A method to assess wetland ecological condition based on land-cover type

Part 1: The user manual

Donovan C. Kotze

A simple Citizen Science tool to assess the ecological condition of a wetland

Version 1.4, November 2016

This is a product of The Water Research Commission: Project No.K5/2350

GroundTruth
Water, Wetlands and Environmental Engineering

WATER RESEARCH COMMISSION

WESSA
PEOPLE CARING FOR THE EARTH

WRC Project K5/235

Executive summary

A wide variety of different land-cover types occur within wetlands and their upslope catchments, e.g. commercial annual crops or open water of dams, and each land-cover type tends to have associated with it particular ecological impacts. For example, commercial annual crops involve the complete clearance of the indigenous vegetation, application of fertilizers, etc. If this land-cover was in the wetland then these impacts could considerably diminish the ecological condition of the wetland, depending on its extent in the wetland. If located in the wetland's upslope catchment, the impacts would be less direct, e.g. the vegetation in the wetland would not be directly removed, but the quality, quantity and seasonal pattern of water inflows to the wetland could potentially be significantly affected even if the land-cover was located some distance upstream, but again dependent on extent. Therefore, by rapidly identifying which land-cover types occur in a wetland and its catchment and how extensive these land-cover types are, inferences can be drawn about the magnitude of impact on the ecological condition of the wetland. This is the rationale underlying the method given in this report, which is being developed with funding from WWF and the Water Research Commission.

The scoring system of the method is based on that applied by WET-Health, which is a tool developed for assessing the ecological condition of South African wetlands. This involves estimating the spatial extent of individual land-cover types (each expressed as a proportion of the wetland and then of its upslope catchment). Proportional extent is then multiplied by the intensity of impact of each individual land-cover type, which ranges from 0 (no impact or deviation from natural) to 10 (critical impact or complete transformation from natural) to give a magnitude of impact score. The impact magnitude scores for all of the individual land-cover types present in the wetland are added together to derive a total ecological impact score for all land-covers in the wetland. In a similar way, a total ecological impact score for all land-covers in the wetland's upslope catchment is derived, accounting for the moderating effect that a buffer zone of natural vegetation around the wetland is likely to have, depending on its extent. Finally, the total score for impacts of land-covers in the wetland is combined with the total score for land-covers in the wetland's upslope catchment to arrive at an overall impact score for the wetland, which also ranges from 0 to 10.

The method builds on the approach of the WET-Health level 1 vegetation component, where default intensity scores have been assigned to each of a range of disturbance (land-cover) types. This approach is extended to the hydrology, geomorphology and water quality components to align them more closely with the vegetation component. The operator of the method is presented with a comprehensive list of land-cover types, to which typical impact intensity scores have been pre-assigned based on the scientific literature, expert judgement and peer-review. The land-cover types are represented in photos to aid in their identification. A list of land-cover types potentially occurring in a wetland's upslope catchment is also provided. The primary task of the operator who is applying the method is to identify the different land-cover types present in a wetland and its upslope catchment and then to identify the extent of these types. The method does not require that the operator assign impact intensity scores, as required by WET-Health, thereby reducing the prominence that subjective judgments play on the part of the operator in the assessment, which is hoped will reduce the vulnerability of the method to inter-operator variability.

This method is divided into two parts: Part 1 (the user manual) is a detailed step-by-step description of the method; and Part 2 (this document) is a description of the technical background to the method, its scientific basis, and the specific rationale underlying the impact intensity scores assigned to different land-cover types.

Part 1 describes of two possible assessment options, both including steps to carry out in the office and steps for the field. The first option, a qualitative sketch-map option, is applicable if a brief scoping of the various factors impacting

upon the wetland is needed but an overall score is not required. The second option, a semi-quantitative map-based option, is applicable if an overall ecological condition/health score is required and/or the condition of the wetland is being monitored and users of the tool have access to Google Earth Pro or other means of generating a land-cover map. In both options, there is provision for considering impacts not accounted for with land-cover, e.g. the point source release of wastewater into the wetland.

Users of the method should have reasonable field experience of wetlands in the region that they are assessing. However, they are not required to be wetland specialists, and might be field technicians or citizen scientists. The method is appropriate for situations where many wetlands need to be assessed across broad landscapes, particularly where good land-cover data are available. Some specific applications include: broad-scale catchment assessment and State of the Environment reporting. The method can also be applied where only one or two wetlands need to be assessed very rapidly or by citizen scientists lacking advanced technical training.

The method does, however, have several limitations which need to be recognized. In particular the method takes little account of the wetland's particular features, e.g. local climate and geology, the wetland's hydrogeomorphic type, the inherent erodibility of the soil in the wetland and the inherent infiltration potential of the soil in the wetland's upslope catchment. Although the method considers the extent to which a buffer zone of natural vegetation around the wetland moderates the impacts from the wetland's upslope catchment, this is done at a very coarse level. Given these limitations, it is important to recognize that the method is generally restricted to scoping-level assessments, and the results need to be seen as tentative, particularly with respect to the water quality component. Thus, a more detailed assessments of some of the assessed wetlands is likely to be required.

Contents

1. What are wetlands and why are they important?

What is a wetland?

The National Water Act, 1998 (Act No. 36 of 1998) defines wetlands as:

"*land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which in normal circumstances supports or would support vegetation typically adapted to life in saturated soils.*"

There is a wide variety of different types of wetlands, and this can make identifying a wetland tricky. For example, there are high altitude wetlands, mangrove forests, peatlands, and even arctic wetlands (http://www.wetlands.org/Whatarewetlands/tabid/202/AlbumID/11392-86/Default.aspx), and RAMSAR has a very broad definition of wetland, which can be found at http://www.ramsar.org/

However, for our purposes, we will use the definition provided by the National Water Act.

So, why are wetlands so important?

Throughout history, wetlands have provided a range of ecosystem goods and services to society. These include services such as reducing flood damage, reducing erosion, groundwater recharge & discharge, providing food, shelter and recreation & tourism http://www.grca.on.ca/stdprod_091596.pdf.

Ecologically, wetlands play a vital role in controlling water flow. In times of high rainfall and floods wetlands tend to slow the water flow, acting to reduce the impacts of flood events (Kotze, 1997). When water flow is slowed by a wetland, suspended matter settles out in the wetland and nutrients are absorbed by the wetland microbes and plants, which are adapted to thrive in these conditions. Thus, water quality is generally improved. (http://www.wetland.org.za/WetlandBasics.html)

Wetlands provide food, shelter, breeding and resting places for many plants, mammal, bird, reptile, amphibian, fish, and invertebrate species. Wetlands provide the critical habitat that many such organisms need to survive http://www.grca.on.ca/stdprod_091596.pdf.

Wetlands in South Africa, as in the rest of the world, are under serious threat, and it is estimated that up to 50% of wetlands in South Africa may have already been lost or degraded. Threats include activities such as channelization, crop production, effluent disposal and water abstraction.

How do our activities impact upon wetlands?

How we use wetlands and the scale on which we do so determines the extent of our impact. Land-use activities (e.g. growing crops or damming water) often affect how a wetland functions and what benefits it provides to society. In many cases, the effects are negative, such as when a wetland is disturbed in order to plant crops, the wetland's function of trapping sediment and holding the soil is reduced. This reduces the benefits that society receives from the wetland in purifying water and controlling erosion.

Impacts on wetlands result from both "on-site" activities in the wetland (e.g. drainage, cultivation disturbance, infilling, and flooding by dams) and from "off-site" activities (e.g. afforestation, mining and crop production) in the wetland's upslope catchment (Kotze, 1997). The wetland's upslope catchment refers to that area upslope of the wetland from which water flows (both above- or below-ground) into the wetland, including the slopes immediately alongside the wetland as well as including slopes further away which feed any streams ultimately supplying the wetland (Figure 1).

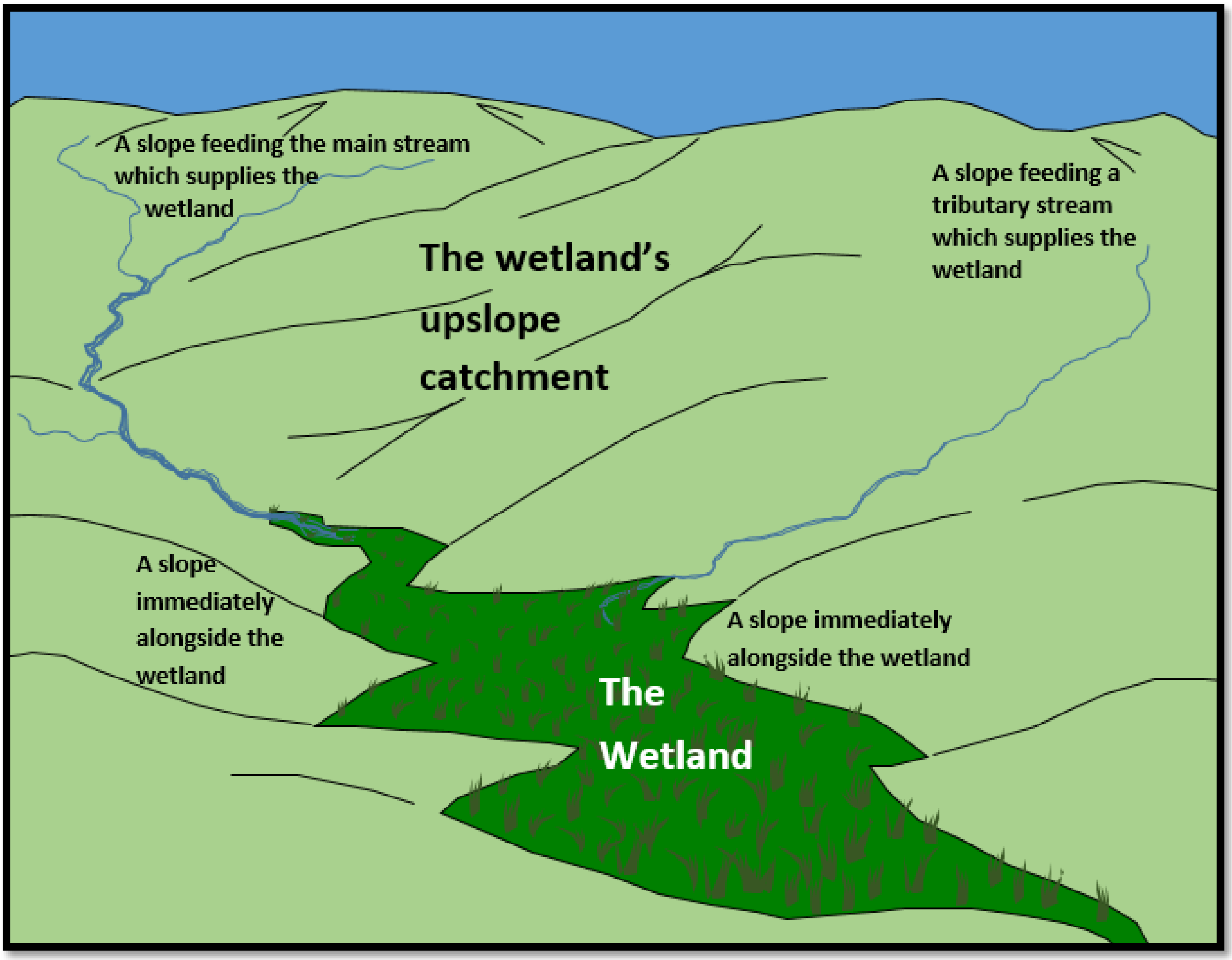


Figure 1: A wetland and its upslope catchment

Wetlands vary greatly in terms of the level to which they are impacted upon by human activities in the wetland and/or in the wetland's upslope catchment. In Figure 1 the wetland and the wetland's upslope catchment are under natural vegetation and no impacts are visible. In Figure 2 extensive areas of natural vegetation in the wetland and the wetland's upstream catchment have been transformed by human activities into various other land-cover types, resulting in large impacts arising from within the wetland and the wetland's upslope catchment.

