIMETRES

c. CONTAINER-GROWN OR B & B CONIFEROUS TREES

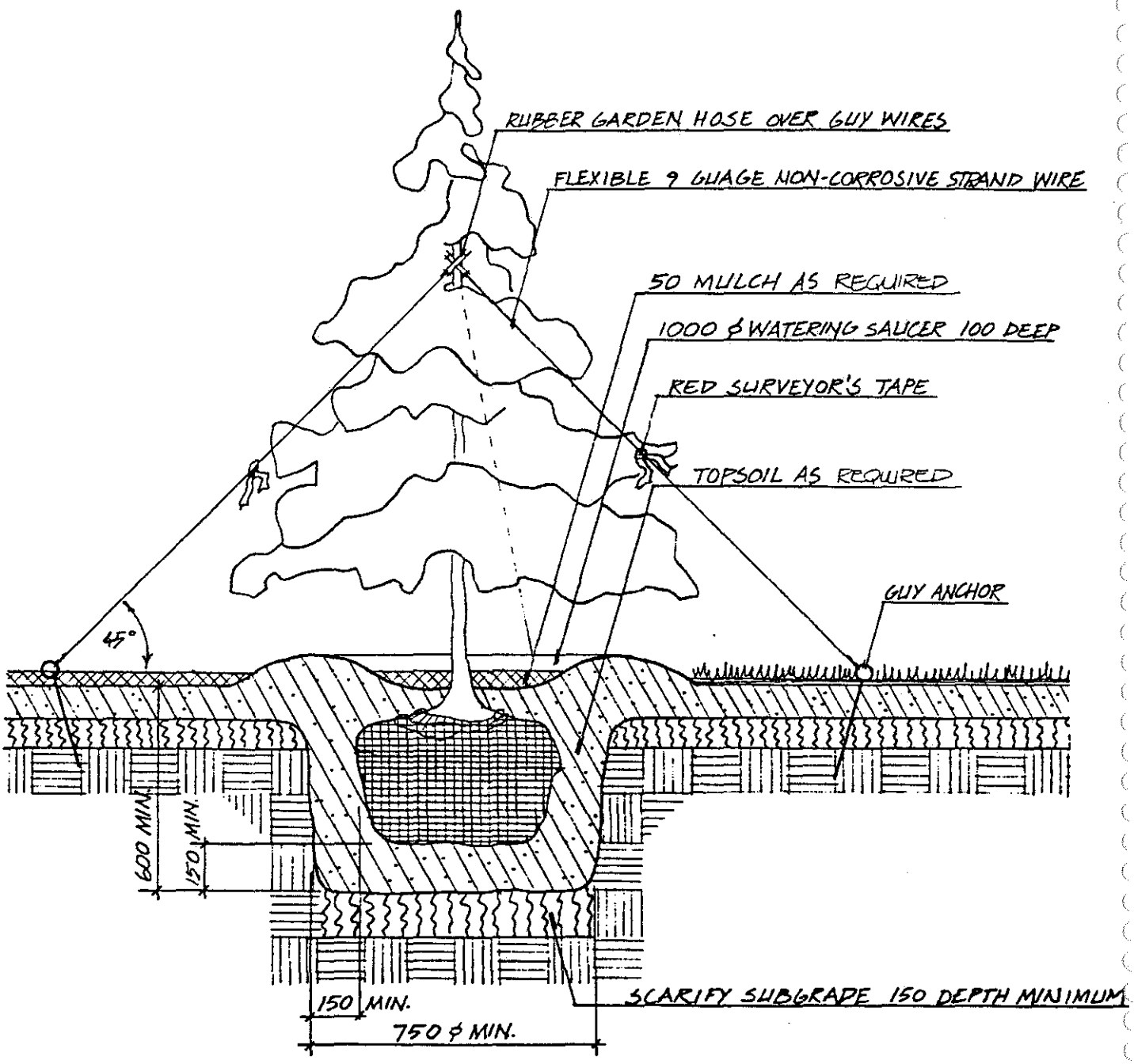
1. Ensure that the planting site is properly prepared (see 4.9).

2. Dig tree pits as described for deciduous trees in (b) above.

3. Follow steps 3 through 7, as outlined in (a) above for shrubs.

4. Guy evergreen trees more than 1200 mm in height with three 600 mm long, 38 x 38 mm pegs set out equal distances apart around the tree (see sketch on next page) and fasten to the stakes with flexible galvanized wire and protect with rubber hose. Attach red surveyor's tape to the guy wires to increase visibility. Guying should effectively prevent movement of the tree.

NOTE: Container-grown and B & B coniferous trees can usually be safely transplanted at any time during the growing season, provided that proper procedures are followed and care is taken.



NOTE: ALL DIMENSIONS IN MILLIMETRES

d. BARE ROOT DECIDUOUS TREES AND SHRUBS

1. Ensure that planting site is properly prepared (see 4.9).

2. Dig planting pit in circular shape with vertical sides to a depth 150 mm greater than that of the root system (fully extended) and a width 300 mm greater than that of the root system (fully extended). Scarify sub-soil below the pit to a minimum depth of 150 mm (see sketch on next page).

3. Plants should be handled with care and the root systems should not be allowed to dry out.

4. Set stakes into the pit and drive them firmly into the subsoil (for trees only).

5. Set plant into the pit. Roots should be fully spread and set with care around the stakes. Fill below the roots (with topsoil) to achieve the correct finish level.

6. Fill in around the roots, compacting with care to stabilize the plant.

7. When the hole is half-filled, soak thoroughly and allow to drain (do not fertilize).

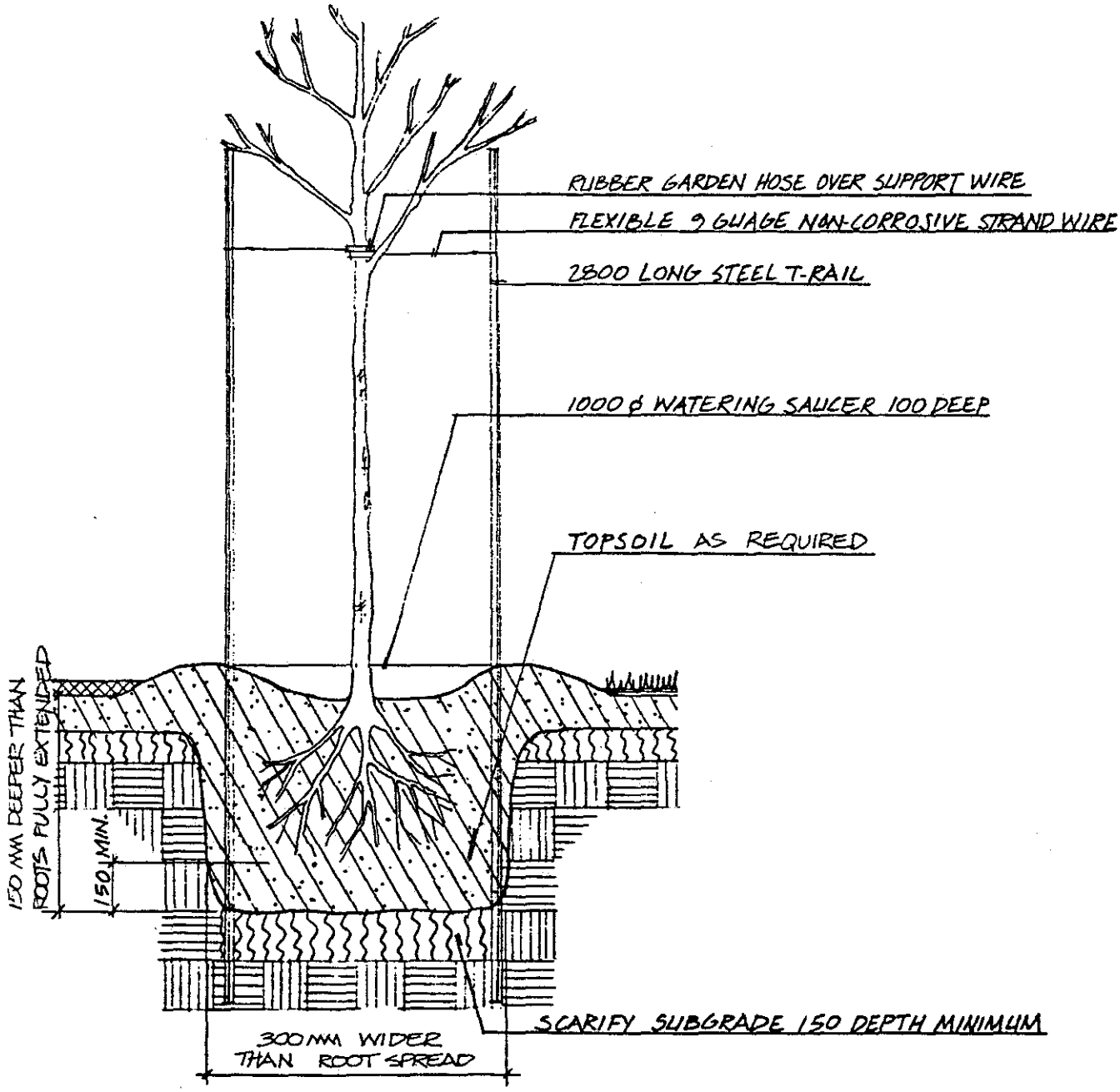
8. Complete filling and compacting of the planting pit, leaving a saucered depression for correct watering.

