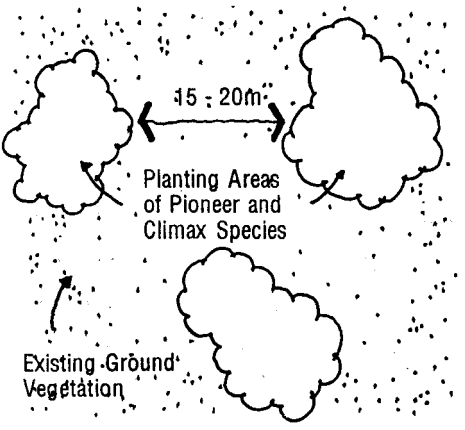
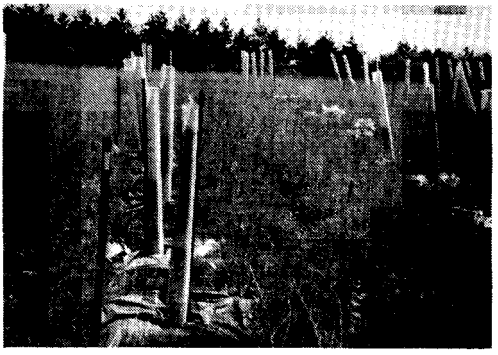
The distance between patches can vary, creating a more natural effect as they grow together. Distances could be as small as 10 metres, or 50 metres or greater. Planting shrubs as edge species may help by reducing wind desiccation and by providing a buffer between tree species and old field vegetation.



New plantings need protection from winter rodent damage to ensure survival. Alternative approaches include:

- fencing small (50-100 m²) patches with fine mesh;
- placing plastic or paper sheeting over small patch surface;
- wrapping individual tree guards around whips or seedlings.

(See also alternative weed control measures under Natural Regeneration.)



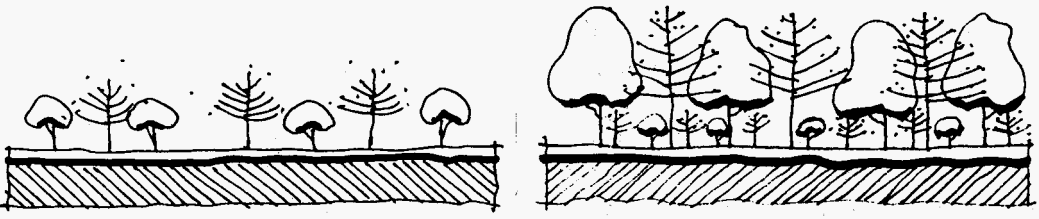
Tree shelters providing rodent protection and microclimate control

Where plantings are not protected from rodents, increase patch size substantially. Such damage occurs at the base of plants primarily in winter.

Managed succession

This approach, first developed in the Netherlands and Britain, is based on the principle of natural succession assisted through management. Planting is initiated with pioneer or fast growing nurse species, continues with slow growing trees, and evolves over time into a climax stand.

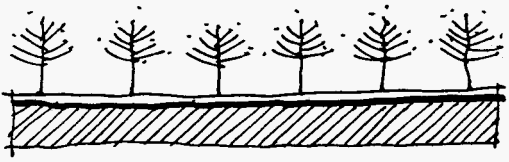
Composition, character and uses of the woodland will be quite different as it evolves. Site conditions in initial stages are less critical than they are in standard plantations, since the nurse crop functions



to ameliorate soil drainage, fix nitrogen, stimulate soil micro-organisms, and create a microclimatic environment suited to the development of climax vegetation.

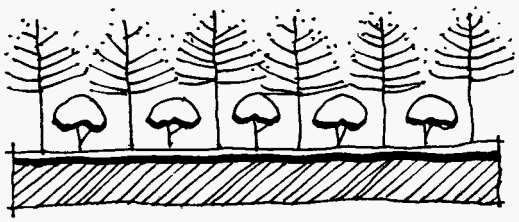
Approaches to Planting

Irrespective of the density of planting, several options can be considered.



