NSW Guide to Surveying Threatened Plants

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Office of Environment and Heritage
59 Goulburn Street, Sydney NSW 2000
PO Box A290, Sydney South NSW 1232

Phone: +61 2 9995 5000 (switchboard)
Phone: 131 555 (environment information and publications requests)
Phone: 1300 361 967 (national parks, general environmental inquiries, and publications requests)
Fax: +61 2 9995 5999
TTY users: phone 133 677, then ask for 131 555
Speak and listen users: phone 1300 555 727, then ask for 131 555

Email: info@environment.nsw.gov.au
Website: www.environment.nsw.gov.au

Report pollution and environmental incidents
Environment Line: 131 555 (NSW only) or info@environment.nsw.gov.au
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Abbreviations

BAR: Biodiversity Assessment Report (BAR)

BBAM: BioBanking Assessment Methodology

BCAM: Biodiversity Certification and Assessment Methodology

EPBC Act: Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*

FBA: Framework for Biodiversity Assessment

GIS: geographic information system

GPS: global positioning system

IBRA: Interim Biogeographic Regionalisation for Australia

OEH: Office of Environment and Heritage

TSC Act: NSW *Threatened Species Conservation Act 1995*

1. Introduction

1.1 Purpose of this guideline

The purpose of this *Guide to surveying threatened plants* is to help proponents and assessors of developments or conservation sites to identify the minimum standards to use when surveying for threatened plants, as required by the Office of Environment and Heritage (OEH) biodiversity offset methodologies such as the BioBanking Assessment Methodology (BBAM; OEH 2014a), the Framework for Biodiversity Assessment (FBA; OEH 2014b) and the Biodiversity Certification and Assessment Methodology (BCAM; DECCW 2011). Under these methodologies, all threatened plants are treated as 'species credit' species (i.e. species that cannot be predicted by using habitat surrogates) and require appropriately timed on-ground surveys to determine the likelihood of their presence or absence at a site. This guideline has been prepared by using a variety of expert sources and should be read in conjunction with the relevant assessment methodology.

Following this guideline is not mandatory. However, proposals that fail to meet the guideline for reasons of efficiency, cost or validity will need to provide an evidence-based rationale for an alternative survey approach (e.g. an alternative published guideline or an expert report).

Although this guideline is designed to meet the requirements of the biodiversity offsets and strategic land-use planning methodologies operating in NSW (i.e. BBAM, FBA and BCAM), it can also be used when targeted threatened-plant surveys are needed for other threatened species assessment processes, such as the Assessments of Significance and Species Impact Statements required under Section 5a and Part 4 (respectively) of the *Environmental Planning and Assessment Act 1979*.

The guideline is not intended for use in identifying vegetation types (instead, see the Native Vegetation Interim Type Standard, Sivertsen 2009) or in identifying plant community types (see the Plant Community Identification Software in the Vegetation Information System database).

We expect that the guide will be reviewed and updated periodically to incorporate new information on best practice in threatened-plant surveys and to reflect any legislative or policy changes.

1.2 Background

A biodiversity offset is a measure used in an effort to compensate for the adverse impacts of an action—such as vegetation clearing or loss of habitat— taken elsewhere as part of development. In NSW, biodiversity offsets are used in decisions that attempt to balance the relative environmental, social and economic merits of a development proposal. Formal offset arrangements are features of:

- the NSW BioBanking Scheme and associated BBAM
- biodiversity offsets for major projects (i.e. state significant development and state significant infrastructure) through the Biodiversity Offsets Policy for Major Projects, as put into use by the FBA
- land-use planning through biodiversity certification of land and the associated BCAM.

In the context of these three mechanisms, threatened plant species include critically endangered, endangered or vulnerable species and endangered populations as listed under Schedules 1, 1A and 2 of the NSW *Threatened Species Conservation Act 1995* (TSC Act), or any threatened plant species listed under Part 13 of the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) as critically endangered, endangered or vulnerable. For plant species listed under the EPBC Act, the Commonwealth may require targeted threatened-plant surveys using methods or techniques other than those specified in this *NSW Guide to Surveying Threatened Plants*.

In the case of proposals being assessed under the Assessment Bilateral Agreement between the Commonwealth and NSW,[1] all impacts on matters of national environmental significance (MNES) that are likely to be significant must be identified separately in the report prepared in accordance with the assessment methodology for the proposed development. This report is called the Biodiversity Assessment Report (BAR). This guideline refers to the methodologies that support biodiversity offset schemes as the **assessment methodologies**, and the land undergoing the assessment as the **site**. The site includes land that may be affected by the development and land proposed as a biobank site or other type of conservation site.