9. Securely fasten tree to stakes (using flexible galvanized wire and rubber hose).

10. Prune as required (see 4.8.1).

11. Carry out establishment maintenance measures, as appropriate (see 4.12).

NOTE: Bare root stock should only be installed when it is in natural dormancy (spring or fall). Dormancy can be extended into the summer by keeping the plants in cold storage until planting.



NOTE: ALL DIMENSIONS IN MILLIMETRES

4.11.3 CUTTINGS

APPLICATIONS:

- establishment of cuttings taken in the field.

INSTRUCTIONS:

1. Cuttings may be planted at any time throughout the spring and early summer. However, planting as early as possible in spring is preferable, to take advantage of adequate soil moisture at that time, and the longer growing season which facilitates maximum root development. Also, early planting may coincide with the taking of cuttings in early spring and thereby eliminate the need for storage.

2. During the planting operation, cuttings must be kept in a cool, moist medium such as moss or water.

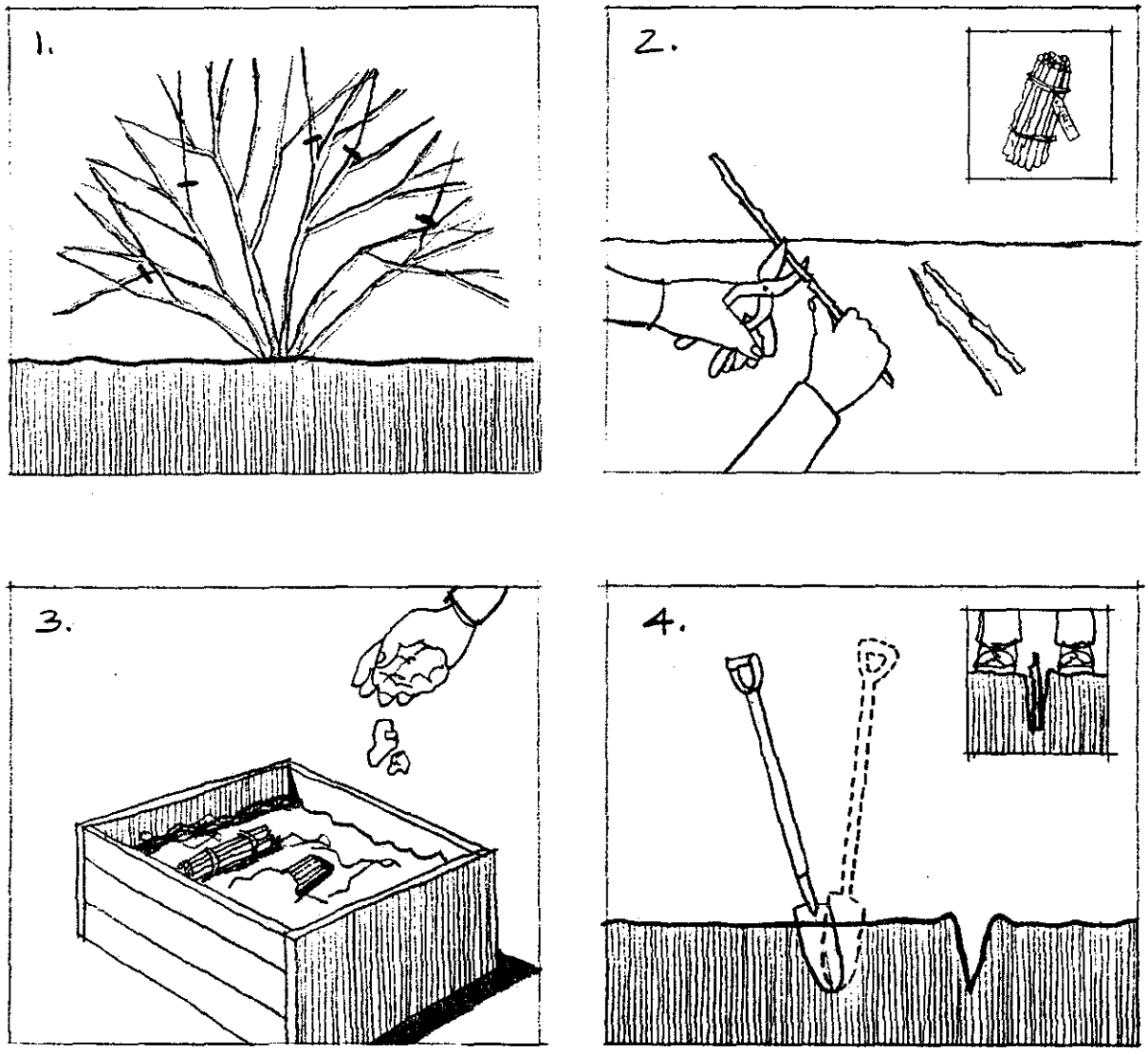
3. Hardwood stem cuttings should be planted vertically (top end up) with the top node showing just above the ground. This may vary according to the species being planted. Cuttings should be planted using a round-mouth shovel. Cuttings should never be forced into unbroken ground as bark tissues may be damaged.