Land-cover within the wetland has the potential to result in the greatest impacts to the wetland. This applies particularly to those land-cover types involving the complete removal of the natural vegetation. In Figure 2 it can be seen that infilling has resulted in the natural vegetation and wetland hydrological conditions being completely lost in two localized portions of the wetland. However, the overall impact of this infilling is limited by the limited extent of this land-cover in the wetland (about 2% of the wetland). Cultivation also involves the removal of the natural vegetation and the impacts of cultivation depend strongly on the level to which water retention in the wetland is reduced by artificial drains in the cultivated area. In Figure 2, although impacts on water retention is moderate as a result of shallow furrows and does not include major artificial drainage furrows, annual cultivation covers about 45% of the wetland, and therefore the overall impact on the wetland is relatively high.

Land-cover located in a wetland's upslope catchment has the potential to impact upon the quantity and seasonal pattern of water inflows to a catchment as well as the quality of the water entering the wetland. In Figure 2, it can be appreciated how the impermeable surfaces of the roads and built-up areas, which reduce the infiltration of water which falls during storm events, are likely to increase the intensity of surface water runoff into the wetland. The quality of water is affected by both non-point source water pollution which arises from diffuse sources, and may enter the water resource via both surface flow or subsurface flow (i.e. flow beneath the surface of the soil, moving slowly between the soil particles) and by point source pollution (Figure 3). However, it is important to recognize that the amount of non-point source pollutant reaching a wetland may be significantly reduced by a buffer of natural vegetation surrounding the wetland. Again, individual wetlands vary greatly in terms of the extent of this buffer zone (Figure 4).

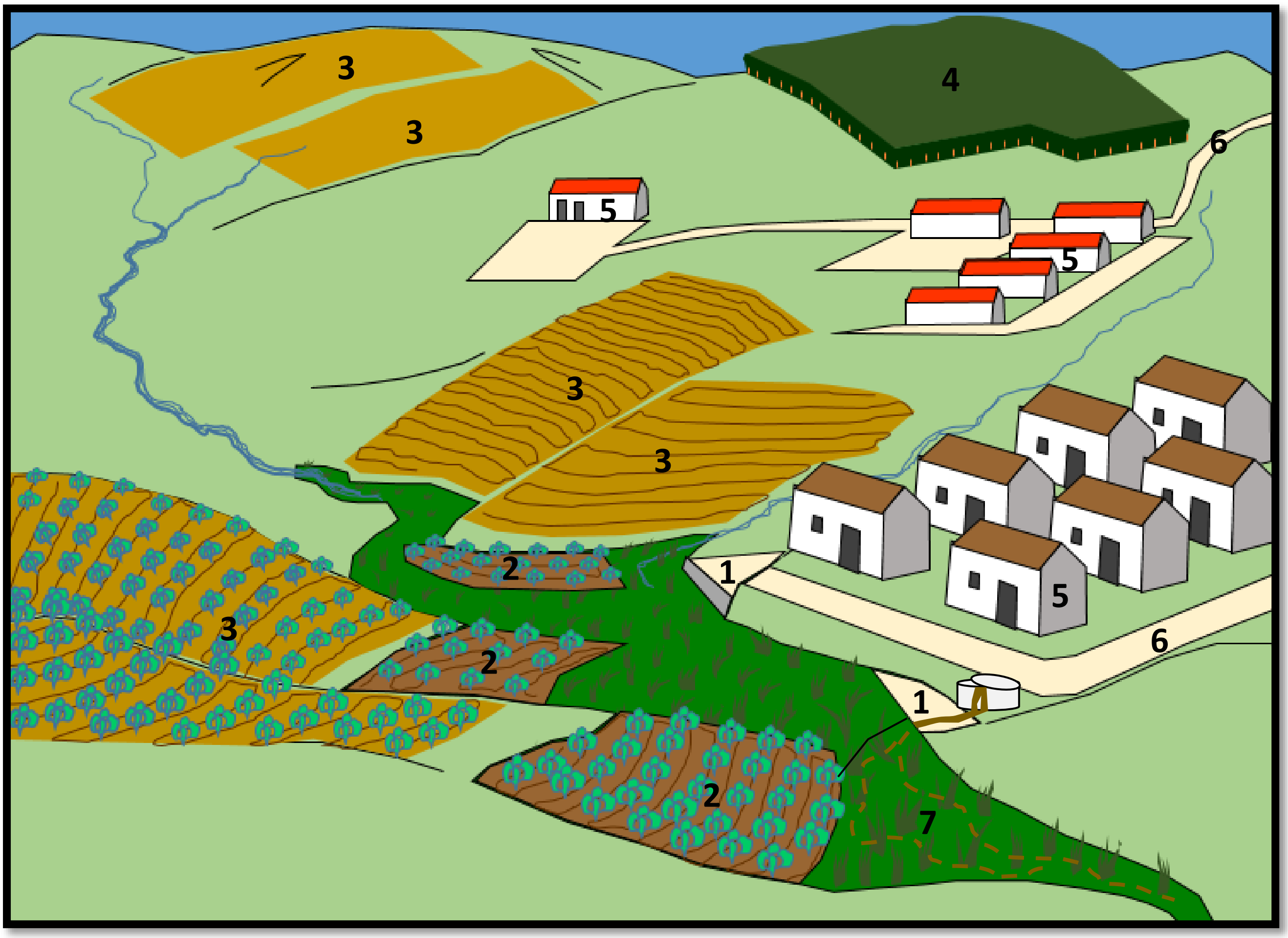


Figure 2: Extensive areas of natural vegetation have been transformed in both the wetland (1=infilling with concrete rubble, 2=commercial annual crops, not irrigated) and its upstream catchment (3=commercial annual crops not irrigated, 4= tree plantations, 5=built-up areas, 6=roads). In addition, an area of natural wetland is affected by the point-source release of untreated wastewater (7).

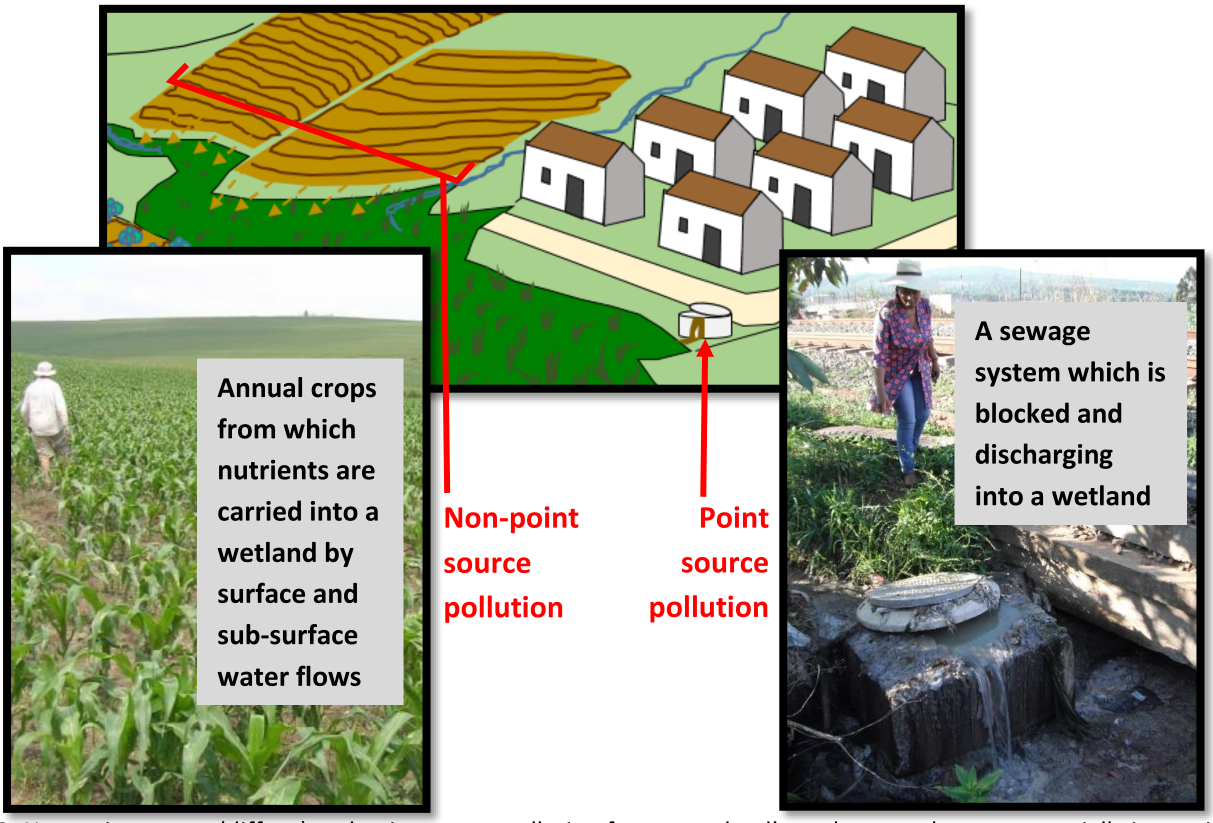


Figure 3: Non-point source (diffuse) and point source pollution from a wetland's upslope catchment potentially impacting upon the water quality of a wetland.

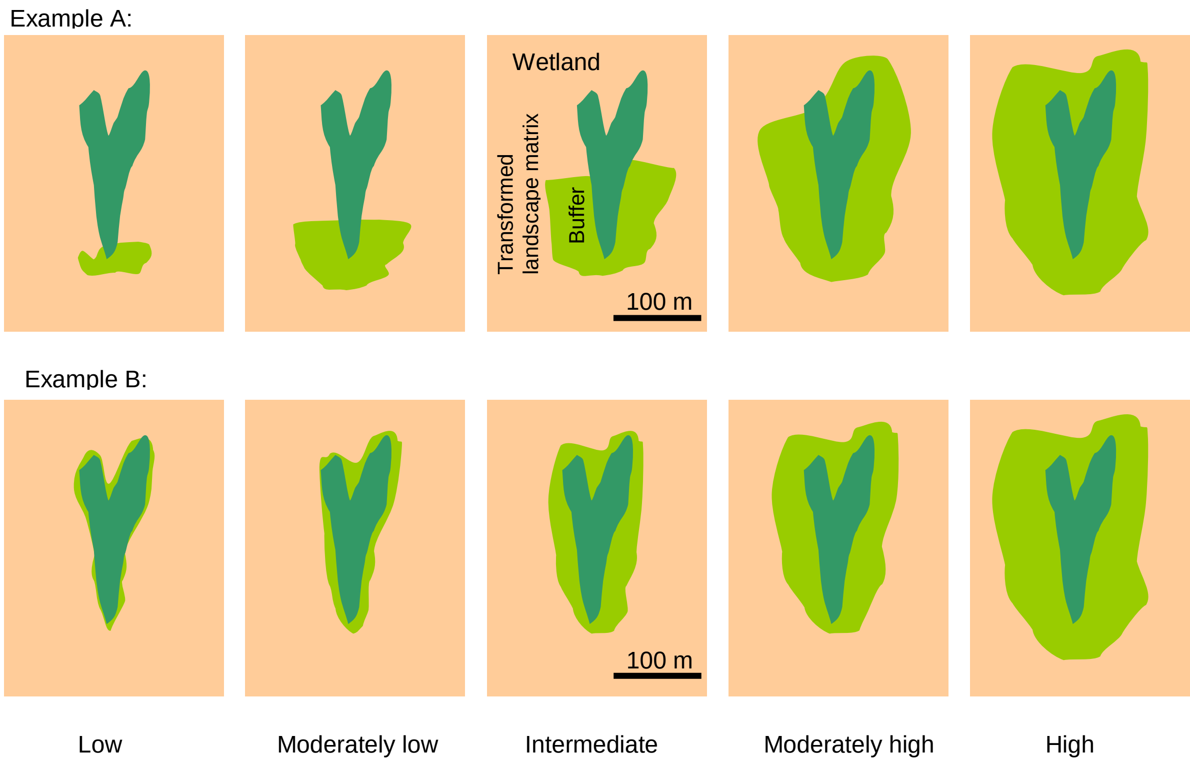


Figure 4: A guideline for scoring the extent of a buffer zone of natural vegetation around a wetland (adapted from Kotze et al. 2009).