1.3 Objective of targeted threatened-plant surveys

The objective of a targeted threatened-plant survey in the assessment methodologies is to establish, with a high level of confidence, the presence or absence of a threatened plant species at a site and, if the species is present, to collect data to determine the number of individuals or the habitat area. This information is then used to calculate species credits.

The survey aims to minimise 'false-negatives' (i.e. when a species is reported as absent from a site when it is actually present). A high level of confidence in the reported results can be assumed if the survey is done by an appropriately skilled person (see section 2.2
Identify the skills of the threatened-plant surveyor) in accordance with this guideline.

1.4 Survey data and biodiversity credit calculations

Assessment methodologies calculate 'ecosystem' and 'species' credits for the impacts of a proposed development, or the effects of management actions, on biodiversity values.

Ecosystem credits are calculated for general biodiversity values and when the occurrence of a species can be predicted from plant community type, distribution, landscape and habitat features.

Species credits are calculated when the occurrence of a species cannot confidently be predicted by using habitat surrogates. Under the assessment methodologies, all threatened plant species are species credit species.

The assessment methodologies require either a targeted species survey or an expert report to determine the presence or absence of a 'species credit' species considered likely to occur at a site. The relevant sections of the assessment methodologies are listed in Appendix 1.

The information gathered from the targeted species survey is entered into the credit calculator. The credit calculator is used to apply the assessment methodologies and to calculate the number and types of credits required to offset the negative impacts on

[1] See the Commonwealth Department of Environment's website for NSW Bilateral Agreement Information

biodiversity of a proposed development or of land that is proposed to be biodiversity certified, or the improvements in biodiversity value at a conservation site.

The biodiversity assessment is based on survey data from the results of targeted flora surveys as well as the information contained in a number of tools, including the Vegetation Information System (VIS) Classification database (includes a Plant Community Type Identification Tool and associated vegetation condition benchmarks), Threatened Species Profiles Database (TSPD), Over-cleared landscapes database (Mitchell Landscapes) and Directory of Important Wetlands Database.

2. Overall approach to the targeted threatened-plant survey

2.1 Take a systematic approach

This guideline describes a systematic approach to targeted threatened-plant surveys.

The survey approach should be considered in the planning phases of the site assessment and incorporates two elements:

- a survey design that maximises the likelihood of detecting the target threatened plant species (including a consideration of seasonal and temporal constraints; see more details in section 3)
- a field survey technique that aims to search a large proportion of an area of **potential habitat**[2] at an appropriate intensity (see more details in sections 4 and 5).

2.2 Identify the skills of the threatened-plant surveyor

The targeted threatened-plant survey must be done by someone with botanical skills and particular expertise in threatened-plant identification and survey. An appropriate threatened-plant surveyor is someone who can demonstrate their relevant experience and qualifications in field survey and plant identification. The appropriateness of threatened-plant surveyors is currently evaluated by OEH on a case-by-case basis.

The surveyor's botanical skills can be demonstrated by relevant qualifications and by the following:

- a history of experience in survey methods and threatened plant identification in NSW,[3] and/or
- a resumé giving details of threatened-plant survey projects done in the relevant region over the previous 10 years, including the employers' names and periods of employment (where relevant).

The experience and qualifications of the threatened-plant surveyor must be documented in the BAR (see section 5.3 Compile a survey report). The threatened-plant surveyor may or may not be an **accredited assessor** under the TSC Act for the purpose of preparing biodiversity assessments under the assessment methodologies. However, **the BAR must be submitted by an accredited assessor**.

It is important to note that the threatened-plant surveyor is not equivalent to an 'expert' as defined in under section 142(1)(b) of the TSC Act. To be considered an 'expert', a person must demonstrate a high level of knowledge in relation to particular biodiversity values (such as a threatened plant species), as the opinion of an expert replaces the need for a field survey. Expert status is determined on a case-by-case basis by the Chief Executive of OEH.

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[2] 'Potential habitat' is defined throughout this guideline as all habitat in which a species is likely to occur (based on current scientific literature and/or the documented known ecology of a species). Only those areas considered to be potential habitat within a site need to be surveyed.

[3] A threatened plant surveyor lacking familiarity with a particular target species will need to research resources, herbarium specimens etc. to prepare for the survey; this may need to be documented in the BAR.

3. Field survey design

3.1 Create a candidate species list

Under the assessment methodologies, the threatened species to be assessed at a site are (BBAM and FBA sections 6.5.1.2, BCAM section 4.3) determined by using the following four filters:

1. species identified as 'species credit' species (all threatened flora) in the Threatened Species Profile Database
2. species known or predicted to occur in the IBRA (Interim Biogeographic Regionalisation for Australia; see Australia's bioregions
3. the presence of habitat features (including known and/or preferred Plant Community Types or other components) associated with the species, as identified in the Threatened Species Profile Database
4. past survey or specimen records from the site that indicate the species' presence.