4. Root cuttings may be planted horizontally or vertically, depending on the requirements of the species.

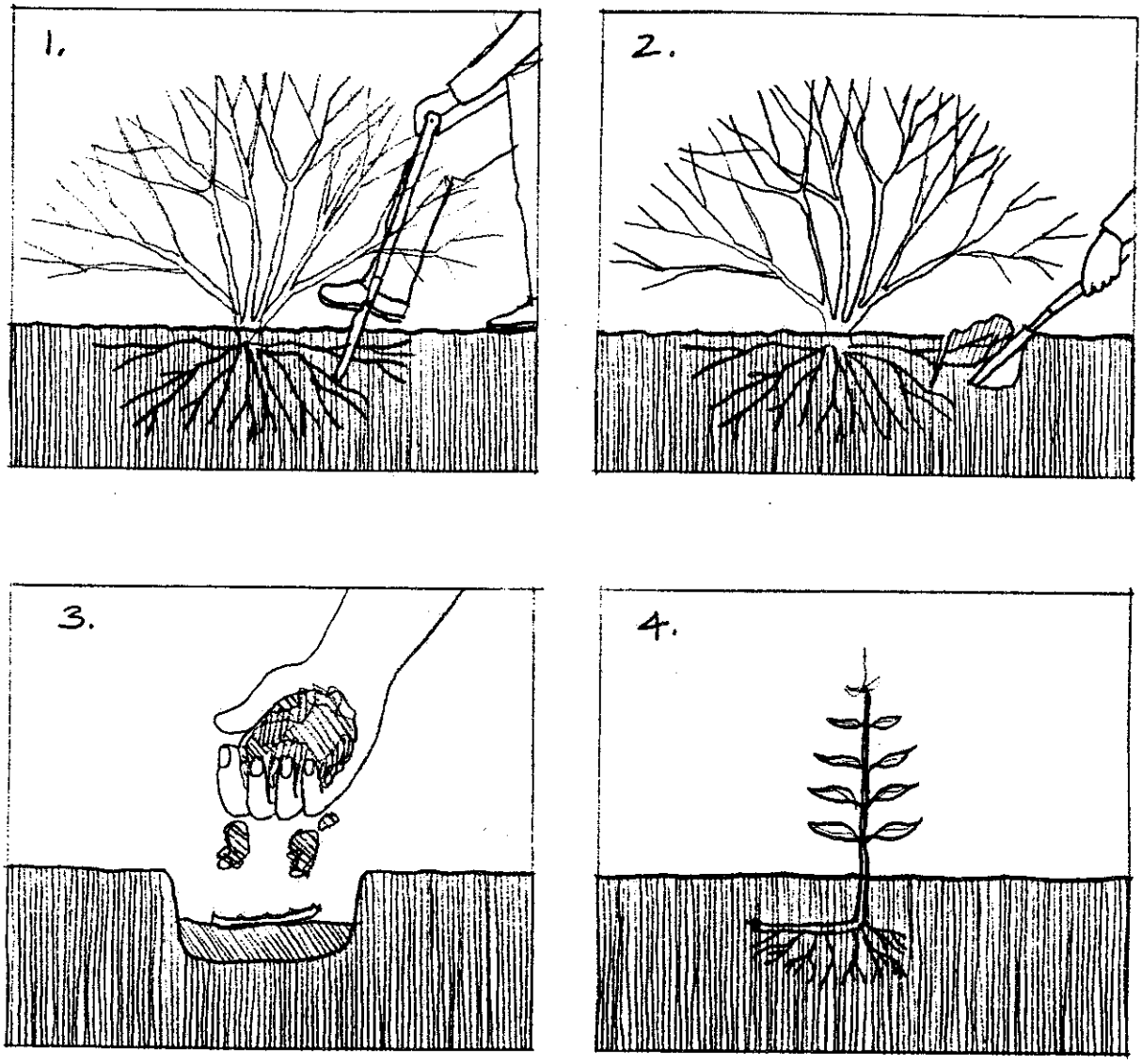
5. Root cuttings planted vertically must be planted with the proximal end up so that the tops of the cuttings are flush with the ground level.

6. Horizontally planted root cuttings should be placed in holes 25 to 50 mm deep and covered with soil.

7. The soil around and over planted cuttings should be packed firmly to remove any air pockets. Cuttings should be well watered at the time of planting and lightly mulched (see 4.12.1 and 4.12.2).



HARDWOOD STEM CUTTINGS (after Crockett 1972)



ROOT CUTTINGS (after Crockett 1972)

4.11.4 SEEDING - METHOD 1

APPLICATIONS:

- sites of 0.2 ha or more

- slopes that will not impede standard grass planting and maintenance machinery.

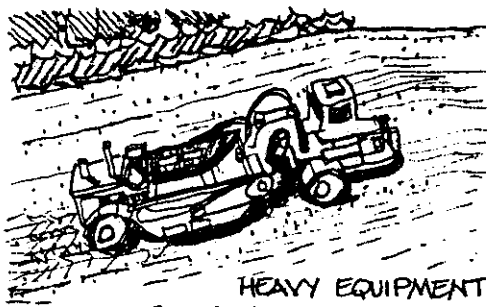
INSTRUCTIONS:

1. Ensure that the entire area has good drainage; that no depressions exist where water may collect and stand for long periods of time.

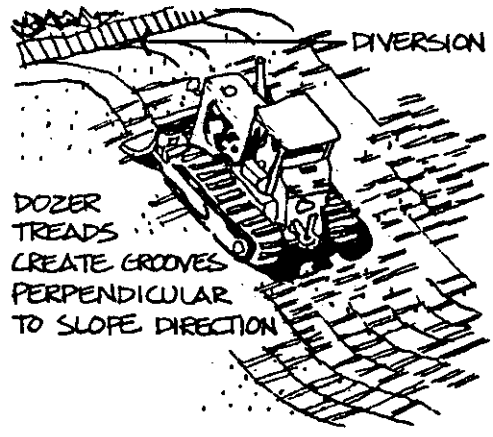
2. Prepare the topsoil.

   a. If the existing soil is to be used, obtain a soil sample from several locations of the area to be planted. Mix the samples thoroughly and have a manageable quantity analized by a soil testing laboratory to determine a fertilizing program. Disc and cultivate the topsoil and mix in the organic matter (i.e. peatmoss) if so instructed by the soil analysis. If the soil is very loose, rolling and regrading may be necessary to avoid uneven settling. NOTE: Test samples must be taken during the growing season and are to be truly representative of the available topsoil if they are to be a sound basis for a fertilizing program.

   b. When using topsoil brought in from elsewhere, first scarify the existing topsoil to a minimum depth of 100 mm by discing or other suitable means. Ensure good drainage in all areas. Scarification techniques should be done in such a way that grooves run perpendicular to the slopes being prepared for seeding. Spread the new topsoil evenly over the entire area to a depth of 100 mm. At this time, soil samples should be gathered as outlined above. Fine grading of the topsoil should be followed by another disc or harrow operation to further loosen the soil and further break up the clods of topsoil.



HEAVY EQUIPMENT USED TO SCARIFY SLOPES SHOULD HAVE TREAD GROOVES RUNNING PERPENDICULAR TO SLOPE DIRECTION.



3. All debris, roots, stones, and other foreign matter should be removed without extreme compaction of the topsoil.

4. Apply the fertilizer as determined by the soil analysis and work it into the top 50 mm of topsoil with a final raking operation. On slopes, the final raking should not be done up and down but rather across the slopes along the contours.

5. Seeding should ensure that the seed is spread evely, with equipment that does not compact the soil excessively. Timing of seeding is influenced by rainfall and the availability of water. Seed mixtures and seeding rates will depend on site-specific conditions, although seed mixes should generally include a small proportion of a fast-germinating nurse crop (see also 4.2.16).

6. Water the soil to obtain a moisture penetration of 3-4 inches and ensure that the water does not collect or uncover and wash away the seed.

7. A light rolling of the grass area after germination will press the heavied soil down and firm the roots.

8. When the grass is 3 inches high, the first mowing should take place. Setting high for the mower should be not less than 2 inches (5 cm) so that the grass is not cut too short and roots are not exposed.