Major impacts to wetlands (as can be seen in the example given in Figure 5) lead to a loss in biodiversity, as the plants and animals adapted to wetland habitats are often unable to adapt to new environmental conditions or to move to other habitats. Loss of water quality and flow regulation are other serious consequences of major impacts to wetlands, often resulting in loss of not only water provisioning but also the ability to use the water provided due to reduced water quality. There is also a loss of harvestable resources when wetlands are lost (e.g. reeds and grasses used in traditional construction).

Figure 5: A valley bottom wetland occupied by commercial annual crops, as well as by dense infestations of invasive alien trees. Only small fragments of natural/semi-natural vegetation remain. However, most of the wetland's upslope catchment is occupied by natural vegetation.

2. Overview of the method and its limitations

The method described in this document is designed to assess the ecological condition or health of a wetland. It is based on identifying the land-cover types (e.g. tree plantations, sugarcane, eroded areas and natural areas) present in the wetland and its upslope catchment and the extent of these types.

As explained further in Part 2, Section 3.1 and 3.2, each different land-cover type tends to have particular ecological impacts associated with it, e.g. in annual crops the complete clearance of the indigenous vegetation and the addition of fertilizers. If located in the wetland's upslope catchment, the impacts would be less direct than if in the wetland itself e.g. the vegetation in the wetland would not be directly removed. Nonetheless, the quality, quantity and seasonal pattern of water inflows to the wetland could potentially be significantly affected. Therefore, by identifying which land-cover types occur in a wetland and its upslope catchment and how extensive these land-cover types are, inferences can be drawn about the likely magnitude of impact on the ecological condition of the wetland. This forms the central approach of the method.

This method consists of two parts. Part 1 is a step-by-step guide for applying the method. Part 2 is a description of the background to the method, its scientific basis, and the specific rationale underlying the impact intensity scores assigned to different land-cover types.

Part 1 provides two options for the user: (a) a sketch-map option and (b) a detailed-map option. Based upon your particular situation, you need to decide which option is most appropriate for you.

The sketch-map option (described in Section 4) generates a qualitative result and is generally appropriate in the following situations:

- A brief introduction of the various factors impacting upon the wetland is required but a score of ecological condition/health is not required.
- The information collected is not being used for monitoring.
- The users of the tool do not have access to Google Earth Pro or any other means of generating a land-cover map.

The detailed-map option (described in Section 5) is generally appropriate in the following situations:

- An overall ecological condition/health score is required to be as accurate as possible.
- The user already has a good background in wetland ecology.
- The condition of the wetland is being monitored based on repeated assessments over time.
- Users of the tool have access to Google Earth Pro or other means of generating a land-cover map.

Both options are based on Table 1 and 2 presented in Part 2, but in the sketch-map option, the tables have been condensed to a greater degree.

Even though the method is considered suitable for a wide range of users, applying it to a diversity of purposes, it is very important that due recognition be given to the limitations of the method, which are summarized below and given in more detail in Part 2, Section 4.

The method has been designed to be applicable to all types of inland wetlands, i.e. wetlands which do not have marine water inputs. However, as will be described in Part 2, Section 4, it has some particular limitations when applied to certain wetland types, notably depression wetlands on a coastal plain. The method takes little account of the wetland's particular features, e.g. local climate and geology, the wetland's hydrogeomorphic type, the inherent erodibility of the soil in the wetland and the inherent infiltration potential of the soil in the wetland's upslope catchment. In addition, it is recognized that even though a set impact intensity is assigned to all land-cover types (e.g. for eucalypt plantations in a wetland it is 6.4) for certain land-cover types the impact intensity may vary quite widely from one site to the next. Furthermore, although the method considers the extent to which a buffer zone of natural vegetation around the wetland moderates the impacts from the wetland's upslope catchment, this is done at a very coarse level.

Given the limitations of the method, it is very important to recognize that the method is generally restricted to scoping-level assessments, and the results need to be seen as tentative, particularly with respect to the water quality component. Thus, a more detailed assessments of some of the assessed wetlands is likely to be required.

3. For who is the method designed & for what purposes can it be used?

Users of the method described in this document should have reasonable field experience of the geographical area that they are assessing. However, they are not required to be a wetland specialist in order to apply the method. Specific users of the method might include:

- Field technicians
- Citizen scientists
- General environmental practitioners
- Wetland practitioners
- Landowners

The method is especially useful for situations where many wetlands need to be assessed across a broad landscape, particularly where good land-cover data are available. Some of the specific applications in this regard include:

- Broad-scale catchment assessment and monitoring programmes
- State of Environment Reporting
- Prioritizing at a landscape/sub-catchment level, e.g. for wetland rehabilitation
- Strategic Environmental Assessments

The method also has application as a learning tool for users whose primary purpose is to build their understanding of how land-use activities potentially affect wetlands.

4. The sketch-map option

This assessment option is mostly carried out in the field and, as can be seen below, it involves fewer steps than the detailed-map option.

4.1 Steps to carry out in the office before going into the field

Select a wetland that you would like to work in

Find a wetland that you are interested in studying. Make sure that you obtain permission from the landowner to work in the wetland. If you have access to the internet, you can use Google Earth or Google Maps (https://www.google.co.za/maps/) to view your wetland and types of infrastructure and land cover in and near to the wetland.

Familiarize yourself with land-cover types you may potentially find in the wetland

Refer to Table 1, which provides a list of land-cover types and the likely intensity of impact these might have on the wetland. Also, look at the photographs of the different land-cover types in Section 6.

Familiarize yourself with land-cover types you may potentially find in the wetland's upslope catchment

Refer to Table 2, which provides a list of land-cover types and the likely intensity of impact on the wetland commonly associated with each land-cover type.

4.2 Steps to carry out in the field

Ensure that you have all of the necessary items before going to the field

Make sure you have Tables 1 and 2 and the photographs of the land-cover types (Section 6) with you to take to the field, they provide the primary prompts for collecting the information in the field. Remember to take a pen/pencil and a notebook. It is also valuable to have available a map of the general area (e.g. a Google Maps of Google Earth print-out of the area). If you have a GPS and a camera, take those along. Any field-guides that you have for the identification of alien plants, e.g. Bromilow (2010) would also be very useful.

Observe the wetland and its catchment from a nearby vantage point and walk through the wetland

Take particular note of which of the land-cover types in Table 1 you can see within the wetland and which land-cover types in Table 2 you can see within the wetland's upslope catchment. Take note of features such as artificial drainage channels, erosion gullies and the presence of invasive alien plants. Try to find someone with a good historical knowledge of the wetland to obtain additional information on past and current use of the wetland, including activities such as discharge of wastewater and pumping of water out of the wetland.

Draw a sketch-map of the wetland and its catchment

The map should include the boundary of the wetland and its catchment and the approximate location of different land-cover types in the wetland and its upslope catchment. The wetland's upslope catchment refers to the area upslope of the wetland from where water feeds into the wetland, through both surface- and sub-surface flows (see Section 2).

Complete Table 1 and 2 (which appear in Section 4.3)

In Table 1, record which land-cover types are present in the wetland and if they occupying a small, moderate or extensive portion of the wetland. In Table 2, record which land-cover types are present in the wetland's upslope catchment and if they are occupying a small, moderate or extensive portion of the wetland's upslope catchment.

Determine which factors are having the greatest impact on wetland health

Review Table 1 dealing with land-cover in the wetland and Table 2 dealing with land-cover in the wetland's upslope catchment to see which factors are having the greatest impacts on the health of the wetland. The higher the intensity and the more extensive the land cover, the greater the magnitude of impact on the wetland. For example, if irrigated commercial annual crops with severe artificial drainage (which has a high impact intensity) occurred over a large area (extensively) in a wetland, then it would have a much greater impact than old abandoned lands with negligible artificial drainage, even if the old lands were equally as extensive in the wetland. If natural areas within the wetland were limited in extent it would be clear that the wetland overall was highly impacted. Conversely, if the natural areas of the wetland had no observable onsite impacts where land-cover types with large, serious or critical impacts are limited in extent in the wetland and its upslope catchment then impacts on the wetland are likely to be relatively low.

It is important to note that for the sketch-map option the information collected on the land-cover types in the wetland and its upslope catchment is used to flag key potential impacts on the wetland. It is not used to derive a health score for the wetland, as is carried out in the detailed-map option.

Identify future changes

Identify anticipated future changes to the health of the wetland based on observed trends. For example, do you expect observed erosion (see photos in Section 6) to continue advancing through the wetland in the future? If so, there would be a continuing increase in the impact. Make suggestions on what is anticipated to happen to the wetland in the future: a large improvement, a slight improvement, remain the same, a slight decline or a large decline in the health of the wetland.

Management actions

Identify and record management actions you think would be required to prevent any further deterioration in the ecological condition of the wetland and could hopefully improve the ecological condition of the wetland.

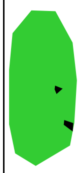
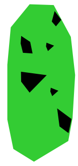
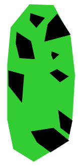
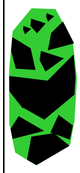
4.3 Tables to fill in for land-cover types in the wetland and the wetland's upslope catchment

For impacts arising from **within the wetland** record in Table 1 the extent of each the different land-cover type present in the wetland. For impacts arising from **within the wetland's upslope catchment**, record in Table 2 the extent of each of the different land-cover type present in the wetland's upslope catchment.

If you wish to see the basis on which the intensity of impact for each land-cover type given in Table 1 and 2 was determined then refer to Part 2, Section 3, where this is described in detail.

In order to show how the method might be applied, the example represented in Figure 2 is presented in Appendix A as Tables A1 and A2, which are abridged versions of Tables 1 and 2, showing only the land-cover types represented in the example.