The credit calculator generates a list of threatened species that require targeted survey. This list is based on filters one to three. Filter four is applied by the threatened-plant surveyor, if information for the species is available.

The threatened-plant surveyor may further refine this list on the basis of the presence or absence of key habitat requirements for the target threatened plant species, such as:

- associated native plant community types and taxa
- topographic, soil or geological preferences
- microhabitats (e.g. preference for rocky outcrops, ground soaks or tree canopies)
- disturbances, such as fire history, and the level and type of disturbance (e.g. slashing, canopy removal).

A candidate species is not considered present at a site when (BBAM and FBA section 6.5.1.3, BCAM section 4.3):

- after conducting an assessment of habitat components the assessor determines that the habitat is substantially degraded,[4] so that the species is unlikely to use the site, or
- an expert report[5] is prepared (in accordance with section 6.6.2 of BBAM and FBA and section 4.5 of BCAM) stating that the species is unlikely to be present on the site, or
- records of the species' presence in relation to the location of the site are at least 20 years old[6] and/or (in the opinion of the threatened-plant surveyor) have doubtful authenticity.[7]

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[4] Some species occur in disturbed habitats or in habitats to which disturbance has been deliberately applied (e.g. by mowing or slashing in the case of some *Diuris* species). In this case, habitat degradation would not justify removal of the species from the candidate list.

[5] Note that an expert, for the purposes of preparing an expert report, needs to demonstrate skills and experience additional to those of the threatened plant surveyor; see section 2.2 Identify the skills of the threatened-plant surveyor.

To help work out whether a candidate threatened species meets any of the above criteria, the plant surveyor can interrogate the species profile available in the Threatened Species Profile Database or can use additional sources of information such as scientific journals and research reports

The justification, including any relevant sources of information, for removing a threatened plant species from the candidate list (thus assuming it is not present at the site) must be documented in the BAR (see BBAM and FBA section 6.5.1.6 and BCAM section 4.3).

All remaining candidate threatened plants must be assessed further in accordance with this guideline.

3.2 Optimise the time of year for the survey

The Threatened Species Profile Database provides guidance on the appropriate time to survey for individual threatened species. This information is also provided by the survey matrix, which is part of the credit calculator. The threatened-plant surveyor may use key biological or regionally specific information (including reference sites and known localities where the species has been recorded) to further refine survey times and thus optimise the detectability of a species. For example, survey times need to be adjusted to account for:

- the species being above ground (e.g. geophytic orchids [orchids with underground food storage organs] may be below ground as corms for a large proportion of the year, or an annual plant may germinate only at a certain time of the year)
- flowering time (e.g. to make plants more easily identified)
- fruiting time (e.g. when fruits are required for identification)
- natural disturbances or climatic events that trigger germination (e.g. recent fires, floods or rainfall)
- ground disturbances (e.g. for species frequently found on disturbed road-verges or species that require fire as part of their life cycles).

Any variation in the survey time from that identified by the Threatened Species Profile Database should be justified and reported in the BAR (see BBAM and FBA section 6.6.1.4). If the plant surveyor finds that a changed survey time is more appropriate for local populations than that in the Database, he or she should contact OEH to ensure that this information is updated in the Database.

In some situations, surveying at the optimum time to detect a threatened plant may not be possible or feasible. Examples are cases where project time frames are constrained; where the detectability of a species depends on natural disturbance or a climatic event and the time since the last of these events exceeds the life span of the species; or where suboptimal conditions such as prolonged drought or an extreme, random event has substantially affected the site.

In situations where a threatened-plant survey can't be done at the optimum time or under optimum conditions, the proponent may choose to use an expert report (in accordance with

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[6] When applying this criterion, the surveyor should consider the lifespan of the species (i.e. if long lived), the level of survey in the region, and the level of change that has occurred in the region over the last 20 years. Under these circumstances, species with records greater than 20 years old should not automatically be removed from the candidate list (i.e. deemed to be absent from the site).

[7] Justifications should be supported by recent scientific literature and should be reported in the BAR. Any record deemed to have doubtful authenticity must be reported to OEH via bionet@environment.nsw.gov.au.

section 6.6.2 of BBAM and FBA and section 4.5 of BCAM) to assess the species' presence or absence or the species. Alternatively, the species can be assumed to be present at the development site (BBAM and FBA section 6.5.1.7, BCAM section 4.3). A 'species credit' species cannot be assumed to be present at a biobank site (see BBAM section 6.5.1.9).