4.11.5 SEEDING - METHOD 2

APPLICATIONS:

- small sites that require a fast grass cover to stabilize the soil and promote regeneration of natural vegetation.

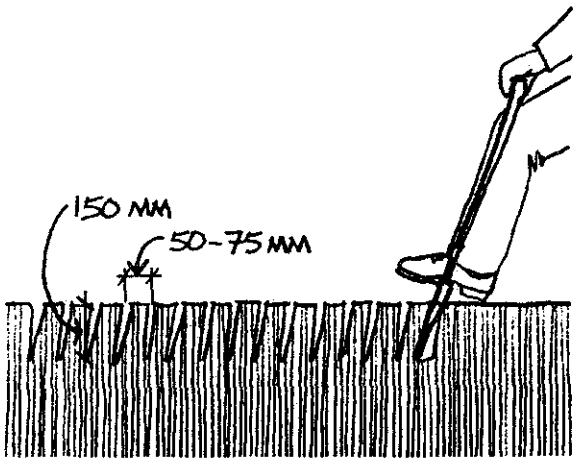
- gullies, paths, roads, outfalls, garbage sites, construction zones, stockpiles.

INSTRUCTIONS:

1. Ensure that drainage is good throughout the entire area to be restored and that appropriate techniques have been implemented to control soil erosion (i.e. check dam within a gully) (see 4.2.6 - 4.2.10).

2. Obtain soil samples of existing topsoil as outlined in 2(a), Restoration Technique 4.11.4, to determine the proper fertilizing program.

3. Scarify existing topsoil to a depth of approximately 150 mm using a spade or fork. Alternate the rows of cut and ensure that cuts are made perpendicular to the slope to slow the action of water movement and trap soil particles.



4. Remove all debris, roots, stones, and other foreign matter, apply fertilizer as determined by the soil analysis and rake into top 50 mm of scarified topsoil.

5. Apply at a rate appropriate to the seed mix used and rake into the top 5 mm of topsoil without compacting newly seeded areas.

6. Water the soil to obtain a moisture penetration of 100 mm and ensure that the water does not collect or wash away the seed.

7. A light rolling of the grass area after germination will press the heavied soil down and firm the roots.

4.11.6 SEEDING - METHOD 3

APPLICATIONS:

- sites where the intent is to establish native grasses and wildflowers from seed.

INSTRUCTIONS:

1. Prepare seed bed as in Seeding Method 1 (4.11.4) for large sites or as in 4.9 for small sites.

2. Fall planting is preferred to permit stratification of seeds.

3. On large sites, a seed drill or culti-packer type seeder is recommended for seeding.

4. On small sites, a hand-operated broadcast seeder is sufficient, provided that relatively even seed distribution is achieved and that the seed bed is subsequently lightly raked and lightly compacted.

5. A seed mix ratio of 80:20 (grasses: forbs) should be used and applied at a rate of 1-2 lb. per acre.

6. Oats or rye (annual) can be used as a cover or nurse crop to protect the site against wind and water erosion and weed competition (see also 4.2.16).

7. Greatest success is usually achieved through the use of 15-20 types of forbs (wildflowers) and 5-7 species of grass. Specific species selected depends on site conditions and intended image/character and function of the site.

8. During the last two weeks of June of the first growing season, the site should be mown to a height of 150-200 mm. This cuts fast growing weeds, prevents the nurse crop from going to seed and allows the wildflowers to become better established.

4.11.7 SEEDING - METHOD 4

APPLICATIONS:

- small sites where the intent is to establish some or all of the woody vegetation from seed.

INSTRUCTIONS:

1. Fall planting is preferred to permit natural stratification of seeds.

2. If competing vegetation, exposure to wind and/or compacted soils are evident, follow procedures for site preparation for planting (4.9).

3. Immediately before planting, the prepared site should be raked to create numerous 'furrows' no more than 40 mm deep. Furrows should run across any slopes.

4. Broadcast the seeds over the seed bed. Fruits containing more than one seed should be macerated between the palms or otherwise broken up. Seeds should be randomly scattered, not purposefully placed in the bottoms of furrows.

5. Seeded areas should be mulched for over-winter protection (see 4.12.1; see also 4.2.16).

6. At some time before germination the following spring, areas exposed to full sunlight may need to be shaded (see 4.12.3).

7. During the following growing season, supplementary establishment watering may be required (see 4.12.1).

4.11.8 SODDING

APPLICATIONS:

- small areas where an instant turf is required.

INSTRUCTIONS:

1. Follow steps 1 through 4 of 4.11.4, as site conditions dictate.

2. Sod should be laid as soon after delivery to the construction site as possible to avoid drying. If the sod cannot be laid immediately, it should be stored in a shaded location.

3. The sodbed should be moist prior to laying the sod, and in no case should installation be made on dry powdery soil.

4. When laid on slopes, the first row of sod should be laid at the bottom of, and across, the slope, unless a slope is to be sodded as the cut progresses. Subsequent rows should be laid tightly against each other from the bottom of the slope to the top.

5. To promote uniform growth and strength, lateral joints within the rows should be staggered similar to a pattern of bricks.

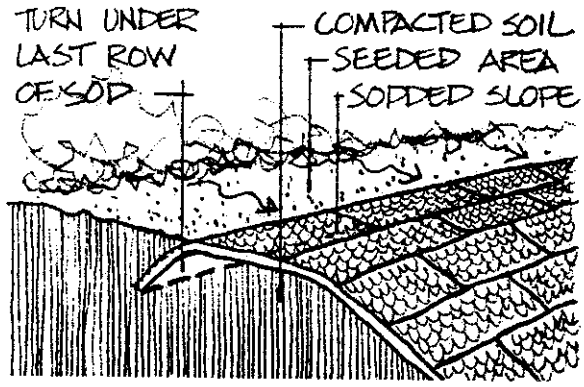
6. The edge of the last row at the top of the slope should be turned under slightly and soil should be compacted over the edge to conduct water onto the top of the sod and avoid undercutting.

7. All open joints should be filled with topsoil to prevent the roots from drying.

8. On slopes steeper than 3:1, the sod should be secured with wodden pegs spaced not over 600 mm apart, vertically and horizontally.

9. Upon completion of the sodding operation, ensure good contact with the sodbed by tamping or rolling and thoroughly watering so the moisture penetrates to the sodbed.

SURFACE RUNOFF CONDUCTED ONTO SODDED SLOPE TO AVOID UNDER-CUTTING.



4.11.9 HYDROSEEDING

APPLICATIONS:

- for fast, economical seeding and fertilizing of slopes, ditches and large open areas.

INSTRUCTIONS:

1. See 4.11.4 - follow steps 1 through 3.

2. Seed, fertilizer and mulch and water are mixed in a tank forming a slurry. This mixture is mixed and sprayed over the area under high pressure according to the operating instructions for the hydroseeder.

3. See also 4.2.16.

4.11.10 INDUCING SUCKERING, LAYERING AND SPROUTING

APPLICATIONS:

- sites where 'spreading' of existing on-site vegetation is desired, or areas where propagation of 'wildlings' is desired.

