ABUNDANCE OF 'INDICATOR' SPECIES

The indicator

What is it?

The relative or absolute abundance of a particular 'indicator' species or group of species.

Discussion

There are many situations when the abundance of a particular species or group of species will be important as indicators. The abundance of seedlings and saplings of species that are highly palatable to introduced browsing animals may be assessed to indicate how successful animal control operations have been in improving understorey condition.

It is often useful to monitor species that are an important food source for birds or are important canopy species.

Species or groups of species that are selected as indicators will vary from site to site depending on the species present and management objectives. The key issues section below identifies some important considerations in selecting indicator species.

Some key issues

Selection of appropriate species is important. Some important features are:

- Relevant to the issue you are interested in – for example, are browsed by introduced animals, an important food source for birds, etc.
- Sufficiently common that you will be able to locate it readily.
- Has either a sufficient local seed source or source of vegetative propagation (for example, underground stem rhizomes, or stems for epicormic shoots). Without this, it may need to re-colonise the area, which can be very slow.
- Has a sufficient growth rate so changes will occur quickly.

Be careful using the same indicator species in different areas. Aspects such as browse preference for different species can vary greatly between areas.

PHOTOS: PETER HANDFORD

FIGURE 36: The abundance of particular species such as hen and chicken fern (*Asplenium bulbiferum*: right) can be examined.

Measurement methods

A variety of methods can be used to assess abundance. They are suitable for different situations of vegetation stature, abundance and management issues. Table 5 below shows how vegetation stature and abundance can affect the choice of method. An outline of the main methods of assessing abundance is also set out below.

Frequency – presence or absence

The presence or absence of a particular species within a bounded plot or at a given point is recorded, which allows frequency to be calculated as the percentage of plots/points at which the species occurs.

For example: Fifty 5m-radius plots are established along a transect to examine the frequency of kamahi seedlings between 0.5m and 1.35m in height, and kamahi epicormic shoots between 0.5m and 1.35m in height. Six of the plots contained kamahi seedlings and 15 contained epicormic shoots. This gave seedling frequency of 12 percent and shoot frequency of 30 percent.

Plot size is important because it will directly affect frequency. The larger the plot size the more likely the species will be present. Plot size should be not so small that the species of interest is rarely present neither should they be so large that the species is almost always present because this will make any increase hard to detect. Ideally, plot size should be such

TABLE 5: Use of different methods for assessing plant abundance

Growth form	*Distribution*	*Density*			
		Very low	*Low*	*Medium*	*High - very dense clumps of individuals or patches – making counting difficult*
Distinguishable individual plants	**Scattered**	Map & total count of individuals – if practical	Frequency/ density	Density	% cover
	Clumped (discrete patches)	Map & total of count number of patches – if practical	Density of patches, and density within patches	Density of patches, and density within patches	% cover
Indistinguishable individual plants (for example, vines or rhizomes)	**Scattered**	Map & % cover in each area (average % cover) – if practical	% cover	% cover	% cover
	Clumped (discrete patches)	Map & count number of patches, area of patches – if practical	Density of patches and size of patches	Density of patches and size of patches	% cover

that a frequency of between about 10 percent and 60 percent is obtained. The same plot size must be used for any comparisons between areas or over time. Using the same permanently marked plots is also advised (*see* 'What is the advantage of re-measuring change …', p.97)

This is a relatively quick and easy method, generally involving a low level of measurement skill. However it does not involve assessing the 'amount' of a species at a sample plot/point so it can be less effective at picking up small changes than cover or density-based methods.

Comments

- Quick and simple to measure
- Selection of plot size is very important
- Can pick up large changes when densities are quite low
- Not as good at picking up small changes

Density

This is normally assessed using bounded plots. All individuals (for example, tree stems, or ground fern crowns etc) are counted within the plot area. Abundance is then described as individuals per square metre, or per hectare.