3.3 Identify areas of potential habitat at the site

Only the potential habitat of the target species within the site needs to be surveyed. To identify potential habitat, the threatened-plant surveyor will need to consider the site in relation to its range of plant habitats. The assessment methodologies require the site to be divided into plant community types. The potential habitat for a species may be related to only one plant community type, or it may be restricted to specific niches such as rocky outcrops, riparian zones or areas of the tree canopy. In instances where the habitat is unknown or poorly known, then the entire site will require survey.

Available resources, including mapping or imagery showing vegetation, soils, geology, altitude and topography, can be used to derive the relevant site characteristics, including (but not restricted to) native vegetation cover, plant community type or association, vegetation condition, and smaller landscape features such as riparian zones, swamps, dry north-facing slopes, waterlogged valley floors and rocky outcrops.

For example, the vegetation condition may determine the potential habitat for some threatened plant species, as it reflects past land-uses such as grazing and selective logging, or past clearing. Some orchid species will not occur in areas that have been grazed, although some species of *Diuris* favour cleared grassy patches (because of their optimum sunlight conditions) (Espallargas 2005).

To meet the requirements of the assessment methodologies, the threatened-plant surveyor not only needs to do fieldwork to determine the general biodiversity values at the site; he or she also needs to do further surveys to confirm the site's characteristics, because:

- mapping and digital data may not accurately represent or include all plant community types present or all soil and topographic details
- the history of the site and its disturbance is not reliably evaluated from imagery
- small habitat features that provide niches for some species are not easily evaluated from a desktop assessment.

3.4 Prepare a field survey plan

A field survey plan is prepared on the basis of the list of threatened plant species that require survey (section 3.1 Create a candidate species list) and the plant habitat characteristics at the site (section 3.3 Identify areas of potential habitat at the site), as well as in accordance with section 6.6 of the BBAM and FBA or section 4.4 of the BCAM.

The following steps outline the **generalised** method used to create a survey plan:

- **Allocate species to potential habitats.** Only those parts of the survey area that are considered potential habitat for a target threatened plant species require survey for that species.
- **Determine the survey effort for each target threatened plant species.** Table 3 provides guidance for minimum survey effort. In determining the required survey effort, threatened-plant surveyors should draw on their experience and expertise.

- **Group species on the basis of the survey effort, survey time and potential habitat.** Within each of the potential habitat, group the target threatened plant species according to optimum survey time and survey effort. This provides a plan for those species that need to be searched for within each of the potential habitat areas at the appropriate time of year.

Box 1: Questions and answers about field survey design

What do I do if the target threatened plant species has been recorded at the site previously but occurs only in the first five years after fire and the site has not been burnt for 15 years?

Any targeted survey for this species will be unreliable. An expert report can be used to justify the likelihood of the species' presence or absence at the site, or the species can be assumed to be present (in the case of development sites only). If it is assumed to be present, an expert report will be required to estimate its abundance or area of habitat (depending on the unit of measure for that particular species).

Note that if the past survey occurred within the previous five years and meets the standards outlined in this guideline, the results of that survey can be used (see relevant question below).

What do I do if the target threatened plant species can be identified only when it's in flower or fruit, and its flowering or fruiting time is different from that of the other species being targeted for survey?

The survey must be done at the relevant flowering or fruiting time for each species (i.e. the optimum survey time), as surveys outside that time will be unreliable. Additional survey time, during the appropriate survey season, will be required, even if it is the same area of potential habitat.

Alternatively, an expert report can be prepared, or the species' presence can be assumed (in the case of development sites only). If it is assumed to be present, an expert report will be required to estimate abundance or area of habitat (depending on the unit of measure for that species).

What do I do if flowers are needed to identify the target threatened plant species, and they only last two weeks. How can I predict when is the right time to survey?

For a known population, a reference site or sites geographically or biophysically similar to your survey area can be used as a guide to indicate when the species may be flowering. Alternatively, where reference sites are unknown, repeatedly visiting the site (e.g. at 10-day intervals) during potential flowering periods will increase the chances of detection.

If flowers are not needed for identification or detection, do I have to survey during flowering time?

No. However, for some species fruits are the distinguishing feature (e.g. *Asperula*, *Galium* and *Maundia*), and in these cases sampling must be done during the fruiting period.

A survey has been done at the site recently. Do I have to re-survey?

A past threatened-plant survey can be used only if it has a) been done at the proposed site within the last five years; b) meets all the requirements of this guideline (e.g. done by a qualified person, specifically targets the species in question and its seasonality, uses the correct survey technique) and c) an appropriate assessment of the entire area is available.