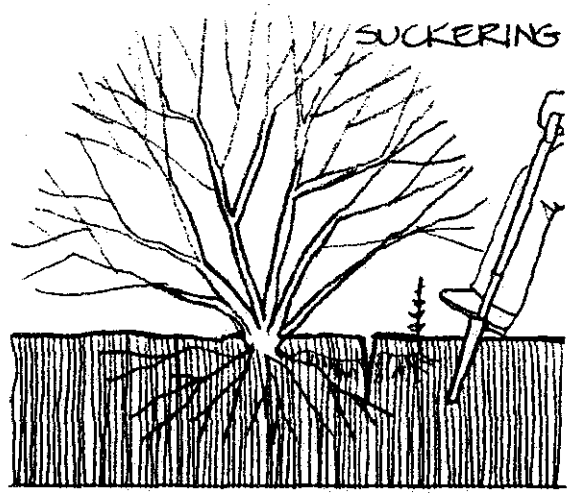
INSTRUCTIONS:

1. Suckers, originating from the roots of young plants, are readily produced by some species when stems and/or roots are cut. Stems may simply be cut with an axe, while roots may be cut with a sharp round-mouth shovel. Liberal cutting should encourage a profusion of suckers.

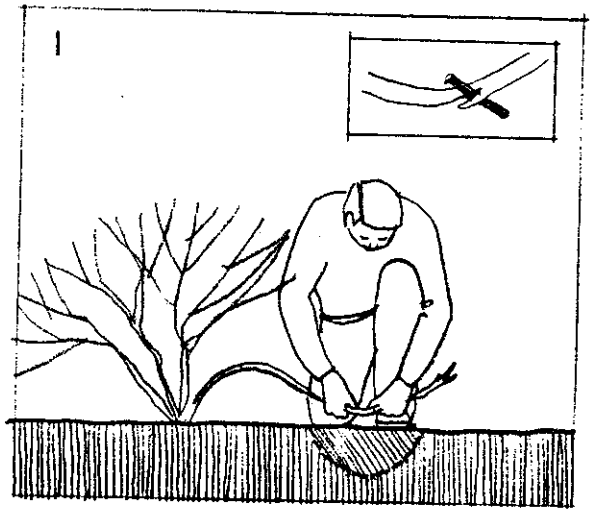
2. Suckering should be encouraged during the dormant season, to take advantage of the large food stores in the roots. Some species respond best to cutting at particular times during the dormant season.

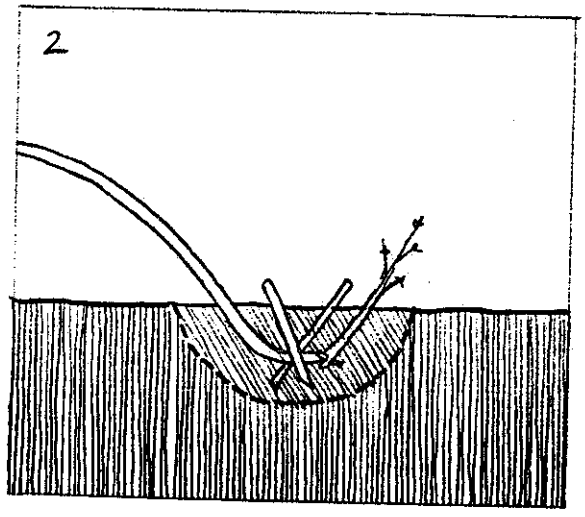
3. Some species may be induced to develop new plants when existing portions of plants are buried. This is known as 'layering'. Procedures for layering vary according to species.

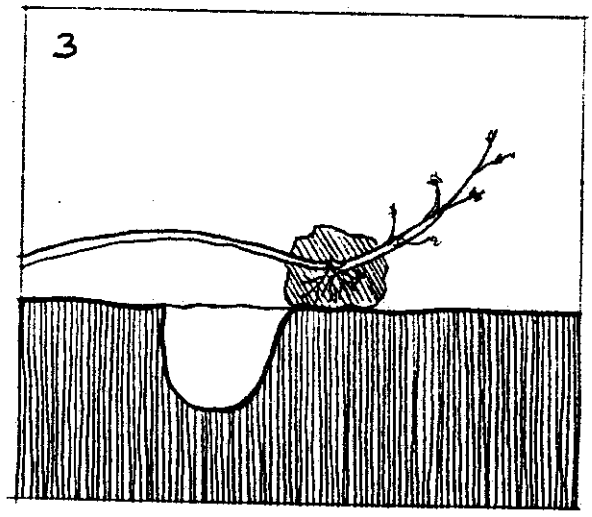
4. Sprouts are new stems originating from existing stems. In some species, they are encouraged when existing stems are cut. Stems should be cut as close to the ground as possible to ensure the production of sprouts which are free from decay. Sprouting is most vigorous in younger plants and should be encouraged during the dormant season to take advantage of the large food stores in the roots.



(after Crockett 1972)







LAYERING (after Crockett 1972)

4.12 ESTABLISHMENT MAINTENANCE

INTRODUCTION

The success rate in establishing vegetation on degraded sites can be maximized by following some basic establishment maintance techniques. These techniques are intended to minimize the effects of dessication, exposure, drought, weed competition and browsing by wildlife when the newly-established plant material is least able to cope with such problems on its own. See also 4.1, 4.6 and 4.9.

4.12.1 MULCHING

APPLICATIONS:

- planting beds where there is a need to cover the soil to prevent dessication by evaporation, to insulate planted seeds from winter cold or to provide limited erosion protection.

- limited weed control in planting beds.

- decorative/aesthetic purposes in planting beds.

INSTRUCTIONS:

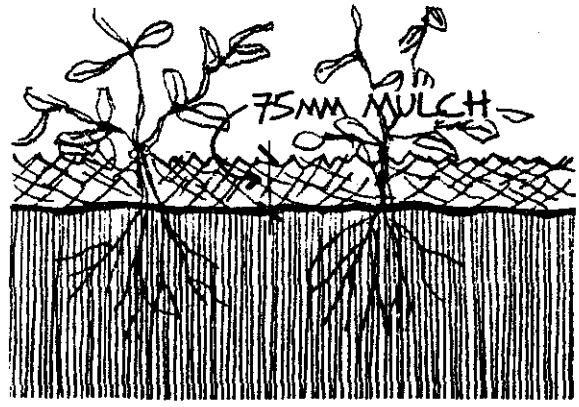
1. After planting or seeding is complete, the planting bed or seedbed should be covered, to a depth of up to 75 mm of suitable mulching material.

2. Suitable materials could include (depending upon specific site circumstances):

   -wet, partially decomposed leaves
   -wood chips or shavings
   -brush
   -poultry litter (coarse) peat moss
   -cedar bark mulch
   -straw
   -various artificial products

3. Because some mulches are readily displaced by wind, regular inspection and periodic replacement may be necessary. In some areas, additional measures may be necessary to stabilize mulch.

4. At some seedbeds, it may be necessary to remove some or all of the mulch after germination. This possibility should be considered when selecting mulch materials.



4.12.2 ESTABLISHMENT WATERING

APPLICATIONS:

- non-irrigated planting areas during dry spells in the first growing season.

INSTRUCTIONS:

1. Planting sites should be regularly inspected during the first growing season to determine the necessity of watering.

2. Plants should be examined for wilting and soils should be examined for excessive drying.

3. Care should be taken to ensure that watering does not erode soil from recently-established plants.

4. In urban or easily accessible areas, connections to a fire hydrant (if allowed), irrigation turf valve or use of a water wagon would be appropriate. If a fire hydrant is used, care must be taken to prevent damage from the high pressure spray.

5. In less accessible or rural areas, watering cans and pump-packs (as used in forest fire-fighting) would be suitable for small sites. Larger sites may require use of fire pumps and river water.

6. When watering, ensure that good moisture penetration is achieved (at least 75-100 mm), and that water is not applied so heavily as to collect, uncover and wash away seeds, expose roots or create rill erosion problems.