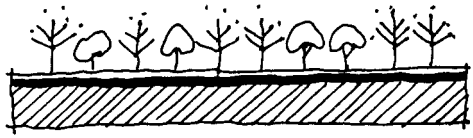
Initial planting of pioneer species only:

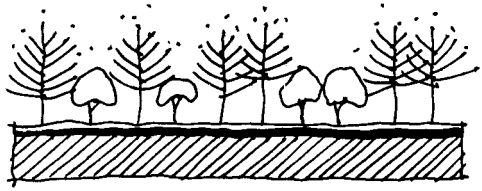
- quickly creates the woodland environment, with canopy closure. Improves the microclimate for climax species;
- requires planting of climax species at a later date;
- relies on natural succession for introducing climax species (requires a seed source and may be slower);
- the final composition of the woodland will be different from the species originally planted.



Combination of pioneer and climax species:

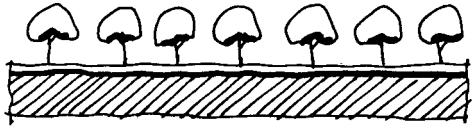
- fast growing pioneer species and climax species are planted at the same time;
- they quickly improve microclimate while the slower growing climax species become established;
- replaced naturally by climax species as the woodland matures;
- the final composition of the woodland will change over time;
- establishment of climax species may take longer or they may not survive.





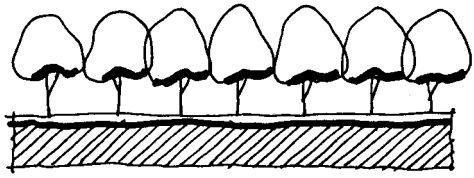
Initial planting of climax species only:

- slower growth of climax species results in a much longer restoration process;
- the final composition of the woodlands reflects the species originally planted.



Planting of a single species:

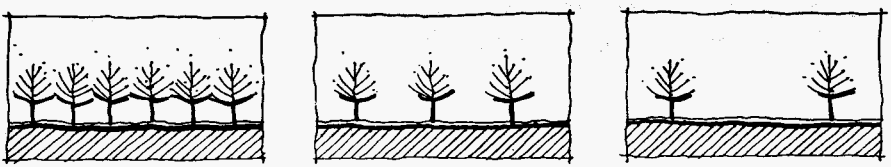
- common in forestry applications;
- results in plantations that are not self-sustaining and are considered to have low ecological value.



Plantations may be suitable for cedar stands, which naturally occur as a single species, but the spacing of the plant material should be random, not regular. As part of ecological restoration, a mixture pioneer and/or climax species is more appropriate.

Spacing

Differences in spacing reflect three basic possibilities: planting the ultimate quantity, planting greater-than-ultimate quantities, and planting less-than-ultimate quantities. Each approach has advantages and disadvantages.



	GREATER-THAN-ULTIMATE QUANTITY	*ULTIMATE QUANTITY*	*LESS-THAN-ULTIMATE QUANTITY*
SPACING	1 m, 1.5 m or 3 m on centre	5 m to 6 m on centre	10 m or more on centre
PLANTING COSTS	high	moderate	low
WOOD-LAND CREATION	fast canopy closure (some pioneer species 5 years)	slow canopy closure	very slow canopy closure
VISUAL APPEAR-ANCE	woodland	open woodland	grasslands with some woody vegetation
MANAGE-MENT	regular thinning of the stand	reducing weed competition	reducing weed competition and replanting bare areas
MANAGE-MENT COSTS	post canopy closure thinning, which is labour intensive and relatively costly	low	low
RODENT DAMAGE	unlikely to create significant gaps in planting	may require some replanting	extensive damage may require replanting of areas
REMARKS	some management until climax species are established (depending on approach to woodland establishment)	initial planting requires neither ongoing management nor extensive time frame	trees planted initially act as seed source and create a suitable microclimate for natural regeneration

Plant material

The size of the planting stock is largely a question of cost. Acreage of most restoration projects precludes the use of large plant material. As a result, seedlings and lining out stock are often used. Both bare root and container grown material have advantages and disadvantages. Planting methods usually rely on hand labour, but

the use of mechanical planting sticks could be a possibility for the planting of large quantities of seedlings.

Plant Material

	BARE ROOT MATERIAL	*CONTAINER GROWN*
COST	cheap	more expensive
HANDLING	easy to transport	bulky and heavy
CARE PRIOR TO PLANTING	roots must be kept moist at all times	potted, less susceptible to drying out
STORAGE	requires cold storage facilities or must be planted right away	can be stored for long periods with occasional watering
PLANTING TIME	narrow window in spring and fall	any time during the growing season
SUCCESS RATE	varies with care given prior to planting	more consistent results

Site preparation

Site preparation is a crucial factor in woodland restoration. As old field vegetation and grasses compete for nutrients, moisture and sunlight, these species must be eliminated before woody species are planted. (For specific remedial measures see Section 5.4 on soil rehabilitation.)

