NIWA
Taihoro Nukurangi

LakeSPI

A method for monitoring ecological condition in New Zealand lakes

User Manual
Version 2

John Clayton
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Glossary

Angiosperm	Flowering vascular plant
Bryophyte	Refers to mosses and liverworts
Dystrophic	Refers to lakes rich in humic material and with brown stained water
Indigenous	Plants that originate naturally from a region or country
Indicator	An ecological indicator is a measure, or an index of measures, that characterizes an ecosystem or one of its critical components.
Macroalgae	Large macroscopic alga comprised of species of *Chara* and *Nitella*.
Macrophyte	Large plant with multicellular structure
Peduncle	Stalk that connects flower to plant
Physico-chemical	Refers to the range of physical (e.g., Secchi disc, dissolved oxygen) and chemical (e.g., nutrient concentration, chlorophyll a) measurements used to characterise water quality
Rhizome:	Underground stem, usually spreading horizontally
Spike	An unbranched compact flowering head
Taxa	Any taxonomic category (e.g., species, genus)
Translucent	Partly transparent
Tuber	Swollen portion of underground stem or root
Whorl	Arising at the same point along an axis

Chapter 1

1. Forward

1.1 Purpose of this manual

The purpose of this manual is to provide procedural guidance on how to carry out the 'Lake Submerged Plant Indicator' (LakeSPI) survey to monitor and assess the ecological condition of New Zealand lakes.

The manual describes what LakeSPI is, the purposes for which it can be used and how to use it. It gives guidance on where and when to undertake LakeSPI surveys, procedures on how to carry out the field assessment, and describes how to generate LakeSPI indices.

The primary users of this manual will be those with a practical interest in applying the LakeSPI method to New Zealand lakes. Other users will include those with a scientific and management interest in the use of LakeSPI as a management tool.

A Technical Report has also been prepared to accompany the LakeSPI User Manual and this should be referred to for a detailed account of method development, the concepts behind the LakeSPI method, interpretation of indices and management application.

1.2 Summary of method

WHAT IS LakeSPI?	
LakeSPI	Lake Submerged Plant Indicators (LakeSPI) is comprised of three indices: Native Condition Index, Invasive Condition Index and an overall LakeSPI Index.
Purpose	A survey method for the assessment of ecological condition of New Zealand lakes.
Biota Sampled	Submerged aquatic plants (macrophytes)
Underlying principles	A lake can be characterised by the composition of native and invasive plants and the depth at which they grow to.
WHAT ARE THE USES OF LakeSPI?	
Uses	To assess, monitor and report on lake ecological condition.
Application	To assist managers in assessing the effectiveness of management activities and to contribute towards regional and national reporting requirements.
SURVEY PLANNING	
Skills	Diving and basic plant identification
Equipment	SCUBA, boat (may be required), field gear (clipboard, pre-printed water proof sheets).
Lake Selection	Any lakes with submerged plants except where salinity, alkalinity, acidity, altitude or size prevents the development of normal submerged vegetation composition. It is not suitable for lakes where submerged plants are rare (i.e., site cover less than ten percent) or non-existent.
Site Selection	Avoid sites affected by unfavourable influences such as stream inflows, steep gradients, exposed shorelines and disturbance areas (boat ramps and weed control areas). Five sites will be sufficient for most lakes.
Timing	Summer or autumn assessments are recommended. Frequency of survey will vary depending on management objectives, a lake’s current condition and vulnerability to change.

HOW TO CARRY OUT A LakeSPI SURVEY

Pre-survey	It is useful to investigate previous lake reports, vegetation lists (NIWA Aquatic Plant Database), and a bathymetric map prior to site selection. Surveyors should be familiar with the necessary health and safety guidelines. An equipment checklist is provided.
Field survey	This involves SCUBA diving at five representative sites within a lake and recording various components of native and invasive lake vegetation onto LakeSPI field sheets.

GENERATING LakeSPI SCORES AND INDICES

Site scores	Data captured on the site field sheet is used to generate three LakeSPI scores for an individual site. Separate native condition, invasive condition and LakeSPI scores are generated using scoring parameters, which relate to each vegetation feature being assessed.
LakeSPI indices	A mean of each of the final site scores for native condition, invasive condition and LakeSPI, result in the final indices: *Native Condition Index*, *Invasive Condition Index*, and overall *LakeSPI Index*.

INTERPRETING RESULTS

Native Condition Index	This captures the native character of vegetation in a lake based on diversity and quality of indigenous plant communities. A high ‘native condition index’ value will represent better lake condition.
Invasive Condition Index	This captures the invasive character of vegetation in a lake based on the degree of impact by invasive weed species. A high ‘invasive condition index’ value will represent poorer lake condition.
LakeSPI Index	This is a synthesis of components from both the native condition and invasive condition of a lake and provides an overall indication of a lake’s ecological condition.
Lake comparisons	LakeSPI assesses and calculates LakeSPI indices based on a maximum potential score for each lake. This allows dissimilar lakes to be more directly compared.

2 Chapter

2. Introduction to LakeSPI

2.1 What is LakeSPI?

LakeSPI (pronounced "Lake Spy") is a management tool that uses Submerged Plant Indicators (SPI) for assessing the ecological condition of New Zealand lakes and for monitoring trends in lake ecological condition. Key features of aquatic macrophyte structure and composition are used to generate three LakeSPI indices:

- 'Native Condition Index' – This captures the native character of vegetation in a lake based on diversity and quality of indigenous plant communities.

- 'Invasive Condition Index' – This captures the invasive character of vegetation in a lake based on the degree of impact by invasive weed species.

- 'LakeSPI Index' – This is a synthesis of components from both the native condition and invasive condition of a lake and provides an overall indication of lake ecological condition.

LakeSPI provides a cost effective management tool that is relatively straightforward in its application and relevant for use by lake managers in all lakes where submerged vegetation is present.

A website has been designed to hold LakeSPI survey information and LakeSPI results can be viewed in a user friendly format from lakespi.niwa.co.nz.

2.2 Uses of LakeSPI

The LakeSPI method can be used to provide an overall indication of a lakes ecological and biological condition. It provides an insight into the native and invasive character of a lake and allows for changes in these conditions and overall lake condition to be monitored over time.

LakeSPI can be used in many ways depending on what the management needs are for individual lakes or for a selection of lakes. The LakeSPI indices will allow lake managers to:

- Assess and compare the ecological condition of different lakes within or between regions.
- Rank the state of lakes in their region and thereby prioritise those most in need of protection, surveillance or management.
- Monitor trends occurring within selected lakes over time.
- Compare current lake condition with indices generated from historical vegetation records.
- Make comparisons between dissimilar lakes of different depths or from different regions.
- Provide relevant information for regional and national reporting requirements, including operational monitoring and state of the environment reporting.
- Help assess the effectiveness of catchment and lake management initiatives.

It is intended that LakeSPI complement rather than replace other lake assessment methods. For example, there are many cases where lakes have not been systematically monitored and LakeSPI can provide a simple, cost effective means for allowing mangers to capture information for such lakes under their management.

A list of questions that LakeSPI can help answer and further comparisons between LakeSPI and other monitoring methods can be found in the Technical Report.

2.3 Underlying principles

Submerged plants provide the essential information required for the LakeSPI method. This is because they are predominantly immobile, macroscopic and perennial in nature, which make them easy to observe, sample and identify. Submerged plants also reflect environmental conditions related to plant growth for an extended period of time prior to sampling.

The LakeSPI methodology uses a simple scoring system to derive a single index to describe the ecological condition of a lake.

The LakeSPI survey seeks to characterise both the **native condition** and the **invasive condition** of vegetation in any lake containing submerged plants. Both of these conditions are individually assessed and measured by a combination of structural and compositional features of the lake vegetation. All of these features are represented by a numerical score, which is then used to construct a **Native Condition Index** and an **Invasive Condition Index** (Figure 1). Selected components from each of these indices are then used to develop a **LakeSPI Index**, which represents the overall ecological or biological status of a lake based on submerged plant vegetation information.

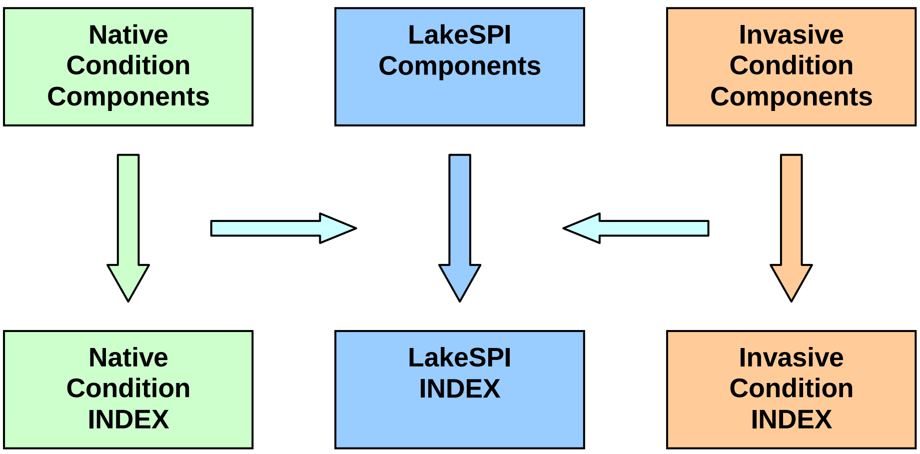


Figure 1. Simplified diagram showing the conceptual flow of creating 'LakeSPI indices'.

Key assumptions for the LakeSPI Index are that the presence of certain native vegetation values will increase the LakeSPI score directly, while the absence of certain invasive vegetation features will similarly increase the LakeSPI score. Therefore, a high Native Condition Index is describing good native vegetation conditions, while a high Invasive Condition Index is describing well-developed invasive vegetation conditions. The latter has the effect of reducing the overall condition or index used to characterise a lake.

Chapter 3

3. Survey planning

3.1 Skills required

The LakeSPI method does require suitably qualified divers and for many lakes the support of a suitably qualified boat operator (see Section 3.2).