A threatened plant has been located on site; it is outside the recorded natural distribution and is likely to have been transplanted to the area (e.g. as an ornamental plant). Should I include it in the survey?

For advice on whether or not to include such a species in the assessment process, the threatened-plant surveyor should contact the OEH Regional Operations Office in the area relevant to the proposed development.

4. Field survey technique

Many threatened plant species have patchy distributions, low population sizes and habitats that can conceal them. Therefore, the survey effort must generally be high to ensure confidence in the results (see section 1.3 Objective of targeted threatened-plant surveys). Additionally, plants are not free to move and (for most species) the probability of detection depends on the total search time (in the appropriate season) rather than the number of site visits (Moore et al. 2011).

Three methods commonly used to survey plant species are random meanders, parallel transects and random quadrats (Cropper 1993, Keith 2000). There is an ever-increasing number of variations of each of these approaches, and these variations are often tailored to a target taxon or habitat (e.g. McCaffrey et al. 2014).

The approach recommended in this guideline is the parallel field traverse (i.e. parallel transects, as used by Cropper 1993).

Detectability of threatened plants is considered to be high using the parallel field-traverse method, because it systematically covers the entire area of potential habitat within a site and can be applied to a diverse range of species, habitats and sites. Using survey plots or quadrats or a random meander within an area of potential habitat is not adequate[8] to meet the objectives of this guideline.

However, the parallel field-traverse method may not be suitable for all species in all situations. Peer-reviewed survey guidelines (e.g. the Commonwealth Government's Draft survey guidelines for Australia's threatened orchids) are available for some specific taxa and should be used in preference to this guideline. An explanation for their use should be provided in the BAR (see BBAM and FBA section 6.6.1.4). Approaches to threatened-plant survey that differ from the ones in this guideline should be discussed with the OEH Regional Operations staff located in the region where the development is proposed.

4.1 Parallel field traverses

The parallel field-traverse survey technique involves searching along a grid of parallel traverses a set distance apart (Table 1) across areas of potential habitat for each target threatened-plant species. Traverses should be recorded on a global positioning system (GPS) and plotted on the site map in the BAR. The life form of the target threatened-plant species and the habitat being searched determine the separation of the parallel traverses (see section 4.2 Width, length and area of field traverses). General estimates of the expected times required to survey an area are provided to help plan the field survey (see section 4.3 Survey effort).

[8] Cropper (1993, p. 32) recognises that 'to cover the area completely and ensure that small or inconspicuous species are recorded, a more thorough technique such as parallel searching should be used'.

4.2 Width, length and area of field traverses

The range of widths of separation of field traverses is described in Table 1. These were developed by considering the distances over which various plant life forms can be seen in, and are able to disperse to, different habitats (including different types of cover).

Distinguishing features of trees (bark, tree habit, canopy colour and shape) and tall shrubs are likely to be visible at 10 to 20 metres distance. In contrast, small life forms, including grasses, sedges, rushes and other graminoids, as well as forbs and herbs, orchids and ferns, are likely to be hidden behind other vegetation or tangled within dense understorey or ground cover; they may therefore be observable only at a maximum distance of 2.5 metres. These are minimum estimates: the plant surveyor may choose to use narrower widths to adequately survey the target species.

Table 1: Maximum distances between parallel field traverses

Life form	**Maximum distance between parallel field traverses (separation width) (metres)**	
	In open vegetation*	**In dense vegetation***
Trees Mallee trees Tall shrubs >6 m	40	20
Medium shrubs 1 to 6 m Cycads and large ferns	20	10
Sub-shrubs (including Chenopods) (<1 m)	15	10
Herbs and forbs	10	5
Ferns (<1 m) Grasses/sedges/rushes and other graminoids Orchids Epiphytes and climbers	10	5
Aquatic plants	Search the appropriate parts of the water body by using a traverse coverage appropriate for the species' growth form.	

* See Walker and Hopkins 1990

The length of field traverses will depend on the area and shape of the potential habitat to be surveyed. Table 2 provides a general estimate of potential lengths of field traverses based on the separation widths identified in Table 1 and a set of general habitat areas.

Table 2: Estimated potential lengths of field traverses

Separation width of field traverse (refer to Table 1) (metres)	**Area of potential habitat (hectares)**				
	1	**2**	**10**	**25**	**50**
	Field traverse length (kilometres)				
5	2	4	20	50	100
10	1	2	10	25	50
15	0.75	1.5	7.5	18.75	37.5
20	0.5	1	5	12.5	25
40	0.25	0.5	2.5	6.25	12.5

4.3 Survey effort

The estimations of survey effort listed in Table 3 are based on a reasonable walking speed of 4 kilometres per hour in open vegetation and 1.5 kilometres per hour in dense vegetation, using the same separation widths of field traverses and potential habitat areas as shown in Table 1. These are broad estimates only and don't include the time taken to collect, tag and count species. Note also that there is considerable variation among people in walking speeds, and this could substantially alter the estimates.