Table 1: Impact intensities for a range of different land-cover types potentially occurring within a wetland

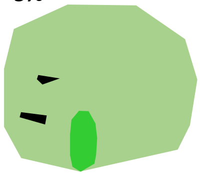
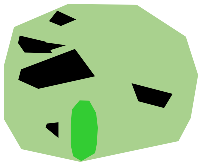
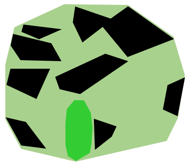
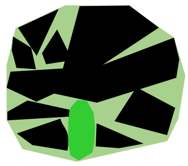
Land-cover/disturbance types		Intensity of impact[1]	Extent in the wetland			
			<5% 	5-25% 	26-50% 	>50% 
Annual crops, commercial	With artificial drainage[2]	Serious				
	Without artificial drainage[2]	Large				
Annual crops, subsistence	With artificial drainage[2]	Large				
	Without artificial drainage[2]	Moderate				
Sugarcane	With artificial drainage[2]	Serious				
	Without artificial drainage[2]	Large				
Vineyards & Orchards	With artificial drainage[2]	Large				
	Without artificial drainage[2]	Large				
Planted pastures	With artificial drainage[2]	Large				
	Without artificial drainage[2]	Large				
Recently abandoned lands	With artificial drainage[2]	Large				
	Without artificial drainage[2]	Moderate				
Semi-natural areas, including old abandoned lands	With artificial drainage[2]	Large				
	Without artificial drainage[2]	Small				
Tree plantations		Serious				
Dense infestations of invasive alien plants	Trees	Serious				
	Herbaceous invasive alien plants, e.g. American bramble.	Large				
Erosion gullies	Erosion gully with negligible vegetation colonization	Serious				
	Erosion gully colonized with vegetation	Serious				
Infilling and infrastructure, including roads and buildings		Critical				
Mines and quarries		Crtical				
Sports fields or gardens		Large				
Recent sediment deposits		Large				
Dams, ponds and areas where were water supply has been artificially sustained	Deep flooding by dams/ artificial ponds or upstream of embankments,	Serious				
	Shallow flooding by dams/ artificial ponds or upstream of embankments in the unit[8]	Moderate				
	Seepage downslope of dams or embankments or areas where water supply has become more sustained (e.g. from irrigation return flows)[12]	Moderate				
Natural areas of the unit with moderate on-site impacts (e.g. with moderate artificial drainage or discharge of wastewater)		Moderate				
Natural areas of the unit with small on-site impacts (e.g. scattered invasive alien plants)		Small				
Natural areas of the unit with no observable onsite impacts		None				

[1]Intensity of impact was determined in Part 2 based on considering impacts to hydrology, geomorphology, water quality and vegetation. See Part 2, Section 3, Table 1 and the rationale following the table. If you wish to see why mines and quarries, for example, have such a high intensity of impact then this is explained in Part 2, Section 3.

[2]See Section 6 where several photographs of artificial drains are given

Additional notes:

Table 2: Impact intensities for a range of different land-cover types potentially occurring in a wetland's upslope catchment

Land-cover types in the wetland's catchment	Impact intensity[1]	Extent in the wetland's upslope catchment			
		<5% 	5-25% 	26-50% 	>50% 
Tree plantations	Large				
Orchards & vineyards	Large				
Annual crops	Large				
Sugarcane	Large				
Mines and quarries	Critical				
Built up areas, roads, railway lines and airfields	Serious				
Golf courses, sports fields & low density settlements	Moderate				
Semi-natural vegetation, including old lands	None				
Natural vegetation	None				
Eroded areas	Large				
Dams	Large				

[1]The impact intensity is based on considering impacts on Water quantity and pattern and on Water quality, as shown in Part 2, Section 3, Table 2 and the rationale following the table.

Indicate the extent of the buffer zone around the wetland (see Figure 4)

Low ☐	Moderately low ☐	Intermediate ☐	Moderately high ☐	High ☐

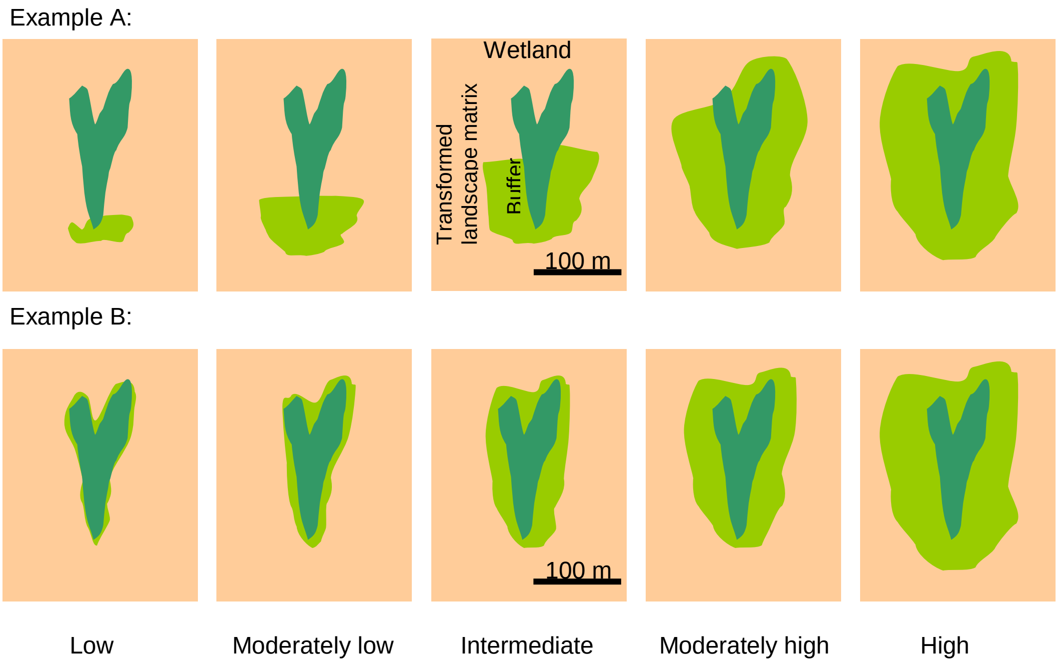


Figure 4: A guideline for scoring the extent of a buffer zone of natural vegetation around a wetland (adapted from Kotze et al. 2009).

Additional notes:

5. The detailed-map option

5.1 Steps to carry out in the office before going into the field

Secure experienced support for carrying out the assessment

If you do not have a good depth of experience in assessing wetlands generally and in the region in which you will be undertaking the assessment then it is advisable to contact someone who does have this experience to help guide you in carrying out the assessment and reviewing what you have done. In particular he/she can help you distinguish natural vegetation from semi-natural vegetation, which can be challenging without good local knowledge of the vegetation.

Identify the boundary of the wetland (i.e. delineate the wetland)

The mapping of a wetland boundary in the field is known as delineation. Delineation requires a high level of experience, especially in the interpretation of the appearance of the soil in the field and in the identification of wetland plant species. Many wetlands in the South Africa have already had their boundaries mapped. This may be for certain regions, as was undertaken for the Mpumalanga Highveld (Mbona et al. 2015) or undertaken coarsely at a national level as part of the National wetlands inventory (http://bgis.sanbi.org/nwi/project.asp). If you lack experience in the delineation of wetlands, you are encouraged to focus on wetlands which have already been mapped/delineated rather than trying to delineate the wetland yourself. Nevertheless, it may not always be possible to focus on a wetland which has already been mapped, in which case refer to the wetland delineation guidelines of DWAF (2006) (available from: http://www.dwa.gov.za/Documents/Other/EnvironRecreation/wetlands/WetlandZoneDelineationSep05Part2.pdf) and the mapping guidelines of Job et al. (in prep.) (which will be completed this year and become available on the Water Research Commission website, http://www.wrc.org.za/pages/KnowledgeHub.aspx) and seek assistance from someone who is experienced with delineation. You may also wish to carry out the delineation as a means of building your understanding about wetlands.

Map the boundary of the wetland's upslope catchment

The wetland's upslope catchment refers to the immediate area (the part of the catchment you are able to observe or physically access within reasonable time) up-slope of the wetland from which water (surface and sub-surface) flows into the wetland. A contour map of the area can be used to map the catchment. As described in Part 2, depression wetlands on coastal plains may be fed by a much larger area than the wetland's local, topographically-defined catchment, making them problematic to map. However, for the purposes of this assessment the wetland's local catchment could be used, based on the assumption that impacts arising from areas in close proximity to the wetland will have the most influence over inputs to the wetland (Malan and Day, 2012).

Identify the hydrogeomorphic type of the wetland

Hydrogeomorphic types refer to the shape of the landform as well as how the water flows through this landform. The landform and the water flow both impact on each other to influence the water flow and landform. Hydrogeomorphic types describe whether the wetland is a floodplain, channelled valley-bottom, unchannelled valley-bottom, depression, seep or flat. For a description of these types refer to Ollis et al. (2013) which is a classification system designed for use by both specialists and non-experts. It is user-friendly, with many illustrations and photographs. Although not absolutely necessary for carrying out the condition assessment, identification of the wetland's hydrogeomorphic type allows an improved assessment of ecological condition.

Familiarize yourself with land-cover types you may potentially find in the wetland

Refer to Table 3, including footnotes, which provides a list of land-cover types and the likely intensity of the impacts commonly associated with each land-cover type on the wetland.

Familiarize yourself with land-cover types you may potentially find in the wetland's catchment

Refer to Table 4, which provides a list of land-cover types and the likely intensity of impact on the wetland's catchment commonly associated with each land-cover type.

Undertake a preliminary map of land-cover

Make a preliminary map of the land-cover types in the wetland and the wetland's upslope catchment. Use Table 3 and 4 as a guide. Create the map using either a GIS (Geographic Information System) or Google Earth Pro (http://www.google.co.za/earth/download/gep/agree.html). Further information on land-use can be obtained from the 1:50 000 topographical maps (http://www.ngi.gov.za/index.php/what-we-do/maps-and-geospatial-information/35-map-products/51-1-50-000-topographical-maps), although remember that many of these maps are likely to be out of date. Also refer to Job et al. (in prep) which shows Google Earth examples of different land-uses/land-covers within a variety of wetlands.

5.2 Steps to carry out in the field

Ensure that you have all of the necessary equipment for in the field

- Table 3 to 5 (central to the collection of information for the assessment), and the photographs of the land-cover types provided in Section 6.
- A pen/pencil and notepad, a GPS (Geographical Positioning System) and a camera
- A field-guide for the identification of alien plants, e.g. Bromilow (2010)

Observe the wetland

Observe the wetland from a nearby vantage point. If you are able to gain some height for this process it would be advantageous. Walk through the wetland to verify the land-cover types mapped in the office. Make sure you visit all of the different land-cover types mapped in the office. It is possible that some land-cover types have been misinterpreted on your preliminary map, e.g. without field verification, old lands might easily be mistaken for planted pastures.

Observe the wetland's upslope catchment

Briefly drive or walk through the wetland's immediate upslope catchment (the part of the catchment you can visually observe or physically access within a reasonable amount of time) to verify the land-cover types mapped in the office. If the upslope catchment does not have roads, rather walk through the catchment. If you are not confident in your own ability to identify land use types in the catchment, talk to a local from the area or expert with good knowledge of history and upstream activities of that particular wetland

Revise the land-cover map

Revise the land-cover map for the wetland and its catchment based on field observations. It may also be necessary to revise the boundary of the wetland. Remember, what we see in the field is real, what we prepared in the office may not be a proper representation of real life.

Note the extent of a buffer of natural vegetation surrounding the wetland

With reference to the revised land-cover map and Figure 4, note the extent of a buffer of natural vegetation surrounding the wetland (Low to High). The higher the extent, the greater is the assumed moderating influence of the buffer on impacts from the upstream catchment.