Apart from the diving and boating requirements, the LakeSPI method itself has been developed with simplicity in mind so that only a basic level of training is required to apply the method and interpret the results.

A basic level of plant identification skills is essential for accurate use of the LakeSPI method (Appendix 6) and it is expected that most people will quickly develop the required proficiency for identification, since difficult taxa such as charophytes do not require identification below community level.

3.2 Equipment required

SCUBA equipment - In addition to the use of standard SCUBA gear it is important that an accurate depth gauge is used with 0.1 metre depth intervals displayed. It is always helpful to carry out a calibration check against a graduated line to confirm gauge accuracy. A compass is an essential underwater navigation aid, particularly if a survey site has any flat or level sections.

Boat equipment - In addition to standard safety equipment carried in boats it can be helpful to carry an underwater viewing box and depth sounder. Sonar equipment with a digital display that is able to record lakebed profiles and display the presence of bottom-rooted vegetation is very useful, particularly during initial site selection. Laser distance finders can be used to estimate the length of any vegetation profiles, while a handheld GPS recorder and a camera are highly desirable for accurate site relocation on subsequent surveys.

Field equipment – The required field equipment is minimal. A clipboard (preferably rigid plastic), a standard pencil (2B recommended) and pre-printed waterproof paper for recording field data are essential. It can be helpful to have a small graduated line with a lead weight attached at one end, so that height of weed beds can be determined. Plastic zip-lock bags and plastic jars should be carried for collecting any plant samples that may require further identification.

An equipment checklist is provided in Appendix 1.

3.3 Boating and diving requirements

In accordance with Occupational Safety and Health (OSH) requirements, any SCUBA divers employed to apply the LakeSPI method should be registered as Occupational Divers with the Labour Department and have a current Certificate of Competency issued by the Department. They should also hold a current Diving Medical Certificate issued by the Naval Health Service.

No diver needs to exceed a depth of 20 metres when applying this method and all divers should follow appropriate dive safety guidelines with respect to dive procedures. Many lakes in New Zealand are at considerable altitude and standard precautions must be followed in terms of flying after diving and driving over high altitude road passes when exiting from a lake. It is the responsibility of the diver and the employer to ensure that only divers with suitable qualifications and experience are used.

Many lakes will require the use of a boat to assist divers while carrying out the LakeSPI method. The Maritime Safety Authority (MSA) should certify any boat used by divers since they administer the Safe Ship Management System for any boats used in occupational activities. Boat operators now require an MSA certificate of competency.

3.4 Lake selection

The LakeSPI method is designed for use in all lakes with submerged plants except where salinity, alkalinity, acidity, altitude (mountain tarns) or their small size prevent the development of normal submerged vegetation composition (see Section 7.1). It is not suitable for lakes where submerged plants are rare (i.e., plant cover within vegetated areas never exceeds 10%) or non-existent. Since the LakeSPI method involves use of SCUBA it should not be used in lakes where water contact has been identified as a significant human health hazard. For more information on lake selection refer to the LakeSPI Technical Report, section 7.3.

3.5 Site selection

To obtain a meaningful LakeSPI score it is important that information is collected from sites within the lake that support common vegetation features and community composition. Initial assessments of a lake will always take longer than any subsequent re-surveys, since during the first visit care has to be taken to locate suitable sites.

A bathymetric map for any lake to be surveyed can be particularly helpful in the selection of sites. If no bathymetric map is available a topographic map should be used to provide an indication of likely bathymetry and other features that can help in the selection of sites. These maps will also help determine whether a boat is required or whether sufficient representative information can be gathered from accessible shoreline areas. Preliminary site selection based on lake bathymetry and other criteria may still prove unsuitable at the time of survey, therefore requiring some sites to be abandoned and alternative sites selected.

Previous reports, herbarium records and the NIWA Aquatic Plant Database can be helpful in anticipating likely plant species to be encountered and in understanding the nature of the lake to be surveyed. This information can also be useful in identifying potentially suitable areas for LakeSPI site selection.

Discussions with agencies responsible for managing the lake, local botanical groups or knowledgeable residents can be helpful in identifying important features about the lake, such as lake level stability, access sites, past or present weed problems, and any areas regularly controlled for weed growth.

Criteria for selection of suitable sites includes:

- Avoidance of unfavourable influences including stream inflows, steep gradients, shallow bottom limits less than the typical depth for plant growth in that particular lake, and exposed shorelines with a wave fetch exceeding 10 km. Also avoid boat ramps where disturbance from boating activities can occur, or areas where regular weed control is undertaken.

- Selection of sites with favourable conditions supporting plant growth including moderate gradients, stable substrate and moderate to high (< 5 km wave fetch) exposure.

The gradient of prospective sites is a particularly important selection criterion. Moderate gradients are preferable to shallow shelving gradients since the latter tends to contain the same information, but extended over a much longer profile. Simplicity of vegetation pattern and speed of survey favour selection of profiles with moderate gradients. However very short steep profiles are not favoured as these often lack vegetation and are more prone to periodic slumping.

The influence of aspect may be worth considering for some lakes, since north-facing slopes can display the deepest vegetation growth. This would be most relevant for clear lakes with deepwater charophyte vegetation where it is useful to have at least one site that contains the deepest likely record for submerged plant growth. Such a site can act as a particularly sensitive marker for vegetation response to small declines in water clarity.

Sheltered sites likely to support emergent vegetation are also more likely to have shallow gradients or insufficient depth to establish a bottom vegetation depth boundary. Furthermore, the presence of emergent vegetation provides no extra points in the LakeSPI scoring method. For these reasons it is recommended that in large lakes, sites with moderate exposure to wave action are preferable, provided submerged vegetation is present. If wave fetch exceeds 10 km then there may be no submerged plants present, so it is recommended that sites with a lesser wave fetch be selected. As noted under 'equipment required' it can be very helpful to have a depth sounder on a boat that can generate images of the lake bed and present an overall image of vegetation density and height to help confirm suitability of a proposed area within which to establish a survey site.

Initial site selection is very important but could be quite difficult for some lakes. Where practicable it is preferable to select sites from around the lake rather than have all sites clustered in an area. If there is uncertainty over selecting suitable sites it is recommended that experienced operators be used to help establish baseline sites. Once representative sites have been established any future assessment using LakeSPI should be based on these original sites. However if for any reason an original site subsequently indicates disturbance (e.g., slumping), then an alternative site should be substituted.

3.6 Number of sites

For most lakes it is anticipated that five sites will be sufficient to obtain meaningful scores.

For large or complex lakes five sites may not be sufficient. An initial analysis of the data as it is collected will indicate whether there is large variation between sites and therefore how many sites may be required to get stable or representative data.

Where it is apparent that large site variations exist it may be necessary to partition the lake into sections. If the factors responsible for large differences in the aquatic vegetation are known (excluding factors such as weed invasion) then it may be possible to score selected regions based on these determinants. For example, diverse catchment activities may surround different arms of a large lake, which in turn may have significant localised influences on water quality. Alternatively, the criteria for partitioning should be based on readily distinguishable features such as geomorphologically distinctive arms or separate basins of a lake (e.g., the Frankton Arm of Lake Wakatipu). Each section of a lake can then be scored and monitored separately to give a more meaningful measure of lake condition.

3.7 Timing

LakeSPI is largely independent of seasonal influences, but it is recommended that summer or autumn assessments be made, as this is when submerged plant growth is usually at its healthiest. Summer and autumn sampling is also preferable from a practical perspective since water temperatures are warmest. The timing of any survey may need to be varied in some lakes, particularly where they have algal blooms and poor water quality conditions (i.e., low visibility). In such cases it may be easier to carry out fieldwork during winter. Where possible it is recommended that any repeat surveys on a lake be carried out at the same time of the year.

Most lake surveys should be easily completed with one day or less of fieldwork. Shallow shelving lakes with extended vegetation across the bottom will naturally be time consuming to survey, but generally it is possible to survey two or three small to medium sized lakes in one day. Large lakes would usually require a full day to survey on account of the travel distance between sites and possible need for additional survey sites. Survey plans need to be flexible enough to respond to weather conditions so that boating and diver safety are never compromised.

3.8 Frequency of survey

The frequency of survey for any lake will depend primarily upon: the lake's current condition and vulnerability to change, and its management objectives and use. Many lakes may only require reassessment every ten years or so. This would apply to large stable lakes and those isolated from disturbance factors. Some degraded lakes may also be of low priority or interest to managing authorities, with the result that they are of low priority for reassessment relative to other lakes. It is recommended that ecologically valuable lakes and those lakes vulnerable to change (from catchment/riparian activities or pest plant or fish species) be assessed every one to three years.

Chapter 4

4. How to carry out a LakeSPI survey

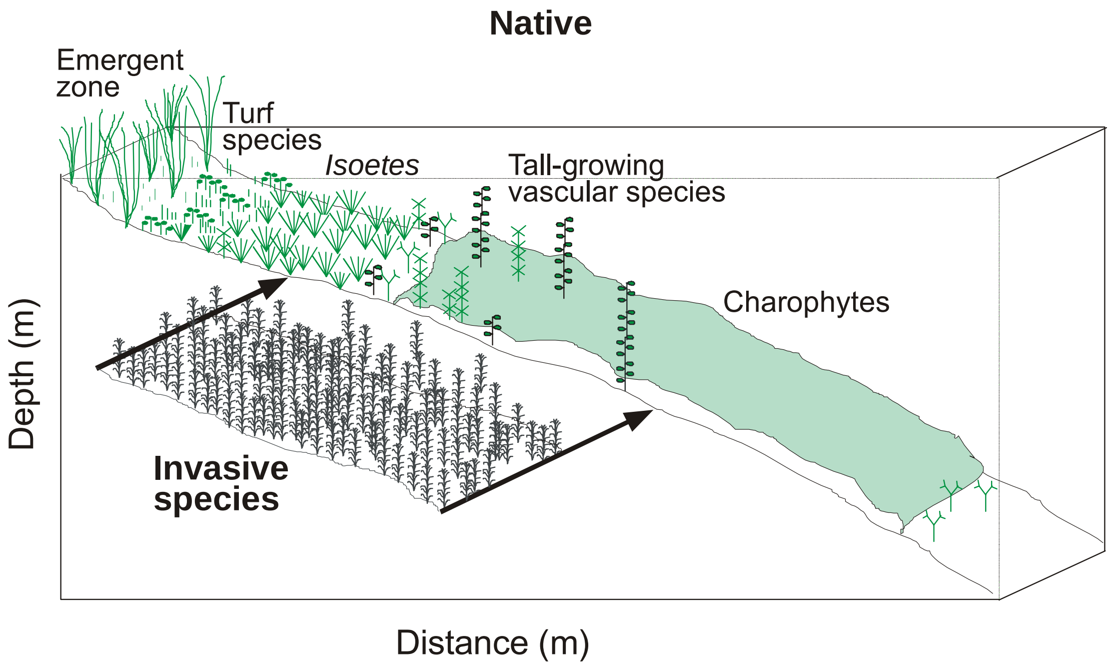
4.1 Introduction to vegetation profiles

The following is a simplified description of the aquatic vegetation found in most New Zealand freshwater lakes. Generalisations are inevitable, however in this context they are useful in helping to understand and visualise lake vegetation structure.