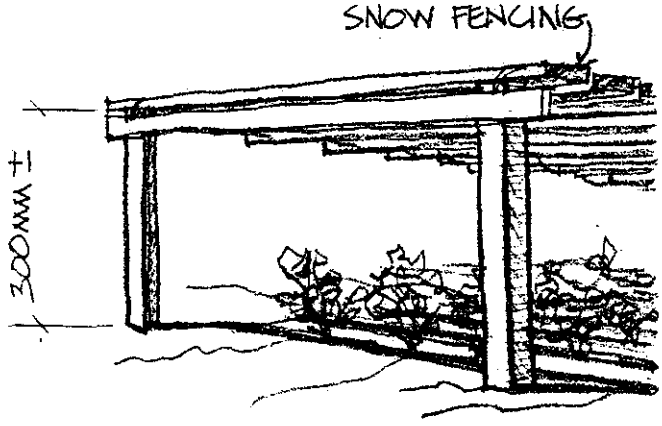
4.12.3 ESTABLISHMENT SHADING

APPLICATIONS:

- woody plant seedbeds in areas exposed to full sunlight.

INSTRUCTIONS:

1. Shading is easily provided, to protect the sensitive first year seedlings, by supporting horizontal snow-fencing approximately 300 mm over seedbeds.



4.12.4 BROWSING CONTROL

APPLICATIONS:

- newly-established planting areas susceptible to browsing (NOTE: the extent to which browsing may be a problem in any given area is difficult to determine until plant material has over-wintered; browsing is most serious in winter, except for problems caused by beaver).

a. Deer

INSTRUCTIONS:

1. Deer browsing may be controlled through the use of barriers and/or repellents.

2. Barriers for large areas should be fences, at least 2.4 m high. Page-wire fencing is adequate. For small areas (up to 12 x 18 m ±), standard snow-fencing will usually suffice.

3. Repellents are of two types: contact repellents, which repel by taste; and area repellents, which repel by smell.

4. Contact Repellents

   - in late fall, apply the contact repellent on a dry day when temperatures are above freezing.

   - treat young trees/shrubs completely; on older plants treat only the terminal growth.

   - be sure to treat to a height of 1.8 m above expected maximum snow depth.

   - as growth renews in the spring and summer, new growth will be untreated; it can be treated by applying the repellent at half the concentration used during the dormant season.

   - contact repellents include:
     i. mixture of lard and crushed hot peppers (or tobasco sauce), painted on the plants
     ii. thiram fungicide solutions, sprayed on the plants.

5. Area Repellents

- are usually less effective than contact repellents, but are also usually less expensive.

- area repellents include:

  i. small-mesh bags or nylon stockings, filled with a handful of human hair, from the plants to be protected (needs to be replaced several times a season)
  ii. small-mesh bags or nylon stockings with moth balls or crystals (need to be replaced as they evaporate).

b. Rabbits/Hares

INSTRUCTIONS:

1. Browsing may be controlled using barriers and/or repellents.

2. A 6 mm mesh wire 'cloth' should be wrapped around the plants to be protected. The mesh cylinder should be braced to keep it away from the plant. Set the mesh at least 150 mm into the ground and ensure that it extends 750 mm ± above the height of the maximum expected snow cover.

3. Larger areas can be protected by using the wire mesh as an area fence.

4. Aluminum foil, wrapped around the plant, may also be effective.

5. Thiram-based formulation can be an effective repellent when sprayed on the plants to be protected.

4.13 MISCELLANEOUS RESTORATION TECHNIQUES

INTRODUCTION

This section of the manual includes a number of restoration techniques that could not be grouped conveniently under any of the twelve categories previously described.

4.13.1 GRAVEL PIT RESTORATION

INTRODUCTION:

The field of pit and quarry rehabilitation is well developed in jurisdictions where legislation requires a rehabilitation program as an integral component of overall pit and quarry operations. In this manual, the intent is only to establish some basic principles and techniques to restore unstable slope surfaces within borrow pits that will prevent further erosion and sedimentation problems, reduce hazards to public safety and allow for subsequent after-use development.

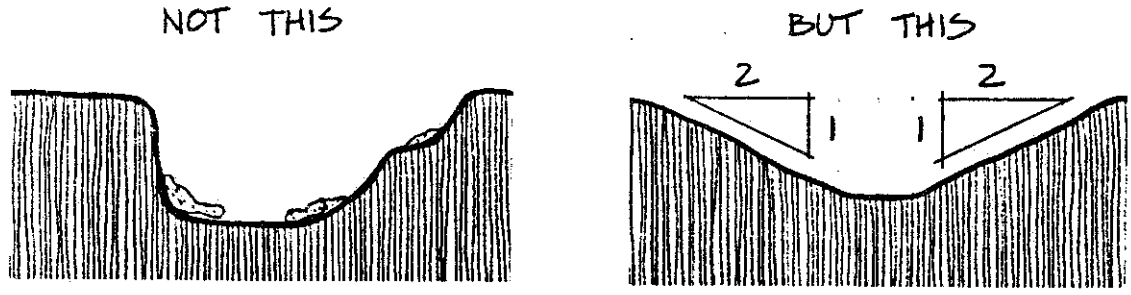
APPLICATIONS:

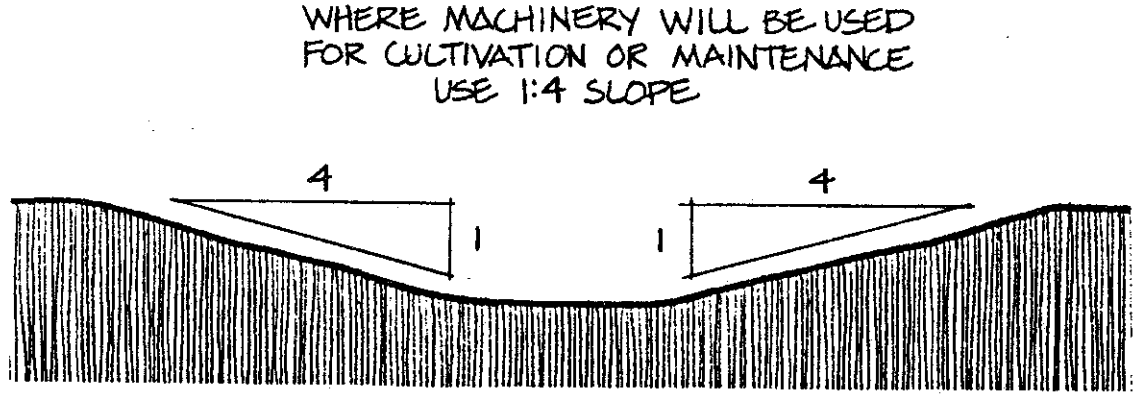
- exhausted or abandoned gravel and borrow pits or scattered, small unauthorized borrow pits or sand excavations.

INSTRUCTIONS:

1. Re-grade pit walls to minimum 2:1 (4:1 where cultivation or maintenance vehicles will be used to restore or maintain the area).

2. Depending on intended use or role of the site, temporary seeding or permanent establishment of plant material may be required (see 4.2.14, 4.2.15, 4.2.16 and 4.11) and weed control may be required (see 4.6).





4.13.2 STOCKPILE RESTORATION

INTRODUCTION:

Stockpiles may be found either in association with gravel pits or borrow pits (as overburden stockpiles) or in isolation (usually overburden or excess fill material from construction projects). As with borrow pits, the key to their temporary or permanent restoration lies in stabilizing the surface of the stockpiles.