Alternative weed control measures

TREATMENT	*ACTION*	*COMMENTS*
MECHANICAL/ MANUAL CULTIVATION	◆ cultivate planting area prior to planting to kill ground vegetation ◆ cultivate manually during growing season (monthly)	◆ labour intensive ◆ application to small or awkwardly sheltered areas ◆ application to close planting where fast canopy closure is a high priority ◆ constant maintenance during growing season
BLACK PLASTIC:	◆ cultivate ground 30 to 45 cm deep; ◆ apply plastic sheeting to surface and peg in place; ◆ puncture holes with a garden fork at 15 cm on centre; ◆ cut crosses in sheeting in planting locations; ◆ install plant material and re-cover with sheeting; ◆ apply 2 to 3 inches of wood chips or leaf mulch over area. ◆ applying mulch prior to the installation of the plant material is more convenient when a random spacing is used.	◆ highly effective ◆ easy to install ◆ low to no maintenance costs to control weeds ◆ non-biodegradable, and must be removed after canopy closure ◆ potential visual problems without mulching on top of sheeting

PAPER PRODUCTS	• install plant material; • remove herbaceous vegetation around the plant; • install paper collar; • apply 2 to 3 inches of wood chips or leaf mulch over area.	• effective • easy to install • low maintenance costs to control weeds • biodegradable in approximately 5 years • suitable for low planting densities and random planting

Mulching

Mulching reduces competition from grasses and other herbaceous species. Mulch should be 7 to 10 cm (3 to 4 inches) thick. The area to which mulch is applied depends on the spacing of plant material. In densely planted areas, the mulch layer can be continuous. For trees and shrubs planted individually, the mulch should be applied over the root zone (60 to 90 cm diameter). Mulch generally consists of wood or bark chips, although other biodegradable materials have been used.

Caution

Do not apply mulch over areas with high soil moisture, until the soil has dried out. Mulch can trap moisture and encourage rotting of newly installed plant material.

5.4 RESTORATION OF DEGRADED HABITAT

For plantations, grazed and biologically stressed woodlands, restoration techniques focus on reintroducing diversity and redressing site conditions. Soil rehabilitation techniques discussed here are also appropriate for areas where topsoil has been removed.

Soil rehabilitation

Three common problems are soil compaction, soil fertility, and lack of organic matter. These conditions often occur simultaneously, especially where topsoil has been removed. Soil compaction will require different solutions from low nutrient levels, or lack of organic matter.

Compaction or poor soil structure

Soil compaction due to grazing or overuse results in reduced water penetration and a lack of oxygen. It creates adverse conditions for roots and seriously limits plant growth, as well as seed germination and establishment.

Soil rehabilitation requires aeration or cracking of soil to improve its physical structure.

Traditional aerators generally effect the root zone of sod and have little benefit for woody species. Newer aerators pull a solid plug object through the soil, loosening compacted soil much more deeply and effectively. Where existing plant material limits the use of other techniques, small explosive charges in the ground can give the desired result. Companies specializing in these techniques should be consulted. Disking or rototilling can also loosen compacted soil.

Caution

Disking or rototilling exposes seeds in the soil to light, resulting in increased weed growth. It disturbs the root zones of existing trees.

Soil fertility and organic matter content

Check soil nutrient and organic matter levels. Consider the application of fertilizers only where a gross imbalance exists that would jeopardize the success of the restoration. Native plant species generally create viable, self-sustaining communities in soils with low nutrient levels. Of greater concern are those soils with higher-than-normal fertility, since this encourages competition from weeds and introduced species. To remove soil nutrients, harvest plant growth for one or more seasons prior to restoration of woodland species.

Deficiencies in organic matter can be improved by:

- adding leaf compost to enhance soil composition and structure;
- adding manure to provide soil nutrients in soluble form;
- growing a green manure crop such as clover or annual grasses. These are plowed under after one growth season;
- planting deep rooting clovers and other legumes to improve soil structure and enhance water penetration.