Aquatic plants can be conveniently divided into distinct depth-related community types ranging from the lake margin down to the deepest plant growth where light penetration becomes limiting for plant growth. This is illustrated in the depth profile drawing (Figure 2), which shows the general vegetation structure of many New Zealand lakes.

Starting at the lake edge the first and most conspicuous community type is the *emergent zone*. This is comprised of a variety of wetland species that tend to be tall growing, erect and occupy the lake margin from just above the water line and can extend out into the water to a depth of around 2 metres. This community is usually only found in sheltered habitats such as around the margins of small water bodies or in protected backwater of larger lakes. In wave-exposed areas this community will be absent.

Turf species (also known as 'low mound [or mixed] community') grow only in shallow water along shorelines of moderate exposure. They can overlap and co-exist with plants in the emergent zone in semi-sheltered habitats or even occupy sheltered shorelines if emergents are absent. There are many different species that contribute to this community type and they all tend to grow as short-stature plants to give the appearance of a grass-like turf. There is one plant (*Isoetes*) that is quite special in this community, since it can grow to greater depths than all other turf species. Normally the turf community only grows down to around 2 or 3 metres depth, where as, *Isoetes* can form a very dense mono-specific community down to around 6 metres and sometimes more, especially in the large clear South Island lakes.



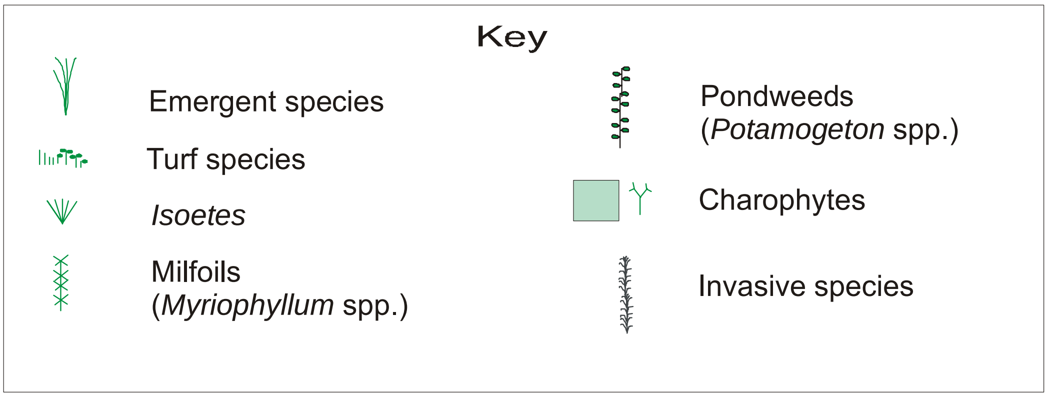


Figure 2. Depth profile illustrating the main components of native lake vegetation and the region of substitution by invasive species.

Charophytes are a native macroalgae that are quite distinctive in that they often form 'meadows' across the bed of a lake. They can grow in shallow water and are often the next common community type to extend beyond either the emergent or the turf zone. They can also extend into deeper water in direct proportion to the water clarity. In clear water lakes they can grow down to depths of 50 metres and they are often the only vegetation type found deeper than the vascular species.

Tall-growing vascular species are comprised mostly of tall-growing angiosperms (flowering plants). There are two commonly recognised native genera *Potamogeton* (pondweeds) and *Myriophyllum* (milfoils). They are often superimposed on top of the two community types discussed above. They tend to have little impact on the density or appearance of the underlying turf or charophyte community because they normally do not grow as a dense community. In fact they may occur at such low densities as to give the appearance of isolated shoots arising from out of a dense ground cover of turf or charophyte vegetation.

The above 'typical vegetation profile' describes **native** community types found widely throughout New Zealand lakes irrespective of lake size. A major deviation arises whenever **invasive** submerged species become established in a lake. All of the main invasive weed species impacting on lake vegetation structure are also tall-growing angiosperms, but they have one distinctive difference from the native milfoils and pondweeds. These invasive species can form extremely dense growths that exclude all other vegetation. They typically occupy the mid-depth range of lakes and are most common from around two to eight metres depth. Although they can grow to a depth of ten metres, their greatest impact tends to be between two to five metres where they are able to exclude most native species. There are several different invasive species present throughout New Zealand, each with their own characteristics (Appendix 6).

Particular features of each of the above community types have been identified and selected as representing useful information about the ecological condition of a waterbody. These features form the basis of the LakeSPI method and are explained in detail in the section on LakeSPI methods.

4.2 Diving a LakeSPI profile

Once sites have been selected on a lake using the criteria as described in section 3.5 and 3.6, the divers are ready to carry out the LakeSPI survey. Field sheets (Appendix 2) have been designed for data collection underwater and will be described in further detail in the next section. To begin the site profile divers first must take a compass bearing at right angles to the shore. This is essential as under water orientation can be confusing, particularly when gradients are low, visibility is poor or the profile is long.

The divers should begin by swimming along the compass bearing which in most cases will lead to the gradient of steepest descent. Although the intention is to follow the overall direction of steepest descent to the maximum depth of plant growth, if the steepest gradient is not as suitable for representing vegetation character, some judgement will be required by the divers and the compass bearing adjusted accordingly. It is important that divers look around and integrate the information they see while swimming. The diver should remain flexible, use common sense and not just focus on an exact line, since the overall objective is to build up a vegetation picture for the site being surveyed.

Often it is worthwhile to swim to the bottom first so that an overall impression can be gained, and then while at the deepest point spend two or three minutes swimming along the lowest boundary to be assured of recording an accurate maximum depth. This action usually allows for a slightly different ascent route, which not only avoids any clouds of turbid water created by bottom sediment disturbance, but also adds further observations to help complete the field sheet.

If field observers record unidentified specimens that have a significant impact in terms of describing lake condition, particularly if they are thought to be invasive species, then it is important to have sample specimens identified. Each sample collected for later identification should contain one or two carefully selected clean healthy shoots (top and bottom portions if very long), kept moist in damp newspaper inside a sealed plastic bag (no free water), and labelled with the lake name, site number and habitat details (e.g., depth, cover, height, ratio). If specimens cannot be identified locally (e.g., Regional Council biosecurity officers or DoC staff) then they can be sent to the NIWA Hamilton office (only after initially conferring with appropriate NIWA staff) for identification. Following the identification of any prominent specimen it is important to complete or adjust field sheets to accurately reflect the information gathered from relevant sites.

4.3 Collecting data using the field sheet

LakeSPI has been developed with simplicity and ease of use in mind and this has resulted in a field sheet (Appendix 2) that can be followed quickly and with minimal effort by trained field surveyors.

The field sheets are used to record information about vegetation structure and composition. For ease of use the field sheet has be divided into five main sections:

General Survey Details	records general details about the site surveyed.
Native Vegetation	records native components of the vegetation.
Invasive Vegetation	records invasive components of the vegetation.
Other Biota Noted	allows additional fauna and flora at the site to be noted.
Comments	allows for further additional information to be recorded.

The following describes in more detail how to record data onto the field sheet for each of these sections.

General Survey Details

This section requires general survey details to be recorded for the survey site (Table 1). It is important that *all* details be filled out clearly and precisely on all field sheets to ensure that no confusion arises between lakes or lake sites during subsequent processing and interpretation of the information.

Table 1. Recording general survey details on the field sheet.

LAKE NAME	Record the full lake name including its common name if applicable.
SUVEYOR	Record the name of diver(s) carrying out the site survey.
DATE	Record date of survey. Time may also prove useful particularly when noting down dive times.
SITE ID	Circle the site letter that corresponds with the site you are surveying on a lake. It can also be useful to use this site ID letter to mark your position on a lake map.
SITE DESCRIPTION	A written description of the site should be recorded to assist with relocation during future surveys. A site photo is often useful to complement this description.
GPS	A GPS reading should be recorded whenever possible since it can be the most accurate way of recording the exact location of a site for future relocation. If GPS is not available grid references should be recorded.
PROFILE LENGTH	Estimate the vegetation profile length by circling one of the measurements marked.

Native Vegetation

This section requires data to be collected on the various components of native vegetation present at a site. If no native vegetation is found at a site then this section can be simply crossed off. If native vegetation is found then the following boxes from the field sheet will require information (Table 2).

Table 2. Recording the native components of vegetation using the field sheet.