For example: A 20m X 4m (80m^2) plot was assessed to examine the abundance of pigeonwood seedlings and saplings. This formed part of a monitoring programme involving several plots through the forest area. A thorough search of the plot revealed 18 seedlings and eight saplings. This gave the following densities for this plot:

Per plot	Seedling		18
	Sapling		8
Per square metre	Seedling	18/80	0.23
	Sapling	8/80	0.1
Per hectare (1 hectare = 10,000 m^2)	Seedling	18x10,000/80	2250
	Sapling	8x10,000/80	1000

Comments

- Provides simple objective data
- Can be a time-consuming method
- Selection of plot size is important (*see* 'What plot size', p.99)

Biomass

This is the total weight or quantity of living material. It is not generally practical to measure this directly for plants so it is usually estimated indirectly through relationships to more easily measured parameters such as diameter of tree stems, crown diameter of shrubs or canopy cover (Spurr & Warburton 1991).

Biomass is not generally used in practical regular monitoring because of these complexities. It can be a useful measure for identifying primary production in scientific studies, or examining carbon storage. Such studies normally include forest floor material as well.

Comments

- Considerable effort required to obtain good accurate data
- Data useful for scientific studies

References

Spurr & Warburton 1991

Cover

Commonly this relates to the percentage of cover of an area of the forest canopy, forest floor, or of a specified height tier. Absolute area of cover, usually in square metres, may sometimes be measured if monitoring, for example, the spread of a particular patch of weeds.

Percentage cover can be measured by any of the methods described under 'Canopy Cover' p. 113-117 above. As discussed in that section, visual estimates of cover have a low level of precision and are only suitable for picking up large changes. Point intercept methods can provide greater precision.

For example: A point intercept method was used to assess percentage cover of different species in the canopy. This involved assessing 100 points at 2m spacing along a transect. At each point the species present in the canopy directly above that point was recorded. The results for each species and associated estimate of percentage of cover were as follows:

Kamahi	32 points	32 percent cover
Hinau	20 points	20 percent cover
Pigeonwood	30 points	30 percent cover
Tree fern species	18 points	18 percent cover

Comments

- Useful in areas of high density and indistinguishable plants

References

'Point intercept …' p.53

DISTRIBUTION OF KEY SPECIES/UNCOMMON SPECIES

The indicator

What is it?

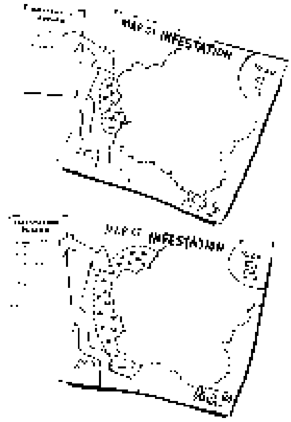
The distribution of important or rare plant species.

Discussion

This indicator becomes particularly important if a particular species is localised or present as small patches in particular locations (for example, New Zealand mistletoe). In these situations its presence at certain locations becomes more important because density across the whole area may be too low to measure.

Maintenance of the species at locations and increase or decrease in the number of locations where the species is present can be monitored as well as changing locations of a species.

This indicator can also be of particular importance with weed species that are new infestations, if their occurrence and spread are important.



see Figure 22, p.74

Some key issues

- Intensity (area covered and effort) of searching needs to be similar to make valid comparisons of changes in distribution over time, or between areas.
- What scale should distribution be assessed at? This needs to be determined depending on factors such as how large an area the species is spread over, and how precisely you need to know individual locations.

Measurement methods

Measuring changes in the distribution of a species will help identify changes in the size of the total population as well as its relative density or cover. For example, an examination using plots through a forest reserve where a species is present may show that the density of individuals remains constant. However, a wider examination of distribution throughout the whole region may show the species is declining. It may be disappearing from some areas while remaining unaffected at others.

If a species is uncommon, widespread random sampling to assess cover or density will be of little help because the species will seldom, if ever, be encountered (*see* also Table 5). In these situations mapping of scattered individuals or groups of the species may be more appropriate.

It is also important to identify if both adults and juveniles are present when assessing distribution (*see* also 'Population structure', p.136). This can give an indication of whether the population is increasing or declining.

Mapping

Thorough searching of an area is undertaken to identify locations of individuals or localised populations. These are then mapped at a scale sufficient to allow their easy relocation in the field. The suitability of different mapping scales will depend on what is being mapped. If a 50-hectare area of a rare canopy species is being identified, then mapping on 1:50,000 maps may be appropriate. If you are examining locations of individual rare plants or patches of plants aerial photographs of 1:5000 or larger scale may be appropriate.