5.3 Steps to carry out after the fieldwork

Determine the spatial extent of land-cover types in the wetland

Identify the spatial extent of the different land-cover types present in the wetland (Table 3) based on the revised map, using Google Earth Pro or a GIS. Record the extent (as a percentage of the overall wetland area) in the Excel spreadsheet versions of Table 3. The Excel spreadsheet automatically calculates the magnitude of the impact for each land-cover type present by multiplying the intensity of impact score pre-assigned to that type by the proportional extent of that type in the wetland. For example, if sugarcane with severe artificial drainage (which has an impact intensity score of 7.1) covers 50% of the wetland then the impact magnitude will be 7.1*50/100 =3.6. Next, Table 1 automatically adds together all of the individual impact magnitude scores for the individual land-cover types present to derive an ecological impact score for land-cover in the whole wetland (see Appendix A for an example).

Determine the spatial extent of land-cover types in the wetland's upslope catchment

Identify the spatial extent of different land-cover types present in the wetland's upslope catchment and record the extent (expressed as a percentage of the wetland's upslope catchment) in the Excel spreadsheet version of Table 4. The spreadsheet automatically calculates the magnitude of the impact for each land-cover type present by multiplying the intensity of impact score pre-assigned to that type by the proportional extent of that type in the wetland's upslope catchment. Next, the spreadsheet automatically adds together all of the individual impact magnitude scores for the individual land-cover types present in the upslope catchment to determine the total magnitude of impact. The extent of the buffer (Figure 4), recorded earlier, is then used by the spreadsheet to reduce the overall impact score of land-cover types upslope of the wetland based on the following multipliers: Low extent = 1 (i.e. the impact score remains the same); Moderately low extent= 0.9; Intermediate extent = 0.8; Moderately high= 0.7; High = 0.6). For example, if the combined magnitude of impact score from land-uses in the wetland's upslope catchment is 4.5 and the extent of buffer around the wetland is high then the adjusted score is 4.5*0.6 =2.7.

Review the combined Overall Ecological Impact score

Excel spreadsheet Table 4 automatically generates a combined overall score based on the total impact score from land-cover types in the wetland and the total impact score from the wetland's upslope catchment. This is done in such a way that the higher score has the dominant effect but is adjusted by the lower score (see Part 2, Appendix 1 which explains how this is done, using examples).

Based on the overall score, the spreadsheet indicates to which of the Present Ecological State (PES) categories shown in Table 5 the wetland belongs. If, for example, the overall impact score was 2.9, it can be seen from Table 5 that the wetland would fall into C category for the wetland's PES.

If there are any other impacts on the wetland that you think have been omitted, or if there are important influencing factors which have not been accounted for, the spreadsheet prompts for this information to be noted.

Identify anticipated future changes to the Overall Ecological Impact score

Identify potential or anticipated future changes to the Overall Ecological Impact score based on observed trends. For example, active erosion anticipated to continue advancing through the wetland in the future, thereby continuing to increase the impact score, and identify which of the following is anticipated: a large improvement, a slight improvement, remain the same, a slight decline or a large decline.

Identify and record management actions

Identify and record management actions you think will be required to prevent any further deterioration in the ecological condition of the wetland and hopefully will also improve the ecological condition.

Archive the assessment results

It is important that the assessment results be carefully archived, together with any photographs and additional information collected during the assessment. This is especially important if the assessment is to be repeated as part of a long-term monitoring programme.

5.4 Tables to fill-in for land-cover types in the wetland and the wetland's upslope catchment

For impacts arising from **within the wetland** record in Table 3 the extent of each the different land-cover types present in the wetland (as a percentage of the total extent of the wetland).

For impacts arising from **within the wetland's upslope catchment**, record in Table 4 the extent of each of the different land-cover types present in the wetland's upslope catchment (as a percentage of the total extent of the upslope catchment). In addition, with reference to Figure 4, identify the extent to which the wetland is surrounded by a buffer zone of natural vegetation.

If you wish to see the basis on which the intensity of impact scores for each land-cover type given in Table 3 and 4 was determined then refer to Part 2, Section 3, where this is described, including reference to supporting scientific literature.

In order to show how the method might be applied, the example represented in Figure 2 is presented in Appendix A as Tables A3 to A5, which are abridged versions of Tables 3 and 5, showing only the land-cover types represented in the example.

Table 3: Overall impact intensity scores, ranging from 0 (no impact) to 10 (critical impact), for different land-cover types potentially occurring **within a wetland**

Land-cover/disturbance types[1]		**Overall intensity of impact**[2]	**Extent (% of wetland)**
Annual crops, commercial, irrigated[2]	Conventional tillage, with severe artificial drainage[3]	7.5	
	Conventional tillage, with moderate artificial drainage[3]	6.1	
	Conventional tillage, with negligible artificial drainage[3]	4.9	
	Minimum tillage, with severe artificial drainage[3]	6.5	
	Minimum tillage, with moderate artificial drainage[3]	4.9	
	Minimum tillage, with negligible artificial drainage[3]	3.9	
Annual crops, commercial, not irrigated[4]	Conventional tillage, with severe artificial drainage[3]	7.1	
	Conventional tillage, with moderate artificial drainage[3]	5.6	
	Conventional tillage, with negligible artificial drainage[3]	4.5	
	Minimum tillage, with severe artificial drainage[3]	6.3	
	Minimum tillage, with moderate artificial drainage[3]	4.8	
	Minimum tillage, with negligible artificial drainage[3]	3.8	
Annual crops, subsistence[5]	With severe artificial drainage[3]	6.4	
	With moderate artificial drainage[3]	4.7	
	With negligible artificial drainage[3]	3.8	
Sugarcane[6]	With severe artificial drainage[3]	7.1	
	With moderate artificial drainage[3]	5.4	
	With negligible artificial drainage[3]	4.4	
Vineyards[6]	With severe artificial drainage[3]	6.2	
	With moderate artificial drainage[3]	4.5	
	With negligible artificial drainage[3]	3.7	
Orchards[6]	With severe artificial drainage[3]	6.6	
	With moderate artificial drainage[3]	5.0	
	With negligible artificial drainage[3]	4.2	
Planted pastures, annual[6,7]	With severe artificial drainage[3]	6.6	
	With moderate artificial drainage[3]	4.8	
	With negligible artificial drainage[3]	4.1	
Planted pastures, perennial[6,7]	With severe artificial drainage[3]	5.8	
	With moderate artificial drainage[3]	4.1	
	With negligible artificial drainage[3]	3.2	
Unmaintained perennial pastures	With severe artificial drainage[3]	5.4	
	With moderate artificial drainage[3]	3.7	
	With negligible artificial drainage[3]	2.6	
Recently abandoned lands[8]	With severe artificial drainage[3]	5.8	
	With moderate artificial drainage[3]	3.9	
	With negligible artificial drainage[3]	2.9	
Old abandoned lands[8]/ semi-natural areas[9]	With severe artificial drainage[3]	5.5	
	With moderate artificial drainage[3]	3.2	
	With negligible artificial drainage[3]	1.8	
Tree plantations	Plantations of eucalypt trees	6.4	
	Plantations of pine, wattle or poplar trees	5.7	
Dense invasive alien plant infestation	Eucalypt trees	6.2	
	Pine, wattle or poplar trees	5.4	
	American brambles or other herbaceous invasive alien plants	4.0	
Erosion gullies	Erosion gully with negligible vegetation colonization	7.7	
	Erosion gully colonized with vegetation (mainly alien species)	6.2	
	Erosion gully colonized with vegetation (mainly indigenous species)	5.6	
Infrastructure (Urban and roads)	Formal residential	8.0	
	Informal residential	7.8	
	Commercial/industrial	8.8	
	Roads	8.2	

Land-cover/disturbance types[1]		Overall intensity of impact[2]	Extent (% of wetland)
Infilling without infrastructure	Natural sediment/soil used as infill	8.1	
	Foreign material/ solid waste (e.g. concrete rubble, plastic) used as infill	8.3	
	Mine dumps (spoil from the mining of underlying rock)	9.7	
Mines and quarries	Mining of clay or sand	8.8	
	Mining of underlying rock	10.0	
Sports fields or gardens[11]	Sports fields or gardens on the original wetland ground surface	4.2	
	Sports fields or gardens on wetland which has been infilled	7.4	
Recent sediment deposits	Recent sediment deposition (deep, resulting in loss of wetland conditions).	7.2	
	Recent sediment deposition (shallow, with wetland conditions persisting, although diminished).	3.4	
Dams, ponds and areas where were water supply has been artificially sustained	Deep flooding by dams/ artificial ponds or upstream of embankments, not used for aquaculture	6.0	
	Deep flooding by dams/ artificial ponds or upstream of embankments, used for aquaculture	6.7	
	Shallow flooding by dams/ artificial ponds or upstream of embankments in the unit[8]	3.1	
	Paddy fields	5.1	
	Seepage downslope of dams or embankments or areas where water supply has become more sustained (e.g. from irrigation return flows)[12]	2.8	
Natural, drained[12]	Natural vegetation with severe artificial drainage[3]	4.1	
	Natural vegetation with moderate artificial drainage[3]	2.1	
Natural, with wastewater flows[13]	Natural area of wetland into which the point-source release of untreated or poorly treated wastewater flows (see Figure 2 and 3).	5.1	
	Natural area of wetland into which the point-source release of treated wastewater flows (see Figure 2 and 3)	3.6	
Natural areas, very frequently burnt	Natural area of wetland which are burnt every year (e.g. as part of a firebreak)	2.2	
Natural areas with small on-site impacts	Natural area of wetland affected by scattered invasive alien plants or other minor impacts	1.2	
Natural	Natural vegetation with negligible/no artificial drainage[3]	0.0	

Additional notes (including GPS coordinates of any point sources of pollution; erosion headcuts, etc.):

[1]Intensive livestock grazing is not listed as a land-cover as such, but is assumed to be associated with planted pastures. If it occurs in any of the other land-cover types listed in the table (e.g. semi-natural vegetation) then it is suggested that the impact intensity score be increased by 2 points. Intensive livestock grazing is taken as a stocking rate of higher than 2 ha per large stock unit.

Direct pumping of water out of the wetland is also not covered because of the difficulty of assessing the extent and intensity of the effect on wetland hydrology (see Macfarlane et al. 2009). However, if information is available for assessing this impact then note this under additional notes and include the impact as artificial drainage, because it has a potentially similar effect to artificial drainage in lowering the water level in the wetland.

[2]Intensity of impact has been scored on a scale of 0 (nil/negligible) to 10 (critical) and Overall Intensity was calculated in Part 2 Table 3 as the average of the Hydrology, Geomorphology, Water quality and Vegetation scores, weighted as 3:2:2:2, as recommended by Macfarlane et al. (2009).

[3]Artificial drainage generally comprises open artificial drainage furrows (canals) which are visible on the ground surface, as well as including the draining effect of erosion gullies and incised stream channels. However, it may also comprise buried perforated pipes that are not visible on the ground surface. Severity of artificial drainage depends on spacing, depth and orientation of drainage furrows/pipes in relation to flows (including sub-surface) and tends to be most severe where drainage furrows/pipes are deep, dense and/or oriented to effectively intercept flows through the wetland. For all cultivation types where the level of artificial drainage is not known, it should be assumed to be moderate, given that most wetland cultivation is associated with at least some level of drainage.

[4]For annual crops, commercial, if it is unknown whether there is irrigation or not then it should be assumed that there is irrigation because annual crops are usually irrigated. If it is unknown whether tillage is conventional or minimum tillage then conventional tillage should be assumed because this is more widespread than minimum tillage.