< 5 m: ☐ Emergents; ☐ Turf community; ☐ Charophytes; ☐ Isoetes; ☐ Milfoils; ☐ Pondweeds. > 5 m: ☐ Isoetes; ☐ Milfoils; ☐ Pondweeds	**NATIVE PRESENCE** This box notes the presence of native vegetation at a site. For the purpose of recording LakeSPI data, native vegetation includes any combination of Charophytes, Milfoils, Pondweeds, Isoetes, Turf communities and/or Emergents present at a site. Native plant groups are recorded as present by ticking the corresponding boxes on the field sheet. If Milfoils, Pondweeds and Isoetes are found at a site growing deeper than 5 m then there is an extra box to tick. Plants do not have to exceed a cover rating for this record and a plant needs only to be present to be ticked for the appropriate depth.
☐ NATIVES (> 10% cover) ☐ CHAROPHYTE MEADOWS (> 75% cover)	**NATIVE MAXIMUM DEPTH** This box is for recording the maximum depth of two aspects of native vegetation. **Natives** – this first box records the maximum depth of any natives present at a site. This includes the presence of any of the native groups listed above providing that they have a greater than 10% cover. **Charophyte meadows** – this box records the maximum depth of charophyte meadows if present at a site. Charophyte meadows are recognised here as being a Charophyte community that has a greater than 75% cover. <u>Notes</u> - Maximum depth should be recorded as accurately as possible to the nearest 0.1 m. - If the maximum depth boundary for native vegetation is not distinctive but rather forms a transition from high to low cover, then a subjective estimate is made of when a cover of approximately 10% has been reached. - If native charophytes continue down to a depth that exceeds the 20 m limit set for LakeSPI data collection the depth should just be recorded as being 20 m+.

☐ < 5 ☐ 6 – 25 ☐ 26 – 50 ☐ 51 – 75 ☐ 76 – 95 ☐ > 95	**NATIVE RATIO** The native ratio is a subjective estimate of the percentage of native vegetation over the entire depth profile. For this ratio the vegetated area (irrespective of height, biomass or density and ignoring bare patches) is assessed along the profile and must add up to 100% when combined with the invasive ratio. This information is recorded on the field sheet by ticking the box that most closely corresponds with the most appropriate ratio percentage for native vegetation. *Helpful hint*: Although the ratio is only a subjective estimate it can be helpful to count the number of fin kicks to estimate distance of any distinct band of native or invasive vegetation relative to total profile length.

Invasive Vegetation

This section requires data to be collected on the various components of invasive vegetation present at a site. If no invasive species are found at a site then this section can be simply crossed off. If invasive species are found then the following boxes from the field sheet will require information (Table 3).

Table 3. Recording invasive components of vegetation using the field sheet.

HEIGHT (m)		%
	Elodea	
	Egeria	
	Lagarosiphon	
	Hydrilla	
	Ceratophyllum	
	Pot. crispus	
	Juncus bulb.	
	Ranunculus tri.	
	Vallisneria	
	Utricularia. gibba	

INVASIVE SPECIES

This box notes the presence of key invasive species present at a lake. Presence is noted by recording the details in corresponding boxes on maximum plant height and composition.

Plant Height – The objective is to note the tallest overall height achieved for any area of invasive species. To record the maximum height the area of weed being measured must exceed a 2 x 2 m square to ensure that isolated tall shoots are not being noted.

Helpful hint – A weighted tape measure can be useful for measuring tall weed beds particularly when they are too dense to dive into.

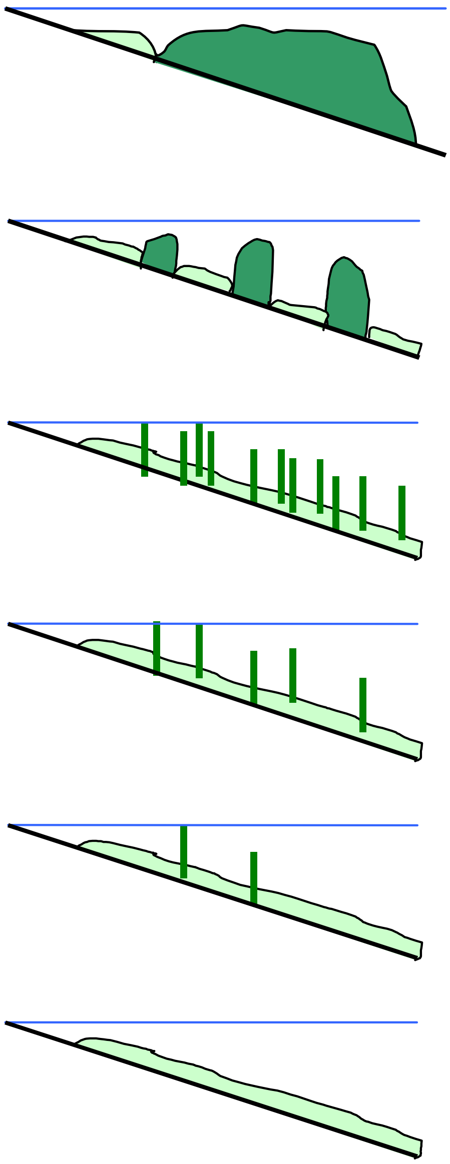
Invasive percentage – this is an estimate of what percentage of each invasive species makes up the total proportion of invasive vegetation found at a site. This is recorded as a percentage and therefore should add to 100.

Maximum Depth	

INVASIVE MAXIMUM DEPTH

This box is for recording the maximum depth of invasive vegetation present at a site. Invasive vegetation however must have a cover greater than 10% at that depth.

☐ < 5 ☐ 6 – 25 ☐ 26 – 50 ☐ 51 – 75 ☐ 76 – 95 ☐ > 95	**INVASIVE RATIO** The ‘invasive ratio’ is the complement partner to the ‘native ratio’ assessment. It is a subjective estimate of the percentage of invasive vegetation over the entire depth profile. This information is recorded on the field sheet by ticking the box that most closely corresponds with the most appropriate ratio percentage for invasive vegetation.
☐ Plants Occasional ☐ Plants Common ☐ Open Canopy ☐ Partly Closed Canopy ☐ Closed Canopy	**NATURE OF INVASIVE COVER** This is a subjective estimate of the highest cover value for any discrete patch or band of invasive vegetation present at a site over the area occupied by an invasive species. **Plants Occasional** = very few invasive plants found. (< 10 plants in a profile). **Plants Common** = invasive plants common but vegetation mainly dominated by native species (or there are no other plants at all). **Open Canopy** = open canopy often allowing other vegetation to grow among it or bare sediment visible. **Partly Closed Canopy** = Clumps of dense vegetation < 2 x 2m or patchy by overall nature. **Closed Canopy** = continuous closed canopy of any invasive species occupying area > 2 x 2m. (For fuller explanation see Figure 3 below)



5 — CLOSED CANOPY
Continuous closed canopy of any invasive species occupying an area > 2 x 2m. Often the invasive species will be *Egeria*, *Lagarosiphon* or *Ceratophyllum*

4 — MOSTLY CLOSED CANOPY
Clumps of invasive species < 2 x 2m but patchy in their nature. Often the same species as above prior to forming a complete cover

3 — OPEN CANOPY
Invasive canopy is open and often allows for other vegetation to grow amongst it. Often species will be *Lagarosiphon* or *Elodea*

2 — PLANTS COMMON
Invasive plants are common but lake vegetation is mainly dominated by native species (or these are absent)

1 — PLANTS OCCASIONAL
Very few invasive species found (e.g., < 10 plants in a profile)

0 — NO INVASIVE SPECIES
No invasive species present at the site (i.e., site with native plants only)

Figure 3. Cover categories and their associated scores used for the 'nature of invasive cover' score. Invasive species are shown by the dark filled in areas.

Other Biota Noted

This section although optional, can provide useful records on the presence of other fauna and flora noted at a site. This may include mussels, snails, koura (freshwater crayfish) and fish. Any excessive growths of algae should be noted. Any unusual plant species should also be noted, especially if they do not appear to fit within the plant or group types noted on the field sheet (e.g., bladderwort (*Utricularia*), bryophytes, rooted floating-leaved lilies).

Comments

This section allows for additional information to be recorded for a site that may help interpret a lakes condition or be useful for future and historic comparisons. This may include:

- *Profile sketch* — a quick diagrammatic sketch to illustrate the different components of vegetation structure and composition seen by the surveyor
- *Land use* — the type of riparian vegetation and nearby land use occurring at the site (e.g, native bush, farm land, recreational area)
- *Unidentified specimens* — If an unrecognisable plant appears not to fit the identification guidelines and is thought to be of potential ecological importance, then samples should be collected and labelled for later identification (see section 4.2)

For an example of a filled out field sheet refer to Appendix 4.

Chapter 5

5. Using field data to generate LakeSPI scores

5.1 Scoring process

The LakeSPI scoring process results in the generation of three independent indices which together help to describe a lakes condition. These indices are:

- Native Condition Index - describes the native condition of vegetation within a lake.
- Invasive Condition Index - describes the invasive condition of vegetation within a lake.
- LakeSPI Index - describes the overall ecological status of a lake.

Individual features of lake vegetation (Figure 4) are assessed using the LakeSPI scoring criteria (section 5.2) and each feature is given a score. Figure 4 shows the way in which individual scoring features add directly to form the Native Condition Index and Invasive Condition Index. The downward facing arrows in the Native Condition and Invasive Condition columns show the sequence of scoring features that are added to create a final Index. The horizontal arrows show which features have their individual scores transferred to the LakeSPI column to create a separate LakeSPI Index. This process of score generation will be discussed more fully in section 5.3.