Comments

- Choice of mapping scale is important
- If accurate coordinates are present (for example, from GPS), a smaller scale may be used
- When comparing distribution, intensity of searching must be similar

Total counts/absolute cover

Total known individuals over an area or within a localised population may be counted, or absolute cover determined (*see* 'Understorey abundance', p.128 and Table 5), where appropriate. Marking of individuals or small populations on the ground (for example, with marker pegs, or tags) may be necessary to ensure they can be relocated. Total numbers/cover can be monitored at regular intervals to identify changes.

For example, a manager wants to examine changes in mistletoe distribution between two areas, one with possum control, one without. Both areas are thoroughly searched for mistletoe before a possum control operation. Mistletoe locations are identified on 1:10,000 scale aerial photographs, and written notes are kept on how to locate each plant. One year after the control operation, the area is searched again to relocate the plants. In the control area, 24 of the original 26 plants were still present, and an additional three were found. In the no-control area, only 16 of the original 22 plants were still present, and no new plants were found.

Comments

- Thorough and consistent search effort required
- Very effective for rare species of well-known distribution

FLOWERING AND FRUITING OF KEY SPECIES

The indicator

What is it?

The amount of fruiting or flowering of key species, sometimes including other features such as damage to fruit or flowers.

Discussion

The amount of flowering and fruiting can be useful and important indicators for several reasons:

- Very important to examining the ongoing reproduction of the plant species involved.
- Important high quality food sources for birds which can affect their breeding success.
- Some (particularly certain larger fruits – eg, hinau) are important food sources for introduced vertebrates, particularly the possum, affecting their fat levels and condition (Cowan 1990).
- As it requires considerable resources for a plant to produce flowers and fruit, consequently, sustained improvements in the level of fruiting and flowering can sometimes indicate an improvement in overall plant health.

Individual New Zealand native plant species vary considerably from year to year in their level of flowering and fruiting, sometimes with higher fruiting levels every two to five years, with some years of nil or very low levels of flowering and fruiting (West 1986, Leathwick 1984, Dijkgraaf 1998). It is important that the impacts of these natural fluctuations are taken into account when using this indicator to look at changes in relation to management.

Some key issues

- It is necessary to develop knowledge of the phenology cycles of the species involved.
- Select species that are easier to assess – for example, have conspicuous fruits and flowers, and are significant to the ecosystem – for example, important food source for birds (*see* appendix 3) or introduced vertebrates or important canopy species.

Measurement methods

Flowering and fruiting can impinge on different parts of the forest ecosystem. Most New Zealand forest plant species fluctuate from year to year in the amount of fruiting and flowering (Leathwick 1984). Successful fruiting and flowering have an obvious relationship to regeneration for the species concerned. Several studies have shown important links between flowering and fruiting of some important forest species and increases in native and pest animals. For example, relationships exist between major seeding or 'mast years' in beech (*Nothofagus* species) and, mice, stoat, and bird abundance (Murphy et al 1995).

Because of their very high nutritive value, flowers and




PHOTOS: DOC

FIGURE 37: Fruiting and flowering of different species forms an important resource to birds and other animals, as well as providing plant regeneration.

fruits are often targeted by introduced browsers such as possums. Measures of the level of impact on flowers and fruit are important to identify the damage caused by pests such as possums.

Several simple approaches to the assessment of flowering and fruiting are possible (*see* Figure 38).

Visual estimates

Regular visual assessment of flowering and fruiting of different plant species, and estimates of the percentage of the canopy with fruit or flowers, can provide valuable early information. Monthly records can be kept of a sample of individual trees, or through general assessment of an area of forest (*see* 'Flowering and fruiting observation record', p.57). As with most visual estimates, this will not provide sufficient precision to identify small changes. However, it can be sufficient to pick up major flowering or fruiting events of significance to management.