In general, the area of potential habitat for a threatened plant is likely to be restricted and, as suggested by Table 3, the times taken to survey will be relatively small and in line with current survey efforts for threatened-plant surveys. Further time savings can be achieved if more than one threatened plant species can be searched for simultaneously.

Table 3: Estimated survey effort

Distance between parallel traverses (refer to Table 1) (metres)	**Area of potential habitat* (hectares)**				
	1	**2**	**10**	**25**	**50**
	Survey time estimate# in open vegetation (approximate hours)				
5	0.50	1.00	5.00	12.50	25.00
10	0.25	0.50	2.50	6.25	12.50
15	0.19	0.38	1.88	4.69	9.38
20	0.13	0.25	1.25	3.13	6.25
40	0.06	0.13	0.63	1.56	3.13
	Survey time estimate# in dense vegetation (approximate hours)				
5	1.33	2.67	13.33	33.33	66.67
10	0.67	1.33	6.67	16.67	33.33
15	0.50	1.00	5.00	12.50	25.00
20	0.33	0.67	3.33	8.33	16.67
40	0.17	0.33	1.67	4.17	8.33

* Potential habitat will constitute only part of the site.

Travel to and from the site is not included.

4.4 Survey design for large potential habitat areas

The survey approach defined in this guideline may be impractical for larger areas of potential habitat where the time taken to search vegetation for small threatened species is high (e.g. grasslands, uninterrupted but narrow riparian habitat, semi-arid and arid shrublands and woodlands, or open woodland grading into disturbed or derived native grasslands). Options to reduce survey effort in these areas include dividing the proposed site into stages; refining the areas of potential habitat through site survey and an expert report; and reducing the survey area by realigning the boundaries or footprint of the proposed development, thereby reducing the area of impact.

For further advice the plant surveyor should consult with OEH Regional Operations staff located in the region where the development is proposed.

5. Implementing the field survey

5.1 Undertake the field traverses

To do the field traverse, the threatened-plant surveyor walks at a reasonable walking pace while making a visual sweep either side of the traverse. This uses the different angles of light to spot the flowers, fruit, leaf shape, leaf colour and habit of the threatened plant.

If a species is detected along a traverse, the GPS coordinates of the location must be recorded. Closer searching is then required to count or estimate the numbers of individuals and/or determine the area of occupancy (see section 5.2 Collect field survey data about individuals).

Several threatened plant species can be searched for during one traverse. To avoid compromising detectability, multi-species searches should be restricted to a maximum of five species in the same stratum (i.e. search for five ground species or five mid-layer species or five canopy species) in the one traverse. Multi-species surveys can also be grouped further by taxon or other similar characteristics in case where species are likely to occupy the same stratum.

Searching for threatened plant species is more reliable on clear days with little or no wind. Factors that may affect searching time include low light levels, bad weather, wet grass and steep slopes (Moore et al. 2011). Details of the survey conditions, the traverse length, and the amount of time spent surveying for each species, together with the GPS log of the areas searched, should be included in the BAR; this may be important in evaluating the survey results. As discussed in section 3.2 Optimise the time of year for the survey, surveys for threatened plants should not be done during drought periods or under other adverse environmental conditions that can affect species detectability. In these situations an expert report can be prepared or the species' presence can be assumed (in the case of development sites only) instead of a survey being done.

A GPS track log (including the datum and Australian Map Grid zone) of the location of the survey field traverses is the most effective way of demonstrating that the survey has been systematic and comprehensive – that is, that the appropriate search effort has been completed within suitable areas of potential habitat. The locations of the field traverses should be presented (by converting the track log into a series of track points using a geographic information system (GIS)) on a topographic map; alternatively, or in addition, geo-referenced aerial photos (or similar) or maps created by using GIS software and supplied as part of the GIS layers can be submitted with the BAR.

Box 2: Questions frequently asked about implementing field surveys

How do I search for a species that occurs in the canopy of a specific tree (e.g. an epiphytic orchid)?

Identify the area of potential habitat for the tree species and the canopy niche. Run parallel field traverses to locate the trees, and observe the canopy for the target threatened species from a location that is appropriate for the plant. (It's essential to use binoculars.)

How do I search for species that are restricted to rocky outcrops?