[5]It is assumed that for subsistence agriculture, tillage is by hand and that limited supplementary irrigation takes place.

[6]It is assumed that annual planted pastures (usually ryegrass), vineyards and orchards are irrigated but perennial pastures and sugarcane are not irrigated.

[7]For planted pastures, it is assumed that fertilizer is applied periodically and the pasture intensively grazed. If it is unknown whether the planted pasture is annual or perennial then it should be assumed that it is annual, because in wetlands these are much more widespread than perennial pastures.

[8]Recently abandoned lands are taken as those that have been abandoned within the last year or two (following a period of being under cultivation, timber plantations or subject to some other form of physical disturbance which removed all of the natural vegetation, e.g. with a bulldozer) and are still strongly dominated by annual weedy (ruderal) plants. Old abandoned cultivated lands are those that have been abandoned for long enough for perennial indigenous species to become well represented. If it is unknown when, approximately, the lands were abandoned, then assume that they are old abandoned cultivated lands (i.e. lands abandoned more than three years ago) unless it can be seen that the area is still dominated by annual weeds. Old abandoned lands are likely to be more widespread than recently abandoned lands.

[9]Semi-natural vegetation refers to vegetation where the species composition has been significantly altered, but characteristic indigenous species are still reasonably well represented, although weedy and/or alien species are also generally well represented. If artificial drainage of the semi-natural areas is not known then it should be assumed to be negligible.

[10]The impact of a road is scored up to the edge of the road embankment. This impact does not include the damming effect of a road which is dealt with under "Dams and ponds"

[11]For sports fields and gardens, if it is unknown whether the area is infilled, then assume that it has been infilled because this is probably the most widespread option.

[12]Drained natural areas often support dense stands of common reed (*Phragmites australis*) or bulrush (*Typha capensis*), which outcompete most of the indigenous plant species.

[13]In order to determine whether point-source discharge of water is flowing through an area of wetland will generally require fairly close observation on the ground

If some areas in the wetland could potentially be placed in more than one land-cover class given in Table 3 then select that class which has the highest impact intensity score. For example if an area of wetland is subject to the point-source release of untreated wastewater into the wetland (Intensity score 5.1) as well as having scattered invasive alien plants (Intensity score 1.3) then the impact intensity score for this area is taken as 5.1.

Table 4: Impact intensity scores for a range of different land-cover types potentially occurring in a wetland's upslope catchment

Land-cover types	**Overall intensity of impact on the downstream wetland[1]**	**Extent in the wetland's upslope catchment**
Tree plantations, eucalypt	5.5	
Tree plantations, pine, wattle or poplar	4.5	
Orchards	5.5	
Vineyards	4.0	
Annual commercial (row) crops, irrigated	5.5	
Annual commercial (row) crops, not irrigated	4.5	
Annual subsistence crops	4.0	
Sugarcane	4.0	
Mines and quarries	8.0	
Built up dense settlements, roads railway lines and airfields	6.0	
Golf courses, sports fields & low density settlements	3.0	
Semi-natural vegetation, including old lands	0.5	
Natural vegetation	0.0	
Eroded areas	5.0	
Dams	4.5	

[1]Intensity of impact is scored on a scale of 0 (nil/negligible) to 10 (critical). The impact intensity is based on considering impacts on Water quantity and pattern and on Water quality, as shown in Part 2, Table 4 and the rationale following the table.

Indicate the extent of the buffer zone around the wetland (see Figure 4)
Low □ = 1; Moderately low □ = 0.9; Intermediate □ = 0.8; Moderately high □ = 0.7; High □ = 0.6

Additional notes:

Table 5: Summary of the overall impacts on the wetland and trajectory of anticipated change

Total magnitude of impact from impacts within the wetland:	
Total magnitude of impact from impacts in the wetland's upslope catchment:	
Combined overall magnitude of impacts (see Part 2, Appendix A):	
Present Ecological State category (see Table 5):	

Any impacts on the ecological condition of the wetland which you consider to have been omitted or important influencing factors (see Part 2, Section 4, Table 4) which have not been accounted for:
TRAJECTORY OF ANTICIPATED CHANGE IN THE WETLAND'S ECOLOGICAL CONDITION OVER THE NEXT 5 YEARS

Large improvement	□	Supporting motivation:
Slight improvement	□	
Remain the same	□	
Slight decline	□	
Large decline	□	

Table 5: Overall impact score categories and corresponding Present Ecological State (PES) categories (modified from MacFarlane 2009)

Overall impact score range	**Impact category**	**Description**	**PES category**
0.0-0.9	None	No discernible modification or the modification is such that it has no impact on wetland integrity.	A
1.0-1.9	Small	Although identifiable, the impact of this modification on wetland integrity is small.	B
2.0-3.9	Moderate	The impact of this modification on wetland integrity is clearly identifiable, but limited.	C
4.0-5.9	Large	The modification has a clearly detrimental impact on wetland integrity. Approximately 50% of wetland integrity has been lost.	D
6.0-7.9	Serious	The modification has a clearly adverse effect on this component of habitat integrity. Well in excess of 50% of the wetland integrity has been lost.	E
8.0-10	Critical	The modification is present in such a way that the ecosystem processes of this component of wetland health are totally / almost totally destroyed.	F

6. Photographs and further information on the land-cover types included in the method

Cultivation

Annual cultivation, commercial	Annual cultivation, subsistence
	
Commercial annual crops (e.g. maize, cabbages, potatoes and other vegetables) generally occur as extensive regularly shaped areas with uniform crop rows	Subsistence annual crops are distinguished from commercial annual crops by generally being more irregularly shaped areas, with less uniform crop rows. Many of the crops grown commercially (e.g. maize) are also widely grown for subsistence, but additional crops, notably madumbes, are also widely grown in wetlands.
	
A madumbe (*Colocasia esculenta*) crop	Most sugarcane in South Africa is grown on a large-scale commercial basis but in the former homeland areas it is also grown on a small scale, e.g. through out-growers schemes.

Planted Pastures

By far the most widely grown annual pasture in South Africa is annual ryegrass, mainly grown over the winter period.

Unmaintained Perennial Pastures

A variety of perennial pasture types may persist as strong dominants in wetlands without any maintenance, including the following:

		
Kikuyu (*Pennisetum clandestinum*)	*Paspalum dilitatum*	Nile grass (*Acroceras macrum*)

Recently Abandoned Lands

Recently abandoned lands are characterized by the dominance of annual weedy plants.

Old Abandoned Lands / Semi-Natural Areas

	
Although annual weeds are clearly visible, they do not dominate the vegetation, and characteristic indigenous species are reasonably well represented.	An area of semi-natural vegetation in a wetland area from which tree plantations have been withdrawn, now characterized by a mix of weedy specie and characteristic indigenous wetland species.

Different levels of artificial drainage potentially present in all crop types

(Examples are given below for annual crops and sugarcane and abandoned/unmaintained lands in annual crops)

Severe	Moderate	None/ negligible
		

In Sugarcane

Severe	Moderate	None/ negligible
		

In addition to drainage furrows, a variety of other forms of artificial drainage may be employed in wetlands, including the following:

	
Ridge and furrow drainage	Raised beds, which is a common form of drainage in subsistence agriculture

Subsurface drainage, which comprises perforated pipes buried beneath the ground surface, are generally not possible to detect based on observation of the land surface alone.

Erosion Gullies

	
An erosion gully with negligible vegetation colonization	An erosion gully with vegetation colonization

Tree plantations

While the forestry industry has withdrawn considerable tree plantation areas from wetlands since the late 1990s, some tree plantation areas still remain in wetlands. In the photograph to the left, the plantation in the foreground is impinging slightly into the margin of a valley bottom wetland.

Dense infestations of alien invasive plants

Many different invasive alien plant species could be found within wetlands, including species which are well adapted to the prolonged saturated conditions of wetlands; as well as typical terrestrial species which are confined to the naturally drier margins of wetlands or to areas of wetland which have been dried out (e.g. by artificial drainage channels).

Severe

An infestation of American bramble (*Rubus cuneiformis*) within a wetland

For guidance in the identification of invasive alien plants, refer to a relevant guide such as Bromilow (2010)

Infrastructure, Residential

Photo: Dean Ollis

Residential infrastructure impinging into a wetland

Infrastructure, Roads passing through wetland areas

Infilling without Infrastructure

	
Infilling with foreign material (ash) in a wetland	A very small area of wetland infilled with plastic, rubble, etc.

Dams, ponds and areas where water supply had been artificially sustained

	
An area of wetland deeply flooded by a dam	An area of common reed (*P. australis*) sustained in the dry season by irrigation return-flows

Shallowly flooded margin of the dam supporting common reed (*Phragmites australis*)

Natural Areas

Natural vegetation in wetlands encompasses a considerable diversity of plant species, height and growth form. In the example on the left the vegetation consists of tall sedges, short sedges and the indigenous hydric fern *Thelypteris interrupta* and on the right mainly short sedges and indigenous grasses. In both examples, note the lack of weedy plants.

	
Vegetation consists of tall sedges, short sedges and the indigenous hydric fern *Thelypteris interrupta*	Vegetation consists mainly of short sedges and indigenous grasses

7. Using the method together with other tools

There may be situations where the use of the method can be complemented very well with the use of other inexpensive methods not requiring a high level of expertise, notably the Clarity tube, MiniSASS and the Riparian Health Audit.

The Clarity tube is a tool for measuring water clarity, and is much better suited for shallow or rapidly moving water than alternative methods such as the Secchi Disk method. Studies have shown that the clarity tube measurements showed a strong relationship to turbidity and total suspended solids, and could be used for water measurements at the inflows or outflows to/from the wetland, as well as within the wetland itself. For more information on the Clarity tube see http://www.groundtruth.co.za/equipment/clarity-tube.html.

MiniSASS a simplified version of SASS, which can be used by citizen scientists to monitor the health of a river or stream, and involves collecting a sample of macroinvertebrates (small animals) from the water. Macroinvertebrate groups vary greatly in terms of their tolerance to pollution, and based on which of the macroinvertebrates groups are found in the sample, the health class of the river is indicated. MiniSASS could be used for water measurements in any streams flowing into or out of the wetland, but like SASS is generally not appropriate for applying within the wetland itself. For more information on miniSASS see http://www.groundtruth.co.za/projects/minisass.html.

The Riparian Health Audit method (Desai in prep.) is as a manual for the rapid assessment of the ecological health of riparian ecosystems and identifying the key impacts that should be addressed to maintain or restore its health. Together with their associated rivers, riparian areas form corridors through the catchment and, often linking different wetlands in the overall landscape.

In addition, once the wetland method (and perhaps also some of the other rapid assessment tools mentioned above) has been applied, it may reveal specific issues that need to be investigated in more detail. For example, application of the wetland method may show a high impact on the water quality of the wetland. If that wetland has a particularly high priority (e.g. in terms of biodiversity conservation) it may be required that the impact(s) be validated through the collection of water samples and the analyses of these samples in the laboratory for important water quality parameters (e.g. soluble phosphate).

8. Acknowledgements

Joint funding of the development of this tool by WWF and the Water Research Commission is gratefully acknowledged. Heather Malan, Mark Graham, Kirsten Mahood, Bonani Madikizela and David Lindley are thanked for providing valuable comments on an earlier version of the tool, and Graham Jewitt, Damian Walters and Mahomed Desai are thanked for providing additional technical feedback. Nokwanda Ndebele, who applied an earlier draft of the method, and Nondumiso Dumakude, who examined the application of the method by independent operators, are thanked for the useful insights these applications provided for revising the method. Heather Malan provided further useful suggestions for improving the document and Kirsten Mahood is thanked for assisting with layout of the document and making it more accessible to the intended users of the method.