Comments

- Provides a general indication of timing, and peak years
- It is important to calibrate visual estimates year to year by taking photographs of fruiting and flowering

References

'Flowering and fruiting observation record', p.57
Leathwick 1984
Williams & Karl 1996
Clout & Gaze 1984

Seed-fall counts

Direct counts of seed-fall can provide precise estimates of its abundance. Such methods are generally easier for species with larger fruits. Two suitable ways of gathering this information are as follows:

Traps: Fixed litter fall traps can be constructed that collect fruit, flowers, leaves and other litter falling from above. These traps often involve some sort of large funnel on a stand above the ground that collects material and directs it into a removable 'jar'. Simple traps can be constructed by mounting a bucket on a stake under the tree. Measurement of the amount of material collecting in these traps, including a count of seeds/fruit is used to monitor changes.

Ground plots: A quicker, lower cost alternative is to establish small circular ground plots below trees that are permanently marked. This method is only suitable for species with relatively large conspicuous fruit such as tawa, hinau, taraire, karaka, etc. A list of species for which this approach could be considered is given in 'Ground plot monitoring of seed and fruit-fall', p.62. In the plot, the fruit on the ground surface and among recently fallen litter is counted.

Other ground plot methods involving randomly located plots can also be used, as long as only fresh fruit is counted.

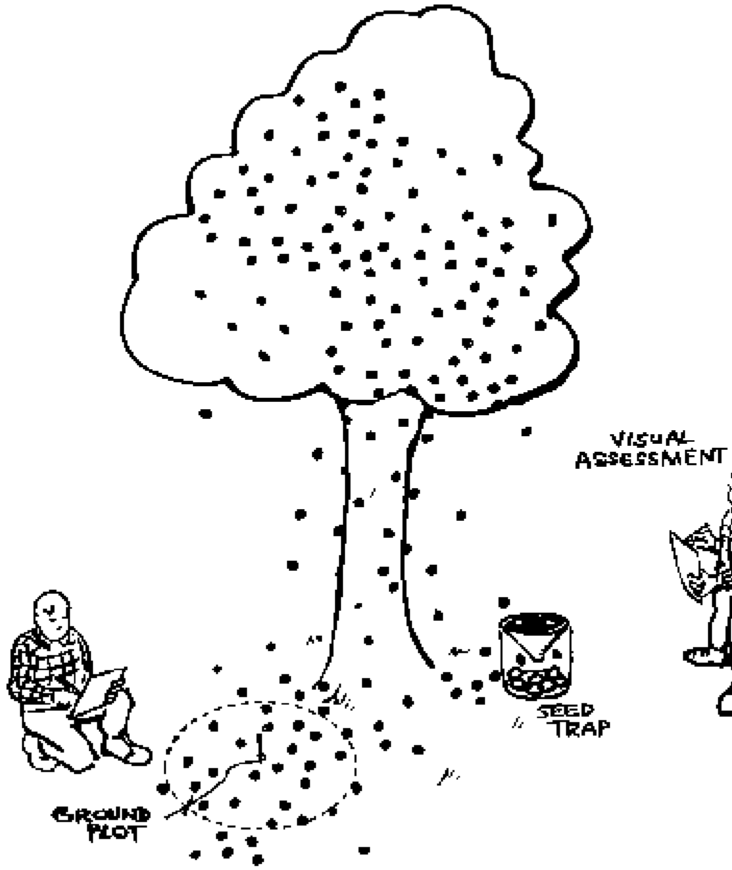
Comments

- Can provide a precise and objective measure
- Does not require much skill as long as only conspicuous, larger fruited species are examined

References

'Ground plot monitoring of seed and fruit-fall', p.62
West 1986
Cowan & Waddington 1990
Dijkgraaf 1998
Burrows 1994
Brockie 1992

FIGURE 38: Different methods of assessment of fruiting abundance.



POPULATION STRUCTURE

The indicator

What is it?

The relative numbers of plants of one species in different age/growth classes.

Discussion

Relative numbers of adult and juvenile plants can be a useful indicator to help determine if a species is increasing, stable or in decline. If no juvenile plants are present, then there may be some concern about the regeneration of the species. With ongoing monitoring, the progress of development from one age/growth/size class to the next can be examined to identify if normal regeneration is occurring or if it is being hindered by some impact such as browsing.

It is important to understand the species being examined, in terms of what is a usual population structure. Some light demanding species may have few seedlings present under a full canopy, but then have bursts of regeneration when the canopy opens after such events as damage by wind storms.