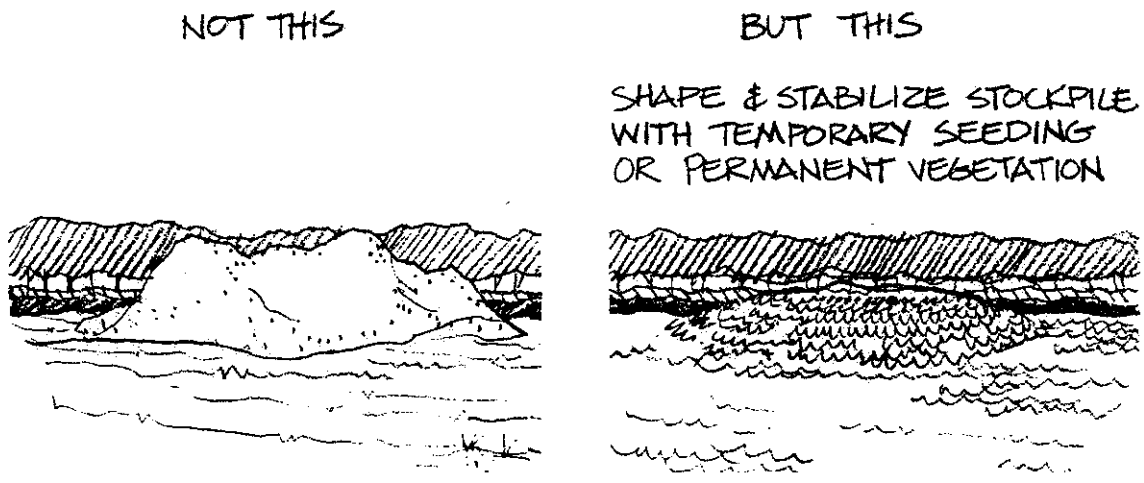
APPLICATIONS:

- stockpiles of topsoil or fill that will not be removed in the near future.

INSTRUCTIONS:

1. Grade all slopes to minimum 2:1 (4:1 if cultivation or maintenance vehicles will be used to restore or maintain the site).

2. Depending on the intended use or role of the site, temporary seeding or permanent establishment of plant material may be required (see 4.11) and weed control may be required (see 4.6).



4.13.3 RESTORING DUMP SITES

INTRODUCTION:

Dump sites could include abandoned domestic 'nuisance grounds', rubble dumps or sites where toxic materials have been disposed (e.g. agricultural and pesticide and herbicide containers, hazardous industrial waste, etc.).

APPLICATIONS:

- abandoned or unauthorized existing dumping sites.

INSTRUCTIONS:

1. Assess the possibility of the site containing toxic or hazardous substances. NOTE: If there is reason to believe that such substances may have been disposed on the site, contact the Land Protection Branch, Saskatchewan Environment before beginning any clean-up operations.

2. Once the safety of clean-up and restoration operations has been determined and appropriate protection measures taken, remove or bury (with clean fill) all previously dumped material. The decision as to whether to remove or bury the material should be made by the restoration co-ordinator, and should be based on such factors as the volume of previously dumped material, the appropriateness of changing grades through the addition of fill, the environmental implications of not removing the dumped material and the relative costs of the two approaches.

3. If toxic or hazardous material has been dumped at the site, it may also be necessary to excavate contaiminated soil. NOTE: A suitable, approved disposal site for any toxic or hazardous materials and contaminated soil must be confirmed prior to the initiation of clean-up and restoration measures.

4. Once the dumped material has been removed or buried, establishment of vegetation may be required (see 4.11).

4.13.4 SKATING RINKS ON LAWNS

INTRODUCTION:

An annual problem wherever turf is flooded for ice rinks, and where the ice is in direct contact with the turf for more than 75-90 days. Techniques to deal with this problem range from annual restoration of the turf, through provision of buffering mulch material over the turf before first flooding (prevention), to establishment of an alternate durable surface for flooding.

APPLICATIONS:

- sites where rink ice is contact with turf through the winter season.

a. ANNUAL RESTORATION

INSTRUCTIONS:

1. Ensure that the site is graded (prior to flooding) to provide for rapid drainage during the spring thaw.

2. In early to mid-May examine the turf and determine the extent of turf winterkill. This will determine whether 'spot' restoration or wholesafe renovation of the turf is required.

3. It is expected that annually, aeration, top seeding and top dressing of affected areas will be required. Less frequently, if wholesale turf restoration is required (every 2-3 years), it may be necessary to cut out old dead turf and re-seed or re-sod (see 4.11.4, 4.11.5 or 4.11.8).

NOTE 1: Delaying initial flooding as late as possible in early winter and placing a thick snow layer on the turf prior to flooding may help to minimize extent of winterkill.

NOTE 2: In the autumn, aerating the turf prior to freeze-up is recommended, to minimize winterkill resulting from compaction.

b. MULCHING BEFORE FLOODING

INSTRUCTIONS:

1. Ensure that the site is graded to provide for rapid drainage during the spring thaw.

2. Place straw or similar mulching material, to a depth of 100-150 mm throughout the area to be flooded, and extending a minimum of 1 metre beyond the perimeter of the flooded area. Roll lightly. A 4-6 mil polyethylene sheet (clear) may be laid over the straw prior to flooding.

3. As early in spring as possible, remove the poly sheet (if used) and all mulching materials.

4. Any winterkill areas should be treated as per (a) above.

NOTE 1: Delaying initial flooding as late as possible in early winter and placing a thick snow layer over the mulch prior to flooding may help to minimize extent of winterkill.

NOTE 2: The spring thawing process may be accelerated by: punching holes through the ice at 300-900 mm intervals; an application of a black organic material such as soot, lampblack or a fertilizer; or a combination of the two. Rapid drainage should also be ensured, as standing water slows the melting process.

NOTE 3: In the autumn, aerating the turf prior to freeze-up is recommended, to minimize winterkill resulting from compaction.

c. ALTERNATE SURFACE

Some grasses (e.g. creeping bentgrass) can withstand up to 150 days under ice. However, the site preparation requirements (especially sub-surface drainage measures) and the very high maintenance levels required to successfully establish and maintain such grasses suggests that they would not be a feasible alternative.

Asphalt or concrete surfaces would be suitable for skating rink development, provided that their presence, permanently, on the site is considered appropriate to the intended use or role of the site.

5. SPECIES - SPECIFIC PRESCRIPTIONS

The compilation of a comprehensive data base which includes pertinent bio-physical requirements and suggested methods of propogation for common vegetative species in the Meewasin Valley, on a species-specific basis, will be a major and long-term project. However, to assist those involved in co-ordinating, planning and implementing the Riverbank Restoration Program, such a data base will be very helpful. Much of the required information exists in numerous texts, research reports and other publications. The task is to assemble the pertinent information under one cover or in an easily accessible electronic data retrieval system.

Included here are a few examples of the types of information considered to be important to such a data base. As the restoration program proceeds, experience and results of the monitoring program may suggest additional information that should be included or refinements/corrections to information already included.

It is recommended that the system be organized, at the most general level, according to plant type (e.g. deciduous trees, coniferous trees, deciduous shrubs, coniferous shrubs, herbaceous plants). Within each general category, alphabetical listings (by taxonomic names) may be appropriate (NOTE: in an electronic data processing system, information would probably be retrievable through the use of either common or taxonomic names).

Following is a short series of species-specific prescriptions for a few of the common shrub species in the Meewasin Valley.