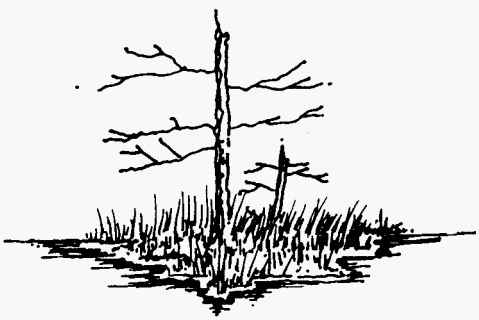
Caution

During the decomposition process, organic matter can tie up available nitrogen and make it unavailable for plant growth. In soils with low nutrient levels, it may be necessary to add a nitrogen fertilizer.

Manure and municipal compost may contain introduced plant seeds. Peat moss is a nonrenewable material and should not be used.

Thinning existing stands and gap creation

Gap creation, or thinning, opens up the canopy and allows light to penetrate to the forest floor. This improves growing conditions for seedlings, enhances their survival, and can add diversity in a plantation or a dense early successional woodland. Several small gaps are preferable to one larger one. Gaps should be small enough that excessive growth of early successional herbaceous species is not encouraged.



Selective removal of a few trees will be sufficient to create a gap. Do not remove large, healthy specimens or dead trees (snags), which serve an important function for many wildlife species.

Planting in or near an existing stand can introduce desired species that become the seed source for natural regeneration. Planting may not be necessary where suitable a seed source exists.

Interplanting

In pioneer stands, interplanting of climax canopy species will speed up the development of mature woodland. Interplanting is also used to introduce midstorey and understorey plants in existing stands that have an established canopy.

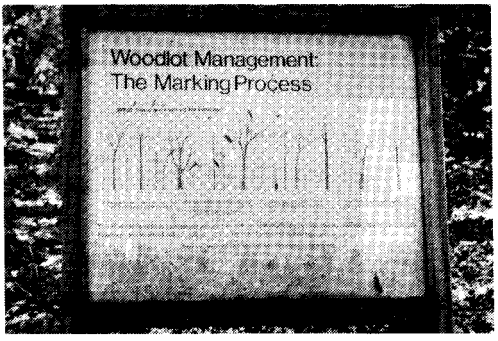
Control of introduced species is difficult in the urban environment. The best control is prevention. Avoid planting introduced species

adjacent to natural areas, and if they are present, remove them. Since this is labour intensive, expensive, and sometimes causes damage to natural areas, it is important to remove the seed source as well. If doing so is not possible, control measures will become part of the ongoing management for the area.

Bioengineering techniques

For steep slopes, bioengineering techniques may be useful. Contour wattles or fascines are used to stabilize cut slopes, and brush layering can be used in fill situations. Both techniques create sheet drainage across the slope, since erosion channels, or rills, can seriously undermine newly placed plant material. For a more detailed discussion of these techniques see Section 6 on Riparian Habitat.

5.5 MANAGEMENT



Management of woodlands occurs primarily during their establishment. The initial period involves maintenance measures to achieve canopy closure. Later, management techniques are aimed at achieving a self-sustaining woodland. Management approaches for different types of woodland landscapes should reflect site specific conditions and restoration objectives. Some general guidelines are given below.

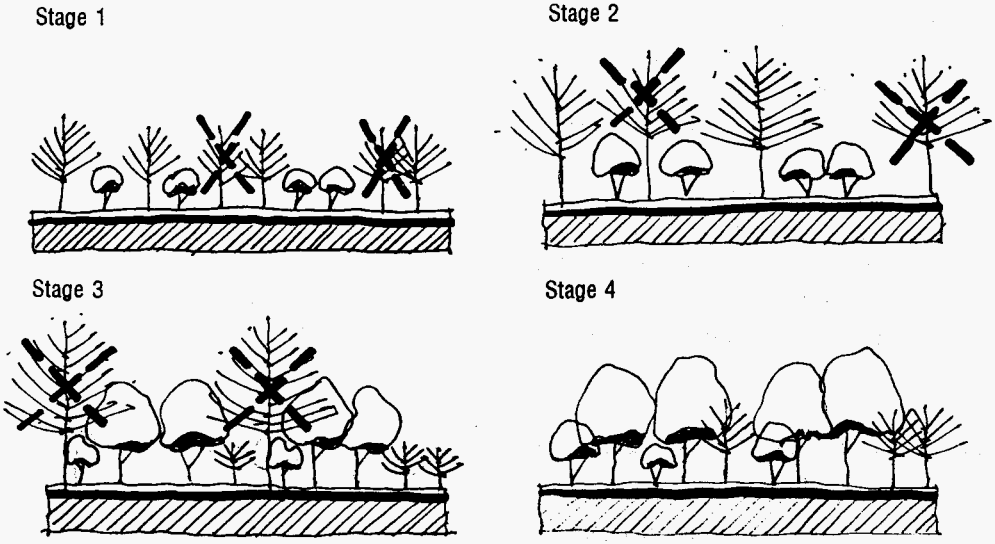
During the initial maintenance period, which lasts until canopy closure (4-6 years):