Locate areas of rocky outcrops on the site by using aerial photography or imagery and field reconnaissance. To minimise safety risks, search rocky outcrops and specific micro-niches (such as cracks and crevices) systematically. Inaccessible areas can be searched with binoculars from a safe vantage point.

How can I use my local knowledge to implement the survey efficiently? For example, I have some experience in searching for a certain cryptic sub-shrub, and I know it occurs only in Banksia ericifolia thickets within a sandstone vegetation community. How do I go about searching?

Use parallel field traverses (in the same way as the effort for tall shrubs) to locate thickets. Search the thickets systematically and comprehensively in a way that is practical and reasonable for the circumstances. Details of the survey effort and references (provide specific citations) or local knowledge justifying the species' restriction to a particular habitat should be documented in the BAR.

When I survey my maximum distances between parallel field traverses usually differ from those recommended in Table 1. Do I have to apply these distances?

The distances presented in this guideline are recommended. However, the plant surveyor may adjust these on a case-by-case basis and document his/her justifications in the BAR. For example, the surveyor's eyesight, the presence of ground or mid-layer vegetation, the light and weather conditions (reduce maximum distances in poor conditions) and the visibility of the species (increase maximum distances in the case of highly viable species) will all affect detectability and thus the distances used.

How do I go about planning and implementing a targeted survey for a grass species with a very broad habitat description? The area of potential habitat is large (150 hectares) and the flowering season is limited.

In situations where the potential habitat of a species covers a large area, the plant surveyor must contact OEH for suitable options to reduce the survey effort and/or find alternative survey designs (see section 4.4 Survey design for large potential habitat areas).

How do I record information about target species that I locate during the survey?

As 'good practice' a voucher specimen should be collected to get herbarium verification of the species identity, particularly if the location represents a range extension for the species and/or the species is difficult to identify. Site locality and habitat details must accompany the specimen. The National Herbarium of NSW provides a plant identification service[9] and resources to ensure adequate specimen collections (see 'Specimens for identification' in section 5.2 Collect field survey data about individuals of this guideline). The information sent with the specimen will become part of a state-wide data store of plant distributions. Royal Botanic Gardens (1992) more fully describes the process of collecting and recording information about plants.

[9] Royal Botanic Gardens website Plant ID and Disease Diagnostic Services

5.2 Collect field survey data about individuals

Location

Field data collection is needed to document the number of individuals or area of habitat for each target threatened species located during the survey. This information is used to derive species credits.

Initially, the locations of individuals (or groups of individuals) of target threatened plant species can be recorded during the field traverses.

Once field traversing is complete, make a thorough search around individuals located during the traverses to establish an area of known occupancy. A defined area (based on the maximum propagule dispersal distance, if known) should be used to focus the search.

Point data should be used to identify the locations of individuals, or a species polygon can be used to define the species' area of occupancy (see BBAM section 6.5.1.19, FBA section 6.5.1.17 and BCAM section 4.3). The locations must:

- be mapped by using digital airborne data (ADS-40) or the best available ortho-rectified aerial image of the development site or BioBank site
- be identified by using the unit of measurement identified by the plant surveyor for that species
- include the locations of the threatened species (points) or areas occupied by the threatened species (polygon)
- contain the specific habitat feature or habitat component associated with that threatened species at the site
- be confirmed by using GPS to identify the locations of the points or polygon on the best available ortho-rectified aerial image of the site.

The above information must be included in the BAR (see BBAM section 6.5.1.20, FBA section 6.5.1.18 and BCAM section 4.3). Location information should be recorded with reference to OEH's sensitive species data policy.

Abundance or area of habitat

Once a threatened plant has been detected at a site, the threatened-plant surveyor must record its abundance or area of habitat (see BBAM and FBA section 6.5.1.8, BCAM section 4.3).

Where the unit of measure is abundance, the number of individuals can be counted, or sampling and extrapolation may be needed to provide an estimate of abundance. Individuals in the study area may represent only part of a population.[10]

Small groups of individuals (<50 plants) can be counted with reasonable confidence. However, larger populations (>50 plants or >0.1 hectare area of occupancy) can't be counted without noticeable error (Cropper 1993, Keith 2000). In this case it is best to extrapolate the density by sampling over the area of occupancy. Samples can be stratified according to areas of differing density, and counts made within quadrats. Any method of estimation should

[10] Keith (1998) describes plant populations as geographically or otherwise distinct groups between which there is little genetic exchange through seed dispersal. Propagules are generally dispersed in the order of metres, with distances greater than 1 kilometre being very rare. In this context, populations are considered distinct if they are separated by discontinuities of >1 kilometre.

be documented in the BAR and should be consistent with OEH's standard for sampling vegetation (see Sivertsen 2009).