9. References

Bromilow C, 2010. Problem plants and alien weeds of South Africa. Third edition. Briza, Pretoria.

Desai M, in prep. Riparian Health Audit. Water Research Commission, Pretoria.

DWAF, 2006. A practical field procedure for identification and delineation of wetlands and riparian areas. Department of Water Affairs and Forestry, Pretoria.

Job N, Mbona N, Dayaram A, and Kotze D, in prep. Guidelines for mapping wetlands in South Africa. Report compiled for Water Research Commission, Pretoria.

Kotze D. C., 1997. Wetlands and people: what values do wetlands have for us and how are these values affected by our land-use activities? WETLAND-USE Booklet 1. SHARE-NET, Wildlife and Environment Society of South Africa, Howick. (Available on http://www.wetland.org.za/WetlandBasics.html)

Kotze D C, Marneweck G C, Batchelor A L, Lindley D S and Collins N B 2009. WET-EcoServices: A technique for rapidly assessing ecosystem services supplied by wetlands. WRC Report No TT 339/09, Water Research Commission, Pretoria.

MacFarlane D M, Kotze D C, Ellery W N, Walters D, Koopman V, Goodman P, and Goge M, 2009. WET-Health: A technique for rapidly assessing wetland health. WRC Report No. TT 340/09. Water Research Commission, Pretoria, South Africa.

Mbona N, Job N, Smith J, Nel J, Holness S, Memani S and Dini J. 2015. Supporting better decision-making around coal mining in the Mpumalanga Highveld through the development of mapping tools and refinement of spatial data on wetlands Report

Ollis DJ, Snaddon CD, Job NM, and Mbona N, 2013. Classification System for Wetlands and other Aquatic Ecosystems in South Africa. User Manual: Inland Systems. No. 22, SANBI Biodiversity Series. South African National Biodiversity Institute, Pretoria. Draft final report to the Water Research Commission, Pretoria.

10. Glossary

This Glossary is adapted from Macfarlane et al (2009) and Day and Malan (2010).

Alien: Plant or animal species that does not occur naturally in the area

Alluvial fan: Gently sloping conical accumulation of coarse alluvium deposited by a stream upon emergence from an area of confined flow or due to a sudden loss of slope

Alluvium: Sedimentary materials deposited by flowing water as velocity slows

Anaerobic: Having no molecular oxygen (O2) present

Anthropogenic: Of, relating to, or resulting from the influence of human beings on natural objects

Assessment: The process of arranging into classes based on careful analytical evaluation

Bedload: Sediment that is transported by being rolled or bounced along the bed of a stream

Berm: A mound or bank of earth used as a barrier against flooding of land

Bioassessment: The use of living organisms to assess environmental condition (usually with reference to some aspect of conservation)

Biodiversity: Variety of living forms including the number of different species, the genetic variety within each species, and the variety of natural areas

Biophysical: The biological and physical components of the environment

Biotic: Living components of the environment

Buffer zone: a strip of vegetated land (composed in many cases of riparian habitat and upland plant communities) which separate development or adjacent land uses from aquatic resources (rivers, wetlands & estuaries (Macfarlane et al. 2014)

Canalization: The creation of artificial drains or the incision caused by erosion gullies where no visible confined flow path existed previously

Capillary fringe: The zone of almost-saturated soil or sediment just above the water table

Catchment: All the land area from mountaintop to seashore which is drained by a single river and its tributaries. Each catchment in South Africa has been subdivided into secondary catchments, which in turn have been divided into tertiary. Finally, all tertiary catchments have been divided into interconnected quaternary catchments. A total of 1946 quaternary catchments have been identified for South Africa. These sub-divided catchments provide the main basis on which catchments are sub-divided for integrated catchment planning and management (consult DWAF [1994]).

Channel: The part of a river-bed containing its main current, naturally shaped by the force of water flowing within it.

Chroma: The quality of a colour; in classifying soils, the relative purity of the spectral colour of a soil, which decreases with increasing greyness. Measured with a Munsell colour chart.

Citizen scientist: A member of the general public who engages in scientific work, often relating to his/her natural environment, and usually leading to new learning skills and a deepening of his/her understanding of the environment. This increased understanding provides a sound basis on which to take action to address issues facing the environment. Citizen scientists generally work as networks of volunteers, often in collaboration with professional scientists.

Clarity tube: an inexpensive, robust and easily transported tool for measuring water clarity in the absence of an expensive turbidity meter. The clarity tube is much better suited for shallow or rapidly moving water than alternative methods such as the Secchi Disk method. Studies have shown that the clarity tube measurements showed a strong relationship to turbidity and total suspended solids.

Classification (of wetlands): The grouping into categories of systems with homogeneous natural attributes (such as aspects of hydrogeomorphology). NOTE: this is different from the 'classification' of water resources according to their departure from some reference condition as required by the National Water Act.

Clastic sediment: See Mineral sediment.

Co-management: where the responsibilities for allocating and using resources are shared amongst multiple parties, often including local communities and a relevant government agency.

Cut-off drain: An artificially created ditch that is intended to intercept runoff before or shortly after entering a wetland and promote its efficient flow downstream, in order to dry out he wetland in order to cultivate the land.

Depression wetland: A typically basin-shaped wetland that increases in depth from the perimeter to a central area of greatest depth (may be flat-bottomed or round-bottomed) typically associated with inward drainage of surface water.

Delineation (of a wetland): The identification of the outer edge of the zone that marks the boundary between the wetland and adjacent terrestrial areas (based on soil, vegetation and/or hydrological indicators (see definition of a wetland)).

Desiccation: The loss of moisture from material.

Discharge: The quantity of water flowing in a stream per unit time, typically in units of cubic meters per second ("cumecs").

Disturbance: Any activity (human or natural) that disrupts natural processes.

Disturbance unit: A vegetation unit of relatively similar disturbance history.

Drain: An artificially created ditch that is intended to promote the efficient flow of water from a region where flow is diffuse or non-existent.

Ecology: The science which deals with the relationship between plants and animals, and their environment.

Ecoregion: a region defined by similarity of climate, landform, soil, potential natural vegetation, hydrology and other ecologically relevant variables.

Ecosystem services: The direct and indirect benefits that people obtain from ecosystems. These benefits may derive from outputs that can be consumed directly; indirect uses which arise from the functions or attributes occurring within the ecosystem; or possible future direct outputs or indirect uses (Howe et al., 1991). Synonymous with ecosystem "goods and services".

Endorheic: Basin or area from which there is little or no outflow of water (either on the surface or underground by flow or diffusion through rock or permeable material).

Environmental conditions: Features of the environment that affect the distribution of plants or animals.

Erosion: Physical and chemical processes that remove and transport soil and weathered rock.

Eutrophication: the process whereby high levels of nutrients result in the excessive growth of plants.

Evaporation: The physical process of molecular transfer by which a liquid is changed into a gas.

Evapotranspiration: The loss of moisture from the terrain by direct evaporation plus transpiration from vegetation.

Exorheic: Area from which there is outflow of water (either on the surface and/or underground by flow or diffusion through rock or permeable material).

Extent of impact: The proportion of a site affected by a given activity.

Fauna: A collective term for the animal life characteristic of a particular region.

Flood attenuation: The holding or slowing of water flow such that it is slowly released to streams.

Floodpeaks: The highest discharges that occur in streams following a rainfall event.

Floodplain: Valley bottom areas with a well-defined stream channel, gently sloped and characterized by floodplain features such as oxbow depressions and natural levees and the alluvial (by water) transport and deposition of sediment, usually leading to a net accumulation of sediment. Water inputs from main channel (when channel banks overspill) and from adjacent slopes.

Flora: A collective term for the plant life characteristic of a particular region or environment.

Fluvial: Related to running water (e.g. a river).

Geology: The study of the composition, structure and processes of the rock layers of the earth.

Geomorphology: The study of the origin and development of landforms of the earth.

Generalist: as used here; an organism that is able to thrive in a broad spectrum of environmental conditions.

GIS: "Geographical Information System;" a computer-based system that stores, manages and analyzes data linked to locations of physical features on earth.

Governance: the socio-political structures and processes by which societies share power.

Groundwater: sub-surface water in the zone in which permeable rocks, and often the overlying soil, are saturated under pressure equal to or greater than atmospheric.

Gully: A well-defined channel created by running water eroding sharply into soil/sediment, typically on a hillslope or an unchanelled valley bottom.

Halophyte: a salt tolerant plant.

Head cut: The upper-most entrance into an erosion gully. The point where the headward extension of a gully is actively eroding into undisturbed soil.

Headward erosion: Extension of a stream, gully or canal up the regional slope of erosion.

Hillslope seepage wetland: Slopes on hillsides, which are characterized by the colluvial (transported by gravity) movement of materials. Water inputs are mainly from sub-surface flow and outflow is via a well defined stream channel or via diffuse flow.

Hydraulic conductivity: A measure of the rate at which water can move through a permeable medium such as soil or rock.

Hydrogeomorphic unit: Recognizable physiographic wetland-unit based on geomorphic setting, water source and water flow patterns.

Hydric soil: a soil that is exposed to conditions of saturation, flooding or ponding long enough during the growing season to develop anaerobic conditions in the upper layer(s).

Hydrology: The study of the properties, distribution, and circulation of water on the earth.

Indicator: Visible sign of human-induced impact.

Indicator species: A species whose presence in an ecosystem is indicative of particular conditions (such as saline soils or acidic waters).

Indigenous: Species that have originated naturally in a particular region or environment.

Infilling: Dumping of soil or solid waste onto the wetland surface.

Institutions: The formal rules, conventions and laws (e.g. marriage), as well as the informal codes of behaviour that constrain and direct societal activities and interactions.

Intensity of impact: The degree to which the component has been altered within the affected area.

Invasive species: A species that has the capacity to out-compete and dominate the naturally occurring species and that can adversely affect the habitats (economically, environmentally and/or ecologically) that they invade.

Inventory (of wetlands): A catalogue of their geographical position, number and characteristics.

Least impaired: Pertaining to wetlands; those which have incurred a minimal degree of human impairment, relative to other wetlands in a region.

Levee: Broad, low embankment built up along the banks of a channel during floods.

Lithology: Study of the nature and composition of stones and rocks.

Land-cover: the physical cover on the earth's surface, including cultivated crops, buildings, natural grassland, etc.

Land-use: how people use the land, e.g. if land is under crops, whether or not the land is irrigated.

Macro-invertebrate: Animals without backbones that are retained by a 500-1000 micron mesh (mesh size depending on definition used).

Magnitude of impact: The actual impact of a particular activity or suite of activities on the component of wetland health being evaluated. Often calculated as the intensity of impact multiplied by the extent of impact.

Manning's Roughness Coefficient: A measure of roughness that is used to determine flow velocity in streams for which dimensions and slope are known.

Management: The implementation of actions aimed at achieving a goal. It may encompass planning, organizing, staffing, directing and controlling.

Marsh: A wetland dominated by emergent herbaceous vegetation and usually permanently or semi-permanently flooded or saturated to the soil surface.

Mineral sediment: The particles of minerogenic material (clay, silt, sand, cobbles and boulders) that are moved by running water.

Minimum tillage: of "tillage": ploughing. Keeping disturbance of the soil to a minimum when cultivating crops.