When using this indicator to compare areas, they need to be similar, ideally only differing in some major agent that is causing change, such as much greater browsing animal numbers in one area. Without this consideration, it can become difficult to interpret the reasons for differences between areas.

Some key issues

- Identify the best way to examine different age/growth classes for the species concerned. This may be by examining height classes, different growth phases (for example, juvenile and adult foliage), or diameter classes for woody species.
- Ensure age/growth/size classes being compared are the same.
- Understand the normal population structure of the species being examined.
- Only compare very similar forest areas.

Measurement methods

Obtaining information on the population structure (number of juveniles and adults) of a particular species provides indications of aspects such as regeneration and growth that identify if a species is increasing, stable or in decline.

This involves examining the relative abundance of juveniles and adults, and changes in proportions over time. With tree species, we commonly expect many more seedlings and saplings than adults, because many seedlings will die or are out-competed, leaving only a small number to eventually grow into mature trees. In situations where seedlings and saplings are present in relatively similar or lower numbers than adult trees, there may be some concern about maintenance of a forest canopy.

Care must be taken in interpreting the results from these sorts of considerations because some species may only regenerate occasionally following major events such as wind-throw. Long cycles over decades may be occurring that are not immediately obvious and are independent of current impacts. However, useful examinations of the same area over time or in relation to management changes, or between similar areas, can sometimes be made. If the impact of browsing ungulates is important, useful comparisons can often be made between the numbers of juveniles occurring in an exclosure, and the number outside. As discussed in 'Understorey abundance', p.119, both man-made and natural exclosures, such as cliffs or gorges, where browsing pressure is excluded can be examined.

Height/size classes

The simplest way to undertake this form of comparison is to collect abundance data, normally density, for different size classes of a species, or group of species. You cannot easily determine age of plants, so you have to assume their size is an indication of age. Suitable size classes for broad comparison with tree species are as follows (*see* Figure 10 p. 35).

Established seedling	Between 0.5m and 1.35m in height
Sapling	Over 1.35m in height, but less than 3cm in diameter at 1.35m
Tree	Over 1.35m in height, and over 3cm in diameter at 1.35m

More detailed size class comparisons are also commonly undertaken by examining the relative numbers of stems in different DBH (diameter at breast height) classes.

Comments

- Important to have consistent size classes between comparisons

References

'Quick plot', p.31

MORTALITY

The indicator

What is it?

The proportion of plants dying over a certain time period, within a certain age/size class.

Discussion

All plant stems have a certain life span and then eventually die. The annual rate of this mortality is an important indicator. An increase in the rate of mortality can indicate a decline in condition due to pests or diseases, or some other environmental factor. However it is essential to have some understanding of the population dynamics of the species involved, before attempting to use this indicator. For example, a long-lived species may have a low natural rate of mortality, whereas a short-lived species may have high levels of mortality. Some even aged stands may have occasional periods of high mortality associated with normal growth cycles.

Examining the size/age classes in which mortality is occurring is also important. An increase in mortality in immature stems can be particularly important – because such stems are clearly not dying from old age.

Some key issues

- Understand the population structure and dynamics for the species and area you are examining.
- Identify the size/age classes in which mortality is occurring.

Measurement methods

Some methods of examining mortality are as follows.

Death of marked trees

Live trees are tagged in plots in a forest area, and are reassessed at regular intervals to determine the number that are live and dead, allowing calculation of average annual levels of mortality. Large numbers of trees need to be tagged and monitored to get a reasonable assessment of mortality by this method (*see* Campbell 1990).

Direct assessment of the amount of dead standing stems at any one time is unreliable because of the difference in the durability of woods of different species. This results in the presence of potentially many more dead standing stems of durable species such as totara, compared to non-durable species such as kamahi.

Comments

- Requires considerable effort because large numbers of trees need to be marked
- Provides a robust measure of mortality

References

Campbell 1990


PHOTO: DOC

FIGURE 39: Dead tree

Change in total mortality over time

The proportion of total standing stems that are dead can be compared from assessment to assessment to identify if the relative amount of dead stems is changing. This relies on being able to identify the species of dead stems – this is not always easy.

Comments

- A less reliable measure than reassessing marked stems

LITTER-FALL

The indicator

What is it?