If the unit of measure is the area of habitat, the threatened-plant surveyor should consider information on the land-use history and/or disturbance of the site, along with previous surveys for the species at or near the site and/or reference populations in the local area. The method used to estimate area of habitat must be documented in the BAR and must include justification of the approach.

If the presence of a species is assumed, an expert report will be required to estimate the species abundance or area of habitat. The method used to estimate abundance or area of habitat must be documented in the BAR and must include justification of the approach (e.g. based on scientific literature).

Specimens for identification

If a plant taxon can't be identified during the field survey and is suspected of being a threatened plant species, a specimen must be collected and preserved for later identification with the help of resources such as field guides and keys. If the individual is a young plant, the surveyor may consider leaving the plant in situ and returning to the site when it is old enough to identify. If a specimen can't be identified to species level, it should be submitted to the National Herbarium of NSW for inspection and formal identification. The National Herbarium of NSW outlines the procedures for collecting plant specimens and vouchering, and provides a plant identification service.

5.3 Compile a survey report

The results of the survey must be documented as a component of the BAR (see BBAM Table 33, FBA Table 20) and should contain an accurate representation of the survey, including the information compiled and analysed in the field survey design (see section Field survey design of this guideline), the field survey technique and effort (see section Field survey technique), and field survey implementation (see section Implementing the). The field survey component of the BAR must demonstrate that an adequate survey has been done and the results are reliable.

The report must be prepared by the threatened-plant surveyor (not the BioBanking accredited assessor, unless they are the same person) and must include:

1. The survey area, divided into potential habitat areas that are linked to the identified vegetation zones for the development or biobank site. Smaller-scale plant habitats superimposed on a geo-referenced map, aerial photograph, or similar should also be included.
2. The candidate species list (scientific and common names) and any alterations, including justifications, to the list derived from the credit calculator.
3. The optimum time to conduct the survey, including documentation and justification of the information used if it differs from that identified by the credit calculator.
4. The survey design, indicating the species proposed for survey within each of the areas of potential habitat, their optimum survey times and the survey effort. The report requires information on the weather conditions on each survey day, the dates on which the survey was done, and any groupings of multi-species searches (see BBAM and FBA section 6.6.1.4, BCAM section 4.4).
5. The locations of field traverses within the potential habitat area for each species (as recorded using a GPS), in GIS files and shown on a geo-referenced map or aerial photograph (see BBAM Table 33, FBA Table 20).

6. The results of the survey, including each species' presence or absence; where it was present; the location and number of individuals of the species or the area of habitat; information such as age class, whether flowering or fruiting, and the condition of individuals; species polygons; the area of occupancy, including the methods used to determine the numbers present (direct counting versus sampling and by what technique) or define the area of habitat. The results should be mapped by using digital airborne data (ADS-40) or the best available ortho-rectified aerial image and the unit of measurement identified for that species (abundance or area of habitat). GPS should be used to confirm locations (see BBAM sections 6.5.1.19 and 6.5.1.20, FBA sections 6.5.1.17 and 6.5.1.18).
7. Reference to any expert reports about those species for which the survey was considered unreliable on the basis of the disturbance history or climatic events, or to export reports compiled in lieu of a targeted threatened species survey (see BBAM section 6.5.1.3 and Table 33, FBA section 6.5.1.3 and Table 20, BCAM section 4.3). This should also include copies of the National Herbarium of NSW determinations or correspondence for any threatened species identified on the site.
8. Documentation associated with voucher specimens taken and their verification, as well as documentation on provision of the threatened species' location and abundance to BioNet OEH.
9. The experience level, qualifications, and justification of the suitability of the threatened-plant surveyor (see section 2.2).
10. The site description and any history (such as previous fire disturbance) that may influence the distribution and abundance of the target species.

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Appendix 1: Links to the assessment methodologies

This *NSW Guide to Surveying Threatened Plant Species* is applied in the following sections of the OEH's assessment methodologies. Note that future updates of the assessment methodologies may make the cross-references given here inaccurate.

Publication	Relevant section
BioBanking Assessment Methodology (BBAM) (OEH 2014a)	s. 6.4 Assessing species that cannot be predicted by habitat surrogates (species credits)
Operations Manual for BBAM and FBA (OEH in preparation)	(in preparation)
Framework for Biodiversity Assessment (FBA) (OEH 2014b)	s. 6.4 Assessing species that cannot be predicted by habitat surrogates (species credits)
Biodiversity Certification Assessment Methodology (BCAM) (DECCW 2011)	s. 4.3 Species that cannot be predicted by habitat surrogates (species credits)
Biodiversity Certification Operations Manual (OEH 2015)	Part 3 Assess threatened species and populations