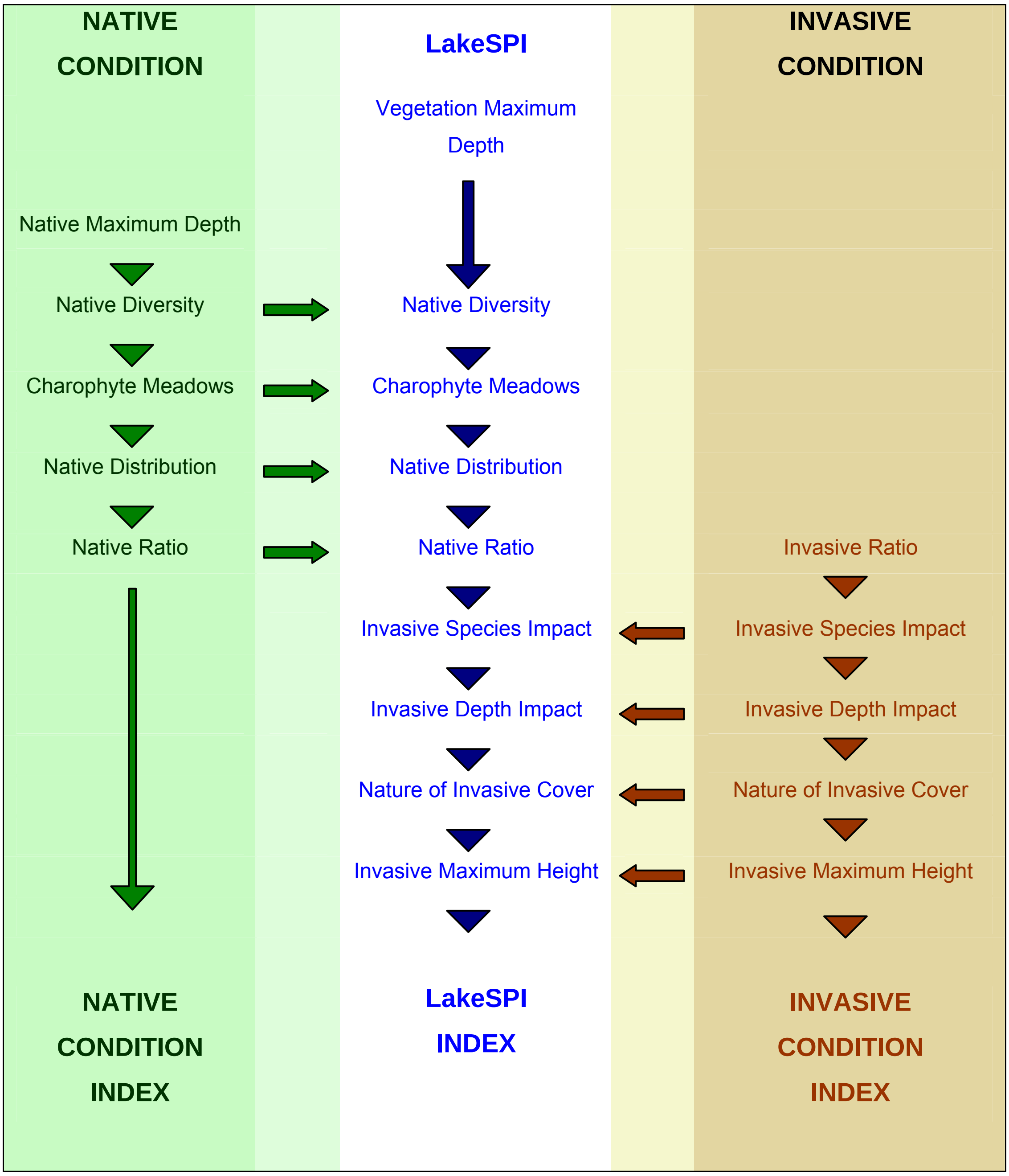


Figure 4. **Conceptual flow of submerged plant measures used to produce a Native Condition Index, Invasive Condition Index and LakeSPI Index.**

5.2. . Scoring parameters

Lake vegetation information captured on the field sheet is used to create individual scores for specific vegetation features.

These vegetation features fit into one of three categories:

1. Independent LakeSPI features
2. Native condition features
3. Invasive condition features

A detailed explanation of the concepts behind each of the scoring features that contribute to the LakeSPI indices is contained in the LakeSPI Technical Report.

5.2.1 Independent LakeSPI features

There is only one feature of lake vegetation that fits into this category – the 'vegetation maximum depth' score. This is a stand-alone parameter, as it does not contribute to the generation of the Native Condition Index or the Invasive Condition Index, however it does contribute directly to the LakeSPI Index (Figure 4).

5.2.1.1 Vegetation maximum depth

The maximum depth of vegetation can be found on the field sheet in one of two boxes depending on whether the deepest vegetation was comprised of native or invasive species.

The maximum depth from the field sheet will fit into one of the depth categories in the middle column of Scoring Box 1 (see below). Each of these depth categories then corresponds to a score in the adjacent outside columns.

If the deepest recorded vegetation is comprised of natives, then the scoring potential for the 'vegetation maximum depth' can range from 0 to 10. For example, if native vegetation was the deepest vegetation at a site and it was recorded growing to a depth of 12.5 m, then this depth will correspond to a 6 for the 'vegetation maximum depth' score.

If the deepest recorded vegetation at a site is composed of invasive species, then the scoring potential for the 'vegetation maximum depth' score ranges from 0 to 5. The same principles apply as above, only for invasive species a cut-off line has been created (shown on the score table by a dotted red line) that limits the maximum potential score to a 5. For example, if invasive species were the deepest vegetation at a site and they were recorded to a depth of 12.5 m, then this depth will correspond to a score that is restricted to a maximum of 5 for the 'vegetation maximum depth' score.

Scoring Box 1

LakeSPI criteria for assessing the 'vegetation maximum depth' score.

NATIVE SCORE	DEPTH (m)	INVASIVE SCORE
0	No plants *or* <10% plant cover	0
1	0 – 2.9	1
2	3 – 4.9	2
3	5 – 6.9	3
4	7 – 8.9	4
5	9 – 10.9	5
6	11 – 12.9	
7	13 – 14.9	
8	15 – 16.9	
9	17 – 18.9	
10	19 m +	

The score for 'vegetation maximum depth' adds directly to the LakeSPI Index (Figure 4).

5.2.2 Native condition features

Native condition features are grouped together as they all contribute to the generation of the Native Condition Index. All but one native vegetation feature (native maximum depth) then contributes directly to the generation of a LakeSPI Index (Figure 4).

5.2.2.1 Native maximum depth

The maximum depth of native vegetation is recorded under the 'native condition' features on the field sheet.

The 'native maximum depth' score can range from 0 to 10 (Scoring Box 2) and has the same depth categories as those used in the above score for 'vegetation maximum depth' (Section 5.2.1.1).

If native vegetation is the deepest vegetation recorded at a site then this depth score will be the same as that recorded for the 'vegetation maximum depth' score.

Scoring Box 2

LakeSPI criteria for assessing the 'native maximum depth' score.

DEPTH (m)	SCORE
No plants *or* <10% plant cover	0
0 – 2.9	1
3 – 4.9	2
5 – 6.9	3
7 – 8.9	4
9 – 10.9	5
11 – 12.9	6
13 – 14.9	7
15 – 16.9	8
17 – 18.9	9
19 m +	10

The score for 'native maximum depth' adds directly towards the Native Condition Index (Figure 4).

5.2.2.2 Native diversity

The 'native diversity' score can be derived from the field sheet by noting the number of native plant types recorded as present under the section 'native presence'.

One point is allocated for the presence of each of the native types and the points are additive. This means that the maximum possible score for this factor at any site would be 5 provided all diversity categories were recorded (Scoring Box 3).

Scoring Box 3

LakeSPI criteria for assessing the 'native diversity' score.

<table>
<tr><th>DIVERSITY</th><th>POINTS</th></tr>
<tr><td>Charophytes</td><td>1</td></tr>
<tr><td>Pondweeds</td><td>1</td></tr>
<tr><td>Milfoils</td><td>1</td></tr>
<tr><td>Isoetes</td><td>1</td></tr>
<tr><td>Turf Plants</td><td rowspan="2">1</td></tr>
<tr><td>Emergents</td></tr>
<tr><td></td><td>Total Score ≤ 5</td></tr>
</table>

Note:
Emergents are only given a point if they are present at a site where there are NO turf plants and providing other native submerged vegetation is present.

Example: If charophytes, pondweeds and milfoils were recorded at a site then the score would be a 3.

The 'native diversity' score adds directly to the Native Condition Index and the same score contributes to the LakeSPI Index (Figure 4).

5.2.2.3 Charophyte meadows

The maximum depth of a charophyte meadow can be found in the corresponding box on the field sheet. This depth is then entered into Scoring Box 4 and depending on the depth of a charophyte meadow a maximum score of 5 can be achieved.

Scoring Box 4

LakeSPI criteria for assessing the 'charophyte meadows' score.

DEPTH (m) OF CHAROPHYTE MEADOW	SCORE
None	0
0 – 4.9	1
5 – 9.9	2
10 – 14.9	3
15 – 19.9	4
20 m +	5

Example: Charophyte meadow recorded to a maximum depth of 12 m will score a 3.

The 'charophyte meadow' score adds directly to the Native Condition Index and the same score contributes to the LakeSPI Index (Figure 4).

5.2.2.4 Native distribution

If milfoils, pondweeds and *Isoetes* are recorded as growing deeper than 5 metres, this corresponds to extra points (Scoring Box 5). A maximum of 3 points can be allocated if all three species are present beyond 5 metres.

Scoring Box 5

LakeSPI criteria for assessing the 'native distribution' score.

DISTRIBUTION (present > 5 m depth)	POINTS
Milfoils	1
Pondweeds	1
Isoetes	1
	Total Score ≤ 3

The 'native distribution' score adds directly to the Native Condition Index and the same score contributes to the LakeSPI Index (Figure 4).

5.2.2.5 Native ratio

The 'native ratio' score corresponds directly to what is recorded in the native ratio section of the field sheet. Each ratio percentage is allocated a score ranging from zero when no natives are recorded to 7 when only native vegetation is present (Scoring Box 6).

Scoring Box 6

LakeSPI criteria for assessing the 'native ratio' score.

NATIVE RATIO %	SCORE
No Natives	0
< 5	1
6 – 25	2
26 – 50	3
51 – 75	4
76 – 95	5
> 95	6
100 % Native	7

The 'native ratio' score adds directly to the Native Condition Index and the same score contributes to the LakeSPI Index (Figure 4).

5.2.3 Invasive condition features

Invasive condition features are grouped together as they all contribute to the generation of the Invasive Condition Index. All but one invasive vegetation feature (invasive ratio) then contributes to the generation of a LakeSPI Index (Figure 4). For addition to the LakeSPI Index, scores must be inverted as demonstrated in the scoring boxes of this section.