The total amount of annual litter-fall in an area of forest, often separated into twigs, leaf-fall, fruit and flowers.

Discussion

Litterfall provides an indication of total primary production or productivity of the forest. This varies greatly between different types of forest, and declines with increasing latitude and increasing altitude (Brockie 1992).

It may give some indication of the relative condition of similar areas of forest (Cowan & Waddington 1991), with more healthy areas producing a larger total amount of litter. Litter-fall also provides the food source for many invertebrates living on the forest floor, directly impacting these populations.

Litter accumulation on the forest floor is affected by the rate of decomposition, which is strongly influenced by climate. Warm, moist areas have much faster decomposition than cold, dry areas.

The use of this indicator may have some potential, but needs to be treated carefully due to the major variation naturally occurring between different forest areas in litter-fall and litter decomposition.

Green litter of some palatable species is commonly eaten from the ground by introduced browsing animals when animal numbers are high, and preferred food is in short supply.

Some key issues

- Understand the litter cycles of the species being studied, for example, when peak litter-fall occurs.
- Comparisons should only be undertaken with similar forests in a similar geographic and climatic location.

Measurement methods

Methods involve the collection of litter and usually assessment of oven dry weight. Other forms of field assessment, such as volume of loosely packed litter may be possible. Two possible methods of collecting leaf litter are identified below.

Litter trays

This is the same approach as identified with seed-fall traps. Collection cones or similar structures of a known collection area, into which litter can fall, are set up under the canopy. These are periodically cleared and the quantity of material collected is assessed.

Comments

- A quite widely used and reliable technique
- Considerable effort required to establish and maintain litter trays

References

Brockie 1992
Cowan & Waddington 1991
Cowan et al 1985.

Litter plots

In a similar way to that set out for seedfall plots, it may be possible to collect and assess litter from small plots on the forest floor, without the expense of establishing litter trays. Within small plots, intact litter is scraped up, to the level of the more decomposed humus layer. The quantity of this material can then be assessed. Care is required if ongoing monitoring is undertaken using the same marked plots, as fixed plots will always have less litter in subsequent measurements due to the accumulated litter sampled in the first measurement.

Comments

- This is a less proven technique than litter trays, and may have somewhat less reliable results
- Less effort will be involved in establishment and maintenance

WEED DISTRIBUTION

The indicator

What is it?

The distribution of particular weed species.

Discussion

The distribution of plant pests is often a very important indicator. Weeds may be new arrivals to an area and have potential to spread. Obtaining up to date information on distribution of weeds allows managers to identify new infestations, and identify sites where eradication may be possible.

Ongoing changes in the distribution of particular species, and their spread into new areas can be assessed.