- evaluate the survival of plant material, and implement remedial measures if required. Small patches where survival has been poor will not affect woodland establishment, but widespread problems need to be addressed;
- check for gnawing or browsing damage, and determine if remedial measures are required;
- control grasses and herbaceous vegetation in planted areas. Reinstall mulch if necessary;

- remove black plastic, if used, once canopy closure has occurred.

Management considerations to achieve a self-sustaining woodland include:

- thinning of stands to reduce overplanting. This generally involves the removal of pioneer species in 2 to 3 successive thinning operations, allowing the slower growing climax species to gradually form the woodland canopy;
- interplanting of climax species in pioneer stands, or addition of midstorey or understorey plants (depending on natural volunteering of species);
- replacing trees in areas where there has been poor take, rodent damage or deer browsing;
- controlling undesired species through burning or manual removal of introduced plant material.



Opportunities:

- leave trees felled as part of the thinning process to enhance wildlife habitat;
- leave snags to provide nesting habitat for birds.

Dealing with invasive species

Garlic mustard, a herbaceous groundcover, is a very prolific grower that displaces native flora. Preferring shady, moist locations, it reaches a height of 60 to 90 cm, lower in dry or sunny locations. Control methods are limited. Hand removal prior to flowering in late May or early June is feasible for small areas.

Tatarian honeysuckle is a deciduous shrub that has escaped from cultivation. It is adapted to shady locations, but also occurs in sunny but moist areas, such as riparian habitat. Removal is very labour intensive due to the dense branching structure. Either roots have to be dug up, or the stumps painted with herbicide to prevent regrowth. The use of herbicides is controversial in urban areas and is often banned. Burning the understorey has also been tried in New England, with varying degrees of success. Burning may not be an acceptable alternative in some urban areas.

European buckthorn is a deciduous shrub that displaces native understorey species and ground flora in woodlands. It is continuing to spread northward. The shrub creates a dense thicket of branches. The heavy shade prevents native flora and understorey species from competing. Eradication is very labour intensive, since both branches and roots must be removed to prevent regrowth. Painting stumps with herbicide is an alternative (often controversial in natural areas).

Norway maple is a deciduous tree that has escaped from cultivation. A number of cultivars have been widely planted in built-up areas, due to their tolerance of urban conditions. In many cities, Norway maples have become so popular that they have been planted—and continue to be planted—as street trees, in park settings and on residential properties. Norway maples are prolific seeders, and their seedlings have a high success rate. They now occur in natural valleys and ravines throughout urban areas, and even in rural zones. Mature trees cast a very dense shade, displacing native canopy trees and understorey species. The lack of understorey contributes to erosion on the slopes of ravines and valleys. On all sites, Norway maples displace native flora and alter habitat. Control in urban areas will be difficult, due to the steady seed supply. In natural areas, management must include the removal of both trees and the seed

source. Norway maples should not be planted near ravines, valleys, or other natural areas.

5.6 MONITORING

A self-sustaining woodland requires little supervision. In the initial phases, the success of restoration may be monitored. In order to obtain relevant results, evaluate both the success of the technique and the survival of the different species. Monitoring rodent damage may indicate the need for remedial measures or additional planting. Consider what went right and what went wrong during the installation and subsequent establishment phase, and the reasons for those results.

Densely planted areas restored by managed succession must be monitored to assess the need for thinning. They require ongoing attention and periodic thinning.

Invasive introduced species should be monitored to determine whether to implement control measures, and, when carried out, how effective they have been.

In urban areas, woodlands should be monitored for safety. Dead or hazardous trees and large dead limbs should be removed where they jeopardize the safe use of public walkways, trails and open areas. Woodlands and other treed areas should be monitored regularly to ensure that no hazardous situations develop.

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