5.2.3.1 Invasive ratio

The 'invasive ratio' scoring parameters correspond directly to what is recorded in the invasive ratio section of the field sheet. Each ratio percentage is allocated a score ranging from zero when no invasives are recorded to 7 when only invasive vegetation is present (Scoring Box 7).

Scoring Box 7

LakeSPI criteria for assessing the 'invasive ratio' score.

INVASIVE RATIO %	SCORE
No Invasives	0
< 5	1
6 – 25	2
26 – 50	3
51 – 75	4
76 – 95	5
> 95	6
100 % Invasive	7

The score for 'invasive ratio' adds to the Invasive Condition Index only (Figure 4).

5.2.3.2 Invasive species impact

All of the nominated invasive species noted on the field sheet correspond to an allocated invasive species score (Scoring Box 8). Although each species is allocated a score, it is only the highest scoring species that is used for the scoring process. This score adds directly to the Invasive Condition Index (Figure 4).

This 'invasive species impact' score also contributes to the LakeSPI Index (Figure 4), but first needs to be inverted as shown in Scoring Box 8 (i.e., the higher the invasive condition score the poorer the lake condition, so this must be reflected by a lower score contributing to the LakeSPI Index).

Example: *Elodea* and *Lagarosiphon* are both recorded at a site. Because *Lagarosiphon* is the highest scoring invasive species, then a score of 4 is allocated and this score will contribute to the Invasive Condition Index. This score is then inverted to a LakeSPI Index score of 3 (as shown in the scoring box) and this score then contributes to the LakeSPI Index.

Scoring Box 8

LakeSPI criteria for assessing the 'invasive species impact' score.

INVASIVE SPECIES	Invasive Condition SCORE	*INVERTED*	LakeSPI SCORE
'No Invasives'	0	▶	7
Juncus bulbosus	1	▶	6
Ranunculus trichophyllus	1	▶	6
Potamogeton crispus	2	▶	5
Utricularia gibba	2	▶	5
Elodea canadensis	3	▶	4
Vallisneria species	4	▶	3
Lagarosiphon major	4	▶	3
Egeria densa	5	▶	2
Hydrilla verticillata	6	▶	1
Ceratophyllum demersum	7	▶	0

5.2.3.3 Invasive depth impact

This measurement is based on measuring the depth range of native vegetation extending beyond the maximum depth of invasive species. This can be calculated from the field sheet data by subtracted the maximum depth range (in metres) of invasives from the maximum depth range recorded for native vegetation.

The scores range from 0 when no invasive species are present or do not exceed a 10% cover, to 5 when no native vegetation is present below the deepest growth of invasive species (Scoring Box 9).

Example: A lake has invasive vegetation growing to a maximum depth of 8 m and native vegetation growing beyond this to a maximum depth of 13.5 m. Subtracting the maximum depth of invasive (8 m) from the maximum depth of native vegetation (13.5 m) results in a depth range difference of 5.5m (13.5 – 8 = 5.5 m). 5.5 m corresponds to an Invasive Condition score of 2 as 5.5 m falls in the scoring range from 4 – 7.9 m of depth range (Scoring Box 9). The Invasive Condition score is then inverted to produce a LakeSPI score, in this case a 3.

The 'invasive depth impact' score adds directly to the Invasive Condition Index to show maximum invasive impact (refer Figure 4). In contrast each score is inverted before contributing to the LakeSPI Index.

Scoring Box 9

LakeSPI criteria for assessing the 'invasive depth impact' score.

DEPTH (m)	Invasive Condition SCORE	*INVERTED*	LakeSPI SCORE
No Invasives	0	▶	5
> 8	1	▶	4
4 – 7.9	2	▶	3
2 – 3.9	3	▶	2
0 – 1.9	4	▶	1
No Natives	5	▶	0

5.2.3.4 Nature of invasive cover

The 'nature of invasive cover' scoring parameters correspond directly to what is recorded in the nature of invasive cover section of the field sheet.

Each cover value is allocated a score ranging from no invasive species present scoring a zero (Scoring Box 10), to a closed canopy of invasive species scoring a maximum score of 5.

The 'nature of invasive cover' score adds directly to the Invasive Condition Index, whereas each score is inverted (Scoring Box 10) before contributing to the LakeSPI Index (Figure 4).

Scoring Box 10

LakeSPI criteria for assessing the 'nature of invasive cover' score.

INVASIVE COVER	SCORE	*INVERTED*	LakeSPI SCORE
No Invasives	0	▶	5
Plants Occasional	1	▶	4
Plants Common	2	▶	3
Open Canopy	3	▶	2
Partly Closed Canopy	4	▶	1
Closed Canopy	5	▶	0

5.2.3.5 Invasive maximum height

The maximum height of invasive vegetation recorded at a site can be taken directly from the field sheet under the Invasive Species section. Only the invasive species recording the greatest maximum height is used for scoring purposes.

The maximum height corresponds to an Invasive Condition score that adds directly to the Invasive Condition Index, whereas the score is inverted (Scoring Box 11) before contributing to the LakeSPI Index (Figure 4).

Scoring Box 11

LakeSPI criteria for assessing the 'invasive maximum height' score.

INVASIVE HEIGHT (m)	Invasive Condition SCORE	*INVERTED*	LakeSPI SCORE
No Invasives	0	▶	3
< 1	1	▶	2
1 – 3	2	▶	1
> 3	3	▶	0

5.3 Generating LakeSPI indices

Generation of LakeSPI Indices can be best explained in three steps. The first step involves establishing LakeSPI scores for an individual site within a lake, the second step shows how these individual site scores are used to generate overall lake scores, and the final step adjusts the final lake scores using the 'Depth Calibration Table' to generate final LakeSPI indices for a lake.

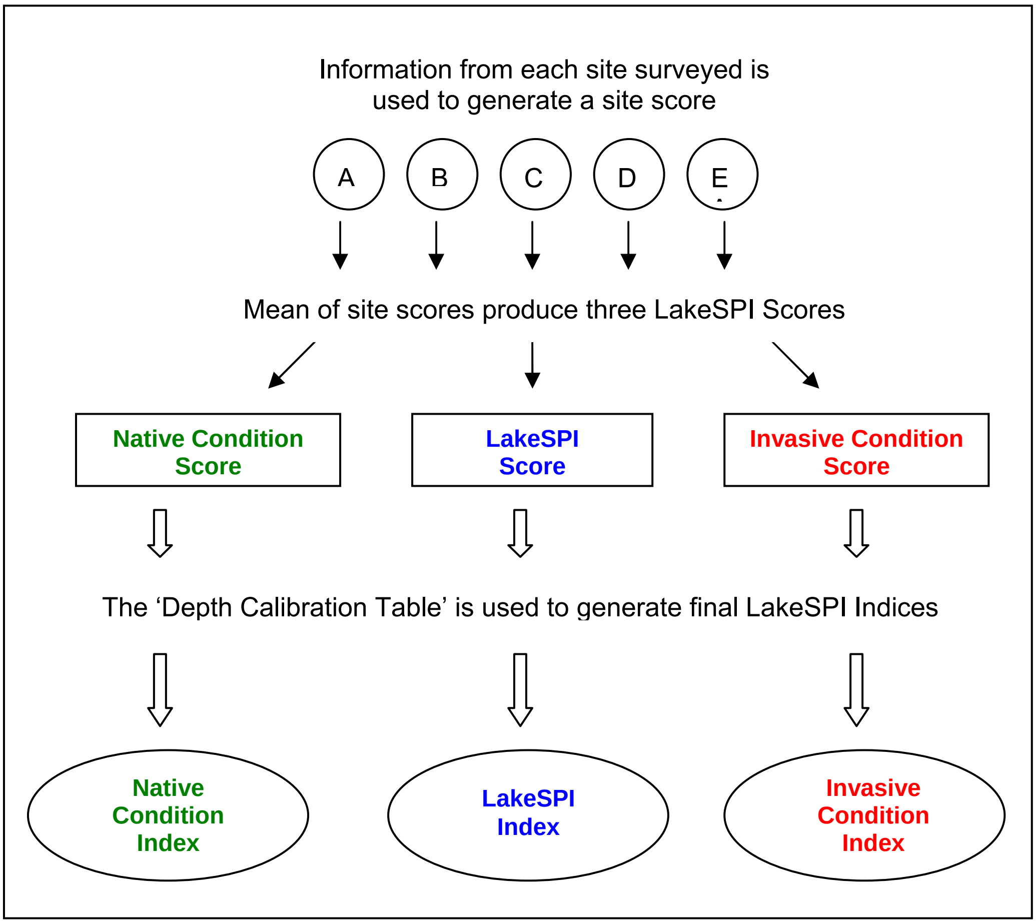


Figure 5. Scoring process for generating LakeSPI indices for a single lake.

Step one – generation of site scores

For each site surveyed around a lake, LakeSPI scores can be generated using the scoring parameters described in Section 5.2. A simple scoring sheet has been developed (Appendix 3), so that when the vegetation features recorded at a site have been converted into scores, these scores can then be placed into their appropriate boxes for the parameters assessed. Once the score sheet has been completed (including the inversion of any scores moving into the LakeSPI column from the Invasive Condition scoring boxes) then all of the columns can be added to generate a Native Condition score, an Invasive Condition score and a LakeSPI score. An example score sheet is shown in Appendix 5.

Step two – generation of lake scores

The generation of lake scores are calculated by taking a mean of the final score generated for the surveyed sites around a lake (Figure 5). This is done for each index:

- A mean of all Native Condition site scores will give the overall Native Condition Score for a lake.

- A mean of all Invasive Condition site scores will give the overall Invasive Condition Score for a lake.

- A mean of all LakeSPI site scores will give the overall LakeSPI Score for a lake.

Step three – generation of LakeSPI indices

Final LakeSPI indices are calculated based on a maximum potential score that can be achieved for each lake and indices expressed as a percentage of that maximum potential – that is, just how close a lake is to its best possible condition.

Maximum potential scores will vary depending on lake depth and therefore maximum lake depth must be known before proceeding with this final step. Use of the 'Depth Calibration Table' (Table 2) below, shows the adjusted maximum potential LakeSPI scores for lakes of varying depths for each of the three LakeSPI conditons.