Some key issues

- See 'Distribution of key species/uncommon species', p.131

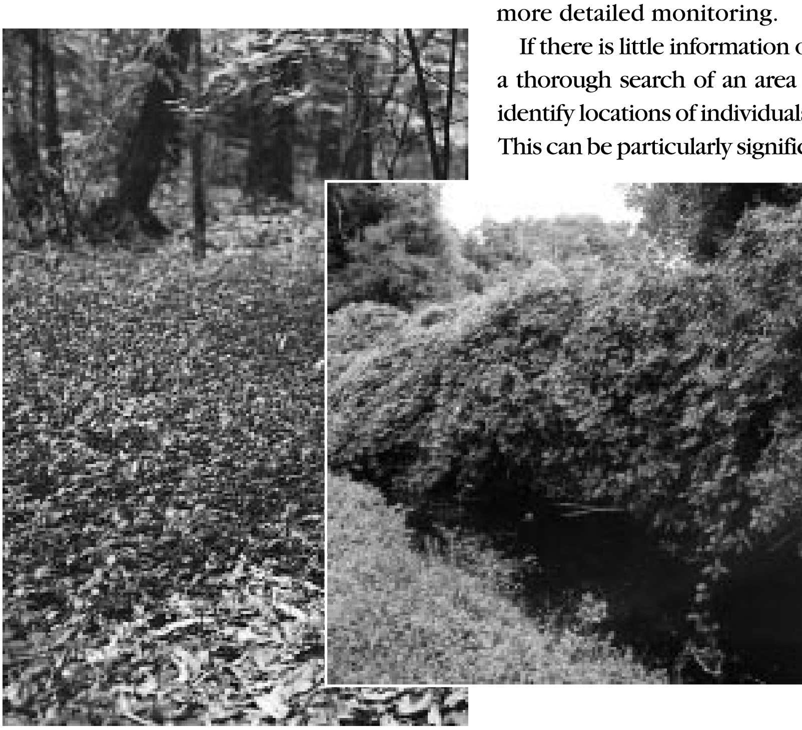
Measurement methods

The methods for assessing distribution are the same as those for examining the distribution of important or uncommon species (*see* 'Distribution of key species/uncommon species', p.131). Some particular points to consider about weed distribution are set out below. Useful information can also be found in the Department of Conservation's *Weed Surveillance Standard Operating Procedure* (DOC 1999)

It is necessary to obtain information about the presence and distribution of important weeds within an area under management. This initial work will be important to any decisions on more detailed monitoring.

If there is little information on the presence of weeds, a thorough search of an area should be undertaken to identify locations of individuals or localised populations. This can be particularly significant with new infestations of weeds because the weeds may be at a very low density and would not be picked up by abundance surveys.

When undertaking such searches, there are certain areas that are particularly vulnerable to the spread of weeds (DOC 1999), and these should form an important focus, particularly if resources to search the whole area are limited.



PHOTOS: PETER HANDFORD

FIGURE 40: Weed infestations of species such as *Tradescantia* (wandering jew) on the left or bindweed and blackberry on the right, can spread and smother regeneration.

Vulnerable areas include:

- Alongside roads and railways.
- Rubbish dumps.
- Places with low scrubby or disturbed vegetation.
- Beside streams, rivers, lakes or the coast.
- Places modified by human activity, for example, farms, cleared land, excavations.
- The edges of reserves, particularly close to settlements.

Mapping of the location of individual infestations should be undertaken for important uncommon species with only localised distribution (*see* 'Distribution of key species/ uncommon species', p.131). Mapping of specific locations of particular infestations enables their spread to be monitored. With localised infestations, it is sometimes possible to monitor the total cover or number of individuals.

For weeds that are more widely dispersed, the broad extent of distribution rather than individual infestations can be mapped. The suitability of different mapping scales will depend on what is being mapped. If a 50-hectare area of continuous evenly distributed weed infestation is being identified, then mapping on 1:50,000 maps may be appropriate. If you are examining locations of individual weed plants or patches of weeds over a small reserve, aerial photographs of 1:5000 or larger scale may be appropriate.

WEED ABUNDANCE

The indicator

What is it?

The relative or absolute abundance of a particular weed species or group of weed species (*see* 'Abundance of indicator species', p.127).

Discussion

The abundance of particular weed species can be important to managers of native forest. It can provide indications of whether the population is increasing or decreasing, and the impact of weed control or other management operations.

Including assessment of the abundance of both juvenile and adult plants is useful (*see* also 'Population structure', p.136) to identify if populations are increasing, with many juveniles, or are apparently fairly stable, with a few mature plants.

The Department of Conservation Standard Operating Procedure (DOC 2000) for monitoring weed control is a very useful reference for designing and undertaking weed abundance monitoring.

Some key issues

- See 'Abundance of indicator species', p.127.
- Select the important weed species to monitor. Look first at those species that have features such as high impact, potential for control, or are established throughout the area and spreading.
- If the species is new and only present as early introductions, a distribution survey (*see* 'Weed distribution', p.142) may be the best approach.

Measurement methods

As with vegetation in general, the approach to assessing the abundance of weeds will depend to a large extent on the growth form, distribution and relative density of the individual species.

Table 5 in 'Abundance of indicator species', p.131 identifies how these issues affect the method used. Methods available are also described in 'Abundance of indicator species'.

WEED POPULATION STRUCTURE

The indicator

What is it?

The relative numbers of plants of one weed species in different age/growth classes.

Discussion

This indicator can provide information on the trend in a weed population (*see* also 'Population structure, p. 136). Presence of mature adult plants that have been present for a long time, with no, or very few, juvenile plants, may suggest a fairly stable population. The presence of a few adult plants and many new juveniles suggests a potentially rapidly expanding population.