NAME - Cornus stolonifera (red-osier dogwood)

BIOPHYSICAL REQUIREMENTS

Soil: all but very dry soils are tolerated

Light: open areas best; moderate shade tolerated

SUGGESTED METHOD(S) FOR PROPAGATION

i. Planting - nursery grown stock
- wildlings
- layering (see below)
- stem cuttings - timing: hardwood cuttings taken in early spring
: softwood cuttings taken in early August

ii. Seeding - seed ripening dates: July to October
- indicators of ripeness: fruit white or lead coloured
- abundant seed crops: probably every 1-2 years.

ADDITIONAL REMARKS

Layering is readily induced. Branches which are not severed from the 'mother' plant are fastened to the ground with hooks or other suitable mechanisms and covered with soil.

NAME - Amelanchier alnifolia (Saskatoon)

BIOPHYSICAL REQUIREMENTS

Soil: moist to well-drained

Light: open areas best; moderate shade tolerated

SUGGESTED METHOD(S) FOR PROPAGATION

i. Planting - nursery grown stock
- wildlings

ii. Seeding - seed ripening dates: July to September
- indicators of ripeness: fruit dark purple or black
- abundant seed crops: probably every 1-2 years

ADDITIONAL REMARKS

NAME - Juniperus horizontalis (creeping juniper)

BIOPHYSICAL REQUIREMENTS

Soil: well drained

Light: open to moderate shade

SUGGESTED METHOD(S) FOR PROPAGATION

i. Planting - wildlings

ii. Seeding - seed ripening dates: probably late summer or fall
- indicators of ripeness: fruit light blue, scarcely glaucous
- abundant seed crops: irregular

ADDITIONAL REMARKS

Unless seed is given special treatment, it does not germinate until the second spring after fall planting. Information on the pretreatment of seed may be found in Seeds of the Woody Plants in the United States; U.S.D.A. Forest Service, Agricultural Handbook 450, 1974.

NAME - Prunus virginiana (common chokecherry)

BIOPHYSICAL REQUIREMENTS

Soil: well drained

Light: open areas best; moderate shade tolerated

SUGGESTED METHOD(S) FOR PROPAGATION

i. Planting - nursery grown stock
- wildlings

ii. Seeding - seed ripening dates: August - September
- indicators of ripeness: fruit dark red to purplish black
- abundant seed crops: annually

ADDITIONAL REMARKS

NAME - Rubus idaeus (red raspberry)

BIOPHYSICAL REQUIREMENTS

Soil: well drained

Light: open areas best; moderate shade tolerated

SUGGESTED METHOD(S) FOR PROPAGATION

i. Planting - nursery grown stock
- wildlings
- root cuttings: size - 150 mm long; thicker roots give best results
: timing - should be taken as early as possible in spring
: planting - horizontally, 10 mm deep
- tip layering (see below)
- suckering (see below)

ii. Seeding - seed ripening dates: July to October
- indicators of ripeness: fruit red, sweet to taste
- abundant seed crops: annually

ADDITIONAL REMARKS

Tip layering is readily induced. In late summer, when the stems of existing plants are long enough so that they naturally bend over and touch the ground, and have elongated so that a bare portion or stem tip extends 80-150 mm beyond the last set of leaves, the tips of such stems are planted. Tips, still intact with the 'mother' plant, are planted tip down at a depth of 100-150 mm and are packed firmly with soil. Rooting begins immediately.

Suckering is readily induced when stands are cut or thinned and when deep roots are severed.

This is a useful barrier species.

NAME - Salix spp. (willows)

BIOPHYSICAL REQUIREMENTS

Soil: moist

Light: open areas best; light shade tolerated

SUGGESTED METHOD(S) FOR PROPAGATION

i. Planting - nursery grown stock
- wildlings
- suckering
- sprouting
- stem cuttings: timing - taken in late winter/very early spring
: planting - vertically 150-200 mm deep with at least 2 buds remaining above the ground

ii. Seeding - seed ripening dates: probably May to July
- indicators of ripeness: fruit yellowish
- abundant seed crop: probably every 1-2 years

ADDITIONAL REMARKS

Seed remains viable for only a few days after ripening. Therefore, seed to be collected should be watched closely so that it can be collected immediately after ripening.

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Wehr Nature Centre (1977): Prairie Propogation Handbook; Fifth Edition; Milwaukee County Park System; Milwaukee, Wisconsin.

APPENDIX I: PARTIAL LIST OF COMMERCIAL SEED SOURCES

CANADIAN SOURCES

Aimers Wildflower Seeds
Cotswolds, The Green Lane
R.R. 1 King, Ontario
L0G 1K0

Golden West Seeds Ltd.
915 - 23 Avenue S.E.
Calgary, Alberta
T2G 1P1

Prairie Seeds Ltd.
R.R. 1
South Edmonton, Alberta
T6H 4N6

Rocky Mountain Seed Service
Box 215, Golden B.C.
V0A 1H0 Canada

U.S.A. SOURCES

Applewood Seed Co.
833 Parfet Street
Lakewood, Colorado
80215 U.S.A.

Arrow Seed Company, Ltd.
Box 722
Broken Bow, Nebraska
68822 U.S.A.

Boehlke's Woodland Gardens
W 140 N 10829 Country Aire Rd.
Germantown, Wisconsin
53022 U.S.A.

Christensen's Nursery Co.
935 Old County Road
Belmont, Calif.
94002 U.S.A.

Clyde Robin Seed Co., Inc.
Box 2855
Castro Valley, California
94546 U.S.A.

Conley's Garden Center Inc.
145 Townsend Ave.
Boothbay Harbor, Maine
04538 U.S.A.

Curtis & Curtis, Inc.
Star Route Box 8A
Clovis, New Mexico
88130 U.S.A.

Dean Swift
P.O. Box B
Jaroso, Colorado
81138 U.S.A.

Environmental Seed Producers
P.O. Box 5904
El Monte, California
91734 U.S.A.

Horizon Seeds, Inc.
1600 Cornhusker Highway
P.O. Box 81823
Lincoln, Nebraska
68501 U.S.A.

Jacklin Seed Company
West 17300 Jacklin Ave.
Post Falls, Idaho
83854 U.S.A.

Lafayette Home Nursery, Inc.
Layfayette, Illinois
61449 U.S.A.

Little Valley Farm
R.R. #1, Box 287
Richland Center, Wisconsin
53581 U.S.A.

Midwest Wildflowers
Box 64
Rockton, Illinois
61072 U.S.A.

Natural Habitat Nursery
4818 Terminal Road
McFarland, Wisconsin
53558 U.S.A.

Northplan Seed Producers
N.A.P.G. Inc.
P.O. Box 9107
Moscow, Idaho
83843 U.S.A.

Prairie Associates
6328 Piping Rock Road
Madison, Wisconsin
53581 U.S.A.

Prairie Nursery (J.R. Smith)
Rt. 1, Westfield
Wisconsin
53964 U.S.A.

Prairie Restoration, Inc.
990 Old Long Lake Road
Wayzata, Minnesota
55391 U.S.A.

Prairie Ridge Nursery
(Joyce Powers)
9738 Overland Road
Rt. 2, Mt. Horeb
Wisconsin
53572 U.S.A.

Prairie Seed Source
Box 831, North Lake
Wisconsin
53064 U.S.A.

Prairie Seed Source
P.O. Box 1131
Des Moines, Idaho
50311 U.S.A.

Sharp Bros. Seed Company
Healy, Kansas
67850 U.S.A.

Stock Seed Farms Inc.
R.R. Box 112
Murdock, Nebraska
68407 U.S.A.

Wildlife Nurseries
P.O. Box 2724
Oshkosh, Wisconsin
54903 U.S.A.

Windrift Prairie Nursery
Rt. 2 Oregon, Illinois
61061 U.S.A.