Table 4. **'Depth Calibration Table' showing the maximum potential scores that can be achieved for lakes with different maximum depths.**

Max lake depth (m)	Maximum Potential LakeSPI Score	Maximum Potential Native Condition Score	Maximum Potential Invasive Condition Score
1- 2.9	34	14	27
3- 4.9	35	15	27
5- 6.9	40	20	27
7- 8.9	41	21	27
9- 9.9	42	22	27
10- 10.9	43	23	27
11- 12.9	44	24	27
13- 14.9	45	25	27
15- 16.9	47	27	27
17- 18.9	48	28	27
19- 19.9	49	29	27
20+	50	30	27

A full explanation of this table can be found in section 8.4 of the LakeSPI Technical Report).

Example: A lake that has a maximum depth of 6m is limited to a maximum LakeSPI score of 40, a maximum Native Condition score of 20 and the Invasive Condition score of 27 remains the same for all lakes.

Once maximum potential scores for the lake have been identified (from 'Depth Calibration Table'), final LakeSPI indices are generated by expressing the 'lake scores' for each LakeSPI condition as a percentage lake maximum potential.

$$\frac{\text{LakeSPI score}}{\text{Maximum Potential LakeSPI Score}} \times 100 = \text{Final LakeSPI Index}$$

Example: A LakeSPI survey carried out on a lake generated the following LakeSPI scores: LakeSPI score of 19, Native Condition score of 16, Invasive Condition score of 23. The lake has a maximum depth of 48m. The 'Depth Calibration Table' shows that a lake greater than 20m in depth has a maximum potential LakeSPI score of 50, a Native Condition score of 30 and a Invasive Condition score of 27. Final LakeSPI indices are therefore generated by calculating the lakes maximum potential using its maximum potential scores. Because the LakeSPI score for this lake was 19 and it had the potential to score 50, the LakeSPI Index is 38 (19 / 50 X 100). The Native Condition Index is 53 (16 / 30 X 100). The Invasive Condition Index is 85 (23 / 27 X 100).

LakeSPI database

LakeSPI indices can be quickly generated for a lake by entering LakeSPI field information into NIWA's LakeSPI database. This database is not currently available to outside parties but after consultation with NIWA, all trained surveyors are welcome to send in there lake data for calculation.

Chapter 6

6. Interpretation of LakeSPI results

A key assumption of the LakeSPI method is that native values indicate better lake condition and they will proportionally increase the value of the LakeSPI index. In contrast, any invasive influences upon a lake will decrease the LakeSPI value. The LakeSPI Index alone provides a useful assessment of the condition of any lake.

The 'Native Condition Index' and 'Invasive Condition Index' used to create the LakeSPI Index however, still play a valuable part in allowing managers to better understand the LakeSPI result. For instance a lake that undergoes a decline in LakeSPI Index will be better understood by looking at the contributing effects of the Native and Invasive Condition Indices. This may then help to identify appropriate management opportunities to better protect or manage lake condition.

Because LakeSPI indices are expressed as a percentage of their maximum potential – that is just how close a lake is to its best possible condition – lakes of differing depths and from different regions can be directly compared.

It is important that for a more complete account of the interpretation of LakeSPI results that the LakeSPI Technical Report be referred to.

Chapter 7

7. User considerations

7.1 Method limitations

Not all lakes can be assessed using the LakeSPI method. Naturally the lake must have submerged plants and cover of vegetated areas must exceed ten percent before the scoring system will work. Any lake with emergent species around the lake margins must also have submerged vegetation present for scoring purposes. Many quite small lakes (such as farm ponds and reservoirs) are surrounded by emergent vegetation with their surface waters often covered by floating plant species. Dense mats of floating plants can exclude light and prevent submerged species from growing, in which case these types of lakes would be unsuitable for application of the LakeSPI method.

The LakeSPI method is not suitable for brackish or estuarine waterbodies, since quite different plant species are found which are tolerant of saline conditions. The LakeSPI method will also not work effectively in any lake where the pH affects the presence of a normal complement of submerged plant types. For example, the Kai-Iwi lakes in Northland have low alkalinity that only supports charophyte vegetation. Whenever water chemistry prevents the presence of vascular species, then scoring criteria for both native and invasive condition will be affected.

The LakeSPI method has not been evaluated for its applicability to high altitude tarns. Some high altitude lakes have very impoverished submerged vegetation and may only contain submerged bryophytes, which have been deliberately excluded from LakeSPI scoring concepts. If mountain tarns support the usual range of plant community types discussed in this report, then the LakeSPI method will work, however further evaluation will be required to better define any limitations for this type of lake.

LakeSPI will pick up new species if they are already well established and having an impact on lake condition, but it is not a method designed to pick up early stages of any new invasive species establishment. A site targeted surveillance method (see Technical Report) is required for this purpose.

7.2 Comparison with other vegetation survey methods used in New Zealand

It is important to distinguish between three quite different aquatic vegetation survey methods, each with different objectives:

LakeSPI monitoring requires a modest level of skill, but it is designed to be a simple, cost effective way of converting carefully selected and representative lake vegetation information into a score that reflects overall lake condition. Care must be taken to select representative sites. LakeSPI is not a substitute for lake vegetation surveys or for surveillance monitoring (see below).

Surveillance monitoring generally requires minimal skill depending on the range of species being searched for. It specifically focuses on sites vulnerable to change, such as public access points and their immediate surrounds where the risk of new weed species incursions is greatest. This form of monitoring is different from LakeSPI and the lake vegetation survey method in that the sites selected will not normally be representative of the overall lake vegetation, the frequency of application is likely to be higher than any other method, and it can not be used to characterize lake vegetation as a whole.

The Lake Vegetation Survey method provides a full description of the vegetation within a lake. Typically a full lake survey will involve twenty-five sites systematically located around a lake, although a lower number of sites may be used where water bodies are small or access is difficult. It requires a high skill level with a wide knowledge of aquatic plant species. It is more time consuming and intensive than either of the other two methods, but its purpose is to generate a detailed description of the vegetation composition and community structure in a lake. This method results in a comprehensive species list, as well as detailed information on species frequency and distribution, species cover and height in relation to depth and various other analyses.

LakeSPI can be used in conjunction with, or as a precursor to, other survey and monitoring methods. For example, it could be used to establish a priority order of lakes for full vegetation surveys or for surveillance monitoring. If a full vegetation survey is required, this same data can be converted into a LakeSPI index. If LakeSPI information were the primary purpose for monitoring, then high risk or valued lakes may also benefit from surveillance monitoring at targeted sites.

7.3 Final remarks

The LakeSPI method has now been used to survey over one hundred lakes throughout New Zealand and is being widely used by regional councils wanting to assess lake condition and monitor trends in and between lakes over time. The LakeSPI method has continued to evolve since its development and changes made in Version Two of this User Manual and Technical Report have received very positive feedback.

When the LakeSPI method was initially released in 2002, it represented a new stage in concept development and interpretation of vegetation features found in New Zealand lakes. Development of the concepts and methodology had not been attempted previously and was only possible by having an extensive knowledge of New Zealand lake vegetation composition and structure, and a commitment to generate an original approach using a practical methodology. Despite the apparent simplicity of the final concepts and the LakeSPI methodology, much intensive testing and debate was required and many significant changes were necessary during the initial development phase. Now after further development and method adjustments, we are confident that the methodology remains robust and is meeting end-user needs.

Version Two of the LakeSPI Technical Report and User Manual are available as PDF reports from the NIWA LakeSPI reporting website – lakespi.niwa.co.nz. The LakeSPI Technical Report provides essential information that accompanies this User Manual and it is expected that some initial training will be required to ensure appropriate implementation and interpretation of this method. For further information please contact the authors.

Chapter 8

8. APPENDICES

Appendix 1	Equipment checklist
Appendix 2	Fieldsheet
Appendix 3	Simple scoring sheet for generation of site scores
Appendix 4	Field sheet example
Appendix 5	Simple scoring sheet example
Appendix 6	Plant Identification Sheets

LakeSPI EQUIPMENT CHECKLIST

- [ ] Rigid Clipboard
- [ ] LakeSPI water-proof field sheets
- [ ] Pencil for underwater use (2B recommended)
- [ ] Graduated line with small weight attached
- [ ] Zip lock bags and plastic jars with water proof labels
- [ ] Lake maps (laminated)
- [ ] Marker pens (e.g. vivids) for marking lake maps
- [ ] Plant identification sheets
- [ ] SCUBA gear (compass and accurate depth gauge essential)

Optional

- [ ] Viewing box
- [ ] GPS
- [ ] Laser distance finder
- [ ] Depth sounder and sonar with digital display

Appendix 2 Fieldsheet

LAKE: **SITE:** A B C D E

DATE: **SURVEYOR:**

PROFILE LENGTH: <25m 25–100m >100m **GPS:**

SITE DESCRIPTION:

NATIVE VEGETATION

MAXIMUM DEPTH

	NATIVES (>10% cover)
	CHAROPHYTE MEADOWS (> 75% cover)

NATIVE PRESENCE

☑		>5 m
	Emergents	
	Turf Plants	
	Charophytes	
	Isoetes	
	Milfoils	
	Pondweeds	

RATIO (%)

	< 5
	6 – 25
	26 – 50
	51 – 75
	76 – 95
	> 95

MUSSELS **KOURA**

OTHER BIOTA NOTED (eg snails, fish, algae)

INVASIVE VEGETATION

INVASIVE MAXIMUM DEPTH (>10% cover)

INVASIVE SPECIES

HEIGHT (m)		= 100%
	Elodea	
	Egeria	
	Lagarosiphon	
	Ceratophyllum	
	Hydrilla	
	Pot. crispus	
	Juncus bulbosus	
	Ranunculus tri.	
	Vallisneria spp.	
	Utricularia gibba	

RATIO (%)