Examining the population structure can be important with species that take time to reach maturity and start producing seed. For example, introduced conifer species (pines, Douglas fir, etc) take years to reach a stage where they are producing seed. Identifying population structure when monitoring these species can help to identify which areas are priorities for control and which areas are not so urgent.

Some key issues

- See 'Population structure', p.136.
- Determine how you will clearly separate age/size/growth classes.

Measurement methods

See 'Population structure', p.136.

WEED MORTALITY

The indicator

What is it?

The proportion of plants dying over a certain time period, within a certain age/size class.

Discussion

As well as being a vital part of understanding general population dynamics of a weed species, assessing mortality can be particularly important when considering the effects of control operations such as herbicide application (DOC, 2000).

Some key issues

- See 'Mortality', p.138.

Measurement methods

Deaths of individually marked plants or the portion of stems or cover within marked plots can be assessed over time, including before and after a control operation. See 'Mortality', p.138 for an outline of measurement methods.

GROUND COVER

The indicator

What is it?

The proportion of the area of the forest floor in different classes of ground cover, such as bare soil, leaf litter, rock, moss, and live plants.

Discussion

Ground cover is an important indicator because it provides information on the likely stability of the forest floor and vulnerability to erosion. This can be important, for example, in examining the impacts of trampling by browsing animals. The amount of ground cover vegetation can provide information on the ability of seeds to germinate and survive as seedlings.

Some key issues

- Determine ground cover classes that will be used, and define them accurately to avoid confusion in the field.
- Ensure classes used are comparable with previous studies, or classes widely used in similar studies.

Measurement methods

Visual assessment

The percentage of ground cover in various categories, such as soil, rock, vegetation and litter, are visually estimated for a plot or the general area around a survey point. Normal difficulties with measurement variation for visual estimates occur.

Comments	**References**
● Only provides very broad estimate	Allen 1992
● Only suitable for examining very large changes	

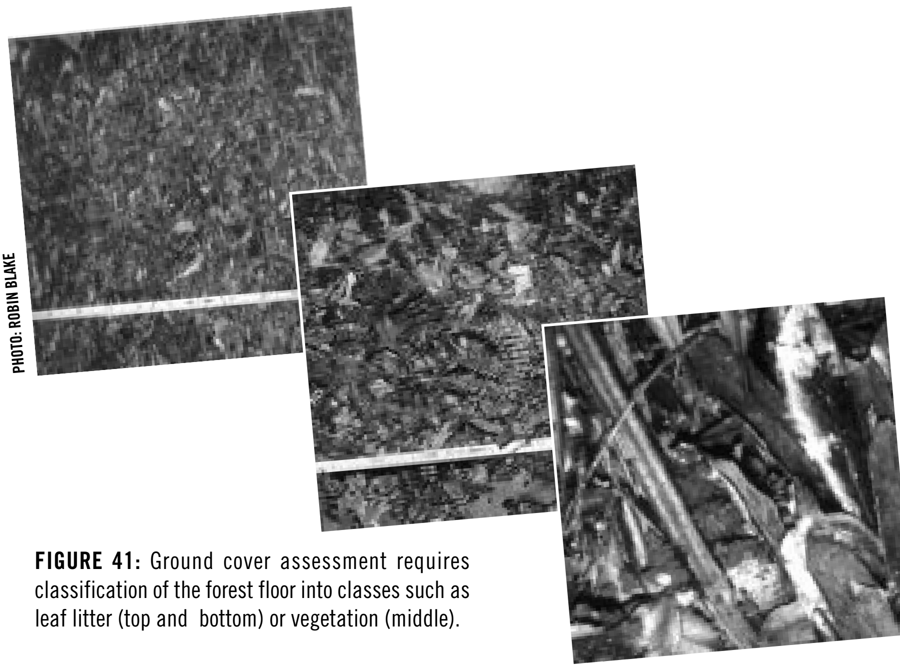


PHOTO: ROBIN BLAKE

PHOTOS: PETER HANDFORD

FIGURE 41: Ground cover assessment requires classification of the forest floor into classes such as leaf litter (top and bottom) or vegetation (middle).