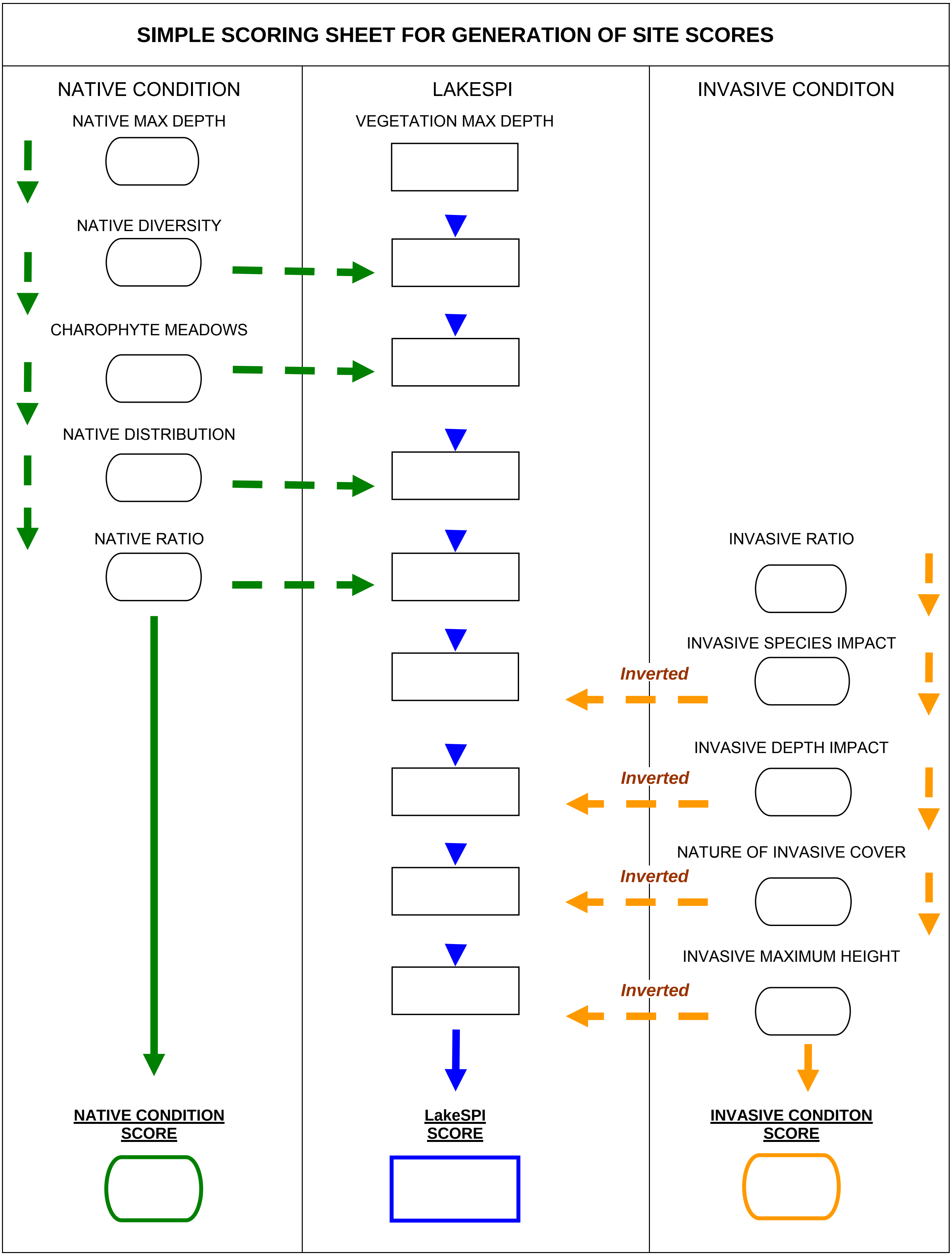
	< 5
	6 – 25
	26 – 50
	51 – 75
	76 – 95
	> 95

NATURE OF INVASIVE COVER

	OCCASIONAL
	COMMON
	OPEN CANOPY
	PARTLY CLOSED
	CLOSED

COMMENTS (profile sketch, land use)

Appendix 3 Simple scoring sheet for generation of site scores



LAKE: Okareka		**SITE:**	A (B) C D E
DATE: 7.2.02		**SURVEYOR:**	J. Bloggs
PROFILE LENGTH: <25m (25–100m) >100m		**GPS:**	123.456
SITE DESCRIPTION: LHS of Millar Road Reserve			

NATIVE VEGETATION

MAXIMUM DEPTH

8.6	NATIVES (>10% cover)
8.6	CHAROPHYTE MEADOWS (> 75% cover)

NATIVE PRESENCE

☑

		>5 m
	Emergents	
✓	Turf Plants	
✓	Charophytes	
✓	Isoetes	
✓	Milfoils	
✓	Pondweeds	✓

RATIO (%)

	< 5
	6 – 25
	26 – 50
✓	51 – 75
	76 – 95
	> 95

MUSSELS ☐ **KOURA** ✓

OTHER BIOTA NOTED (eg snails, fish, algae)

Bullies

Plants clean & green

INVASIVE VEGETATION

INVASIVE MAXIMUM DEPTH (>10% cover)

6.2

INVASIVE SPECIES

HEIGHT (m)		= 100%
1.5 ✓	Elodea	10
	Egeria	
3.1 ✓	Lagarosiphon	90
	Ceratophyllum	
	Hydrilla	
	Pot. crispus	
	Juncus bulbosus	
	Ranunculus tri.	
	Vallisneria spp.	
	Utricularia gibba	

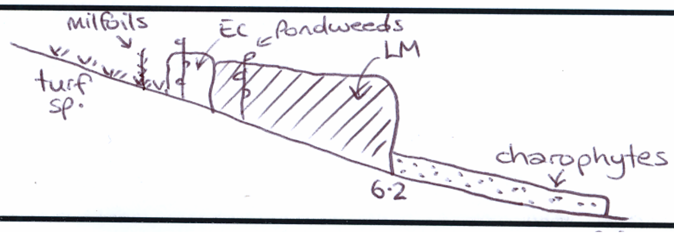
RATIO (%)

	< 5
	6 – 25
✓	26 – 50
	51 – 75
	76 – 95
	> 95

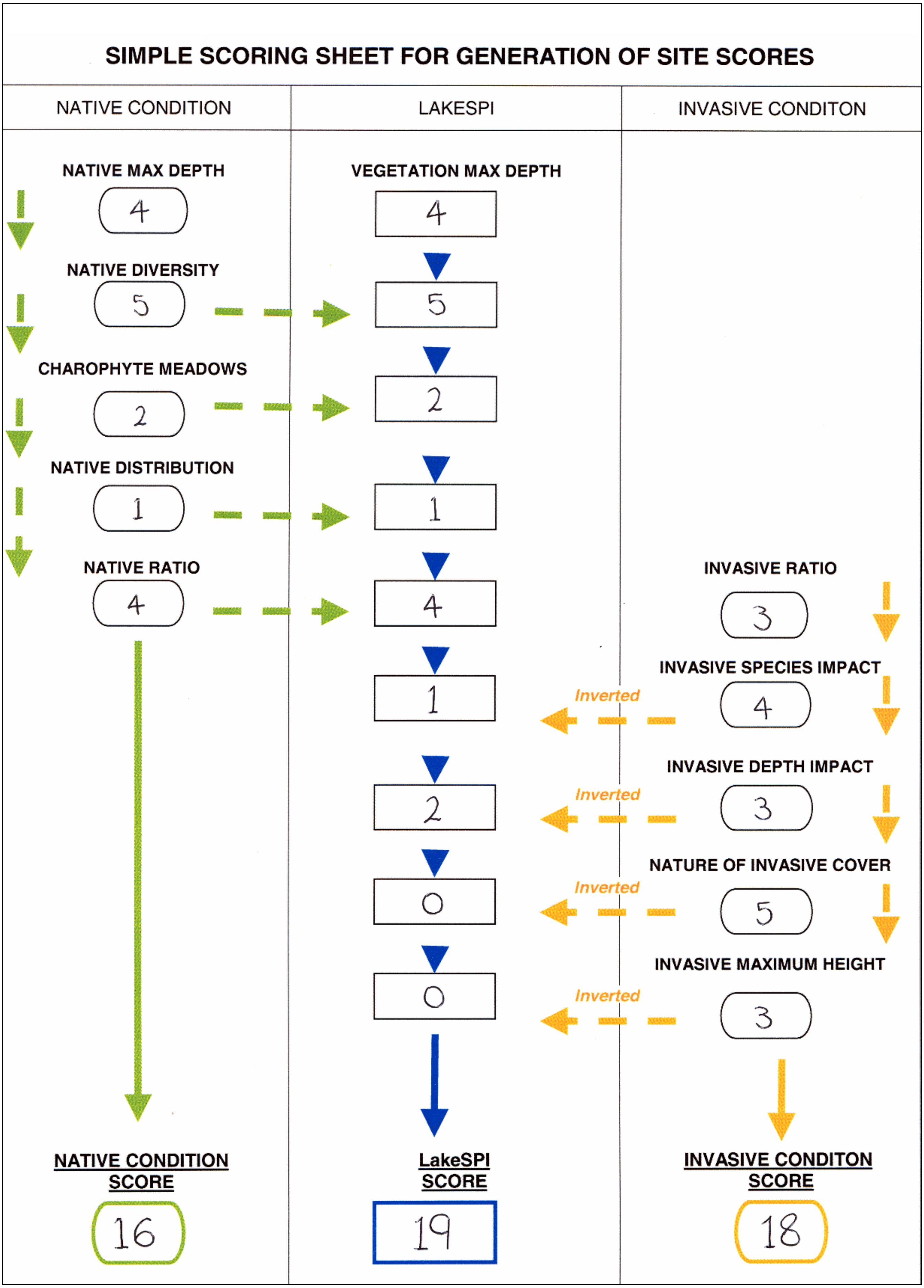
NATURE OF INVASIVE COVER

	OCCASIONAL
	COMMON
	OPEN CANOPY
	PARTLY CLOSED
✓	CLOSED

COMMENTS (profile sketch, land use)



Appendix 5 Simple scoring sheet example



LakeSPI User Manual

Appendix 6 Plant Identification Sheets