MiniSASS: a simplified version of SASS, which can be used by citizen scientists to monitor the health of a river or stream, and involves collecting a sample of macroinvertebrates (small animals) from the water. Macroinvertebrate groups vary greatly in terms of their tolerance to pollution, and based on which of the macroinvertebrates groups are found in the sample, the health class of the river is indicated, ranging across five categories from natural to very poor.

Mitigate: to reduce the impact of.

Mottles: of soils, variegated colour patterns on a uniformly-coloured background.

Munsell colour chart: a standardized colour chart used to describe aspects of the colour and chroma of soil.

Natural reference condition: A system in which natural inputs of resources or toxins has not been modified by recent human intervention, and which experiences levels of disturbance that are regarded as natural.

Nick point: The point where the headward extension of a stream or gully is actively eroding headward into undisturbed soil or sediment.

Organic soil: See Peat.

Oxidation: Combining with oxygen, typically involving the breakdown of organic matter to produce CO_2 and H_2O.

Palustrine: of wetlands; those dominated by persistent emergent plants and commonly called marshes, floodplains, vleis and seeps.

Pan: Endorheic (i.e. inward draining; lacking an outlet) depressions typically circular, oval or kidney shaped, and usually intermittently to seasonally flooded and with a flat bottom.

Peat: Organic soil material with a particularly high organic matter content which, depending on the definition of peat, usually has at least 20% organic carbon by weight.

Perched water table: the upper limit of a zone of saturation in soil, separated from the main body of groundwater by a relatively impermeable unsaturated zone.

Perennial: permanent; persisting from year to year.

Poaching: (= "pugging") the disruption of soil structure as a result of the repeated penetration of the hooves of livestock into wet soil.

Precipitation: The deposition of moisture on the earth's surface from the atmosphere, including dew, hail, rain, sleet and snow.

Present state: The state of a system in which natural inputs of resources or toxins have been modified by recent human intervention, and which experiences levels of disturbance that are unnatural.

Quaternary Catchment: Each catchment in South Africa has been sub-divided into secondary catchments, which in turn have been divided into tertiary. Finally, all tertiary catchments have been divided into interconnected quaternary catchments. A total of 1946 quaternary catchments have been identified for South Africa. These sub-divided catchments provide the main basis on which catchments are sub-divided for integrated catchment planning and management (consult DWAF [1994]).

Ramsar Convention: The Convention on Wetlands that provides the framework for international cooperation for the conservation of wetlands.

Red Data species: All those species included in the categories of endangered, vulnerable or rare, as defined by the International Union for the Conservation of Nature and Natural Resources.

Reference sites: Those sites that are minimally impacted by human disturbance and that reflect the natural condition of a wetland type in a given region.

Rehabilitation (wetland): The process of assisting in the recovery of a wetland that has been degraded or of maintaining a wetland that is in the process of degrading so as to improve the wetland's capacity for providing services to society.

Resilience (of ecosystems): The ability to maintain functionality after being subject to perturbations

Riparian: The physical structure and associated vegetation of areas associated with a watercourse which are commonly characterized by alluvial soils, and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with a composition and physical structure distinct from those of adjacent land areas." (National Water Act). Riparian areas that are saturated or flooded for prolonged periods would be considered wetlands and could be described as riparian wetlands. However, some riparian areas are not wetlands (e.g. where alluvium is periodically deposited by a stream during floods but which is well drained).

Ruderal plant: Short-lived, weedy plants (in this case) that typically invade disturbed ground.

Runoff: Total water yield from a catchment including surface and sub-surface flow.

SASS (South African Scoring System): a system for the rapid bioassessment of water quality of streams in South Africa using macro-invertebrates.

Saturation: of soil; that where the water table or *capillary fringe* reaches the surface.

Scroll bar: A mound of sediment that occurs on the convex bank of a meandering stream, resulting from deposition of sediment on the inner bank of the channel.

Sedges: grass-like plants belonging to the family Cyperaceae, sometimes referred to as nutgrasses.

Sediments: Solid material transported by moving water, which typically comprises sand, silt and clay sized particles.

Solute: Dissolved substance.

Stakeholder: In the context of a wetland, any individual, group or community able to influence or be influenced by the management of the wetland.

State: The condition of a system with regard to its composition, structure or function.

Stocking rate: the number of animal units per unit of land for a specified period of time. An AU is taken as equivalent to a 450 kg animal that consumes 10 kg of dry matter per day.

Sustainable development: development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

Sustainable use (of wetlands): use within the resource's capacity to renew itself.

Sustainable: that which can carry on indefinitely.

Threat: An indication of likely danger or harm.

Tillage: the preparation of soil for agricultural purposes, by ploughing, ripping, hoeing or otherwise disturbing it.

Toxicant: An agent or material capable of producing an adverse response in a biological system, seriously injuring structure and/or function of the system and its organisms or producing death.

Trajectory of change: The predicted nature of change in the state of a wetland from its present state given threats and vulnerability.

Transformed areas: Areas where natural habitat has been completely destroyed.

Valley-bottom wetland: Valley-bottom areas with or without a clearly defined stream channel, usually gently sloped and characterized by sediment deposition.

Water quality: The suitability of water for a user (human or environmental) determined by the combined effects of its physical attributes and its chemical constituents.

Wetland: "Land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which in normal circumstances supports or would support vegetation typically adapted to life in saturated soils." (National Water Act). Land where an excess of water is the dominant factor determining the nature of the soil development and the types of plants and animals living at the soil surface (Cowardin *et al*., 1979); lands that are sometimes or always covered by shallow water or have saturated soils long enough to support plants adapted for life in wet conditions.

Useful websites:

http://www.grca.on.ca/stdprod_091596.pdf (keep in mind this has a Northern hemisphere context)

http://www.ramsar.org/

http://www.wetlands.org/

Appendix A: Application of the method to the example in Figure 2

In order to show how the method might be applied, the example represented in Figure 2 is presented in this Appendix, firstly for the sketch-map option and secondly for the detailed-map option.

The sketch-map option

Tables A1 and A2, which are abridged versions of Tables 1 and 2, show only the land-cover types represented in the example in Figure 2.

Table A1: Impacts associated with the land-cover types occurring within the example wetland shown in Figure 2

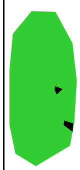
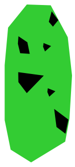
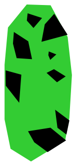
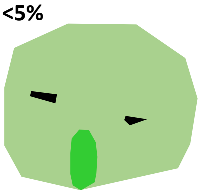
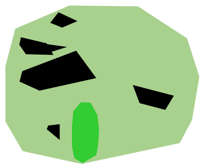
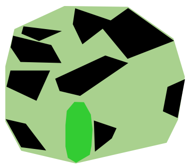
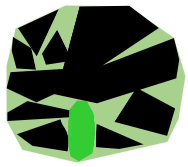
Land-cover/disturbance types	**Intensity of impact**[1]	**Extent in the wetland**			
		<5% 	**5-25%** 	**26-50%** 	**>50%** 
Annual crops, commercial	Serious			X	
Infilling and infrastructure, including roads and buildings	Critical	X			
Natural areas of the unit with moderate on-site impacts (e.g. with moderate artificial drainage or discharge of wastewater)	Moderate		X		
Natural areas of the unit with scattered invasive alien plants	Small			X	

Table A2: Impacts associated with the land-cover types occurring within the upslope catchment of the example wetland shown in Figure 2

Land-cover types in the wetland's catchment	**Impact intensity**[1]	**Extent in the wetland's upslope catchment**			
		<5% 	**5-25%** 	**26-50%** 	**>50%** 
Tree plantations	Large		X		
Annual crops	Large			X	
Built up areas, roads, railway lines and airfields	Serious		X		
Natural vegetation	None			X	

[1]The impact intensity is based on considering impacts on Water inflow quantity and seasonal pattern and on Water quality, as shown in Part 2, Table 4 and the rationale following the table.

Additional notes: Discharge of wastewater is the key factor resulting in moderate on-site impacts to the natural areas in the wetland.

Indicate the extent of the buffer zone around the wetland (see Figure 4)

Low □	Moderately low □	Intermediate X	Moderately high □	High □

As noted in the main document, the sketch-map option does not provide an impact score, but serves to flag those land-cover types in the wetland and its upslope catchment likely to be having the greatest contribution to impacts on the wetland.

The detailed-map option

Tables A3 and A5, which are abridged versions of Tables 3 and 5, show only the land-cover types represented in the example in Figure 2. In Table A6, the same example is compared under different land-cover scenarios (current vs. rehabilitated).

Table A3: Impact magnitude scores for the land-cover types occurring within the example wetland shown in Figure 2

Land-cover/disturbance types[1]		**Overall intensity of impact**[2]	**Extent (% of wetland)**	**Magnitude**
Annual crops, commercial, not irrigated	Conventional tillage, with moderate artificial drainage	5.6	45%	2.5
Infilling without infrastructure	Foreign material/ solid waste (e.g. concrete rubble, plastic) used as infill	8.3	2%	0.2
Natural, with wastewater flows[13]	Natural area of wetland into which the point-source release of untreated or poorly treated wastewater flows.	5.1	13%	0.7
Natural	Natural vegetation with scattered invasive alien plants	1.2	40%	0.5
			TOTAL MAGNITUDE OF IMPACT:	3.9

Table A4: Impact magnitude scores for the land-cover types occurring within the upslope catchment of the example wetland shown in Figure 2

Land-cover types	**Overall intensity of impact on the downstream wetland**[1]	**Extent in the wetland's upslope catchment**	**Magnitude of impact**
Tree plantations, pine, wattle or poplar	4.5	11%	0.50
Annual commercial (row) crops, not irrigated	4.5	30%	1.35
Built up dense settlements, roads railway lines and airfields	6.0	9%	0.54
Natural vegetation	0.0	50%	0.00
		TOTAL MAGNITUDE OF IMPACT:	2.4

[1]Intensity of impact is scored on a scale of 0 (nil/negligible) to 10 (critical). The impact intensity is based on considering impacts on Water inflow quantity and seasonal pattern and on Water quality, as shown in Part 2, Table 4 and the rationale following the table.

Indicate the extent of the buffer zone around the wetland (see Figure 4):
Low □ = 1; Moderately low □ = 0.9; Intermediate ☒ = 0.8; Moderately high □ = 0.7; High □ = 0.6

TOTAL MAGNITUDE OF IMPACT ADJUSTED FOR THE MODERATING INFLUENCE OF THE BUFFER:	1.9

Table A5: Summary of the overall impacts on the example wetland and trajectory of anticipated change

<table>
<tr><td colspan="2" align="right">Total magnitude of impact from impacts within the wetland (WI):</td><td>3.9</td></tr>
<tr><td colspan="2">Total magnitude of impact from impacts in the wetland's upslope catchment (WC):</td><td>1.9</td></tr>
<tr><td colspan="2" align="right">Combined overall magnitude of impacts (see Part 2, Appendix A):</td><td>5.1</td></tr>
<tr><td colspan="2" align="right">Present Ecological State category (see Table 5):</td><td>D</td></tr>
<tr><td colspan="3">Any impacts on the ecological condition of the wetland which you consider to have been omitted or important influencing factors which have not been accounted for: For the purposes of this example, no further impacts are identified.</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td colspan="3">TRAJECTORY OF ANTICIPATED CHANGE IN THE WETLAND’S ECOLOGICAL CONDITION OVER THE NEXT 5 YEARS</td></tr>
<tr><td>Large improvement</td><td>☐</td><td rowspan="5">Supporting motivation: The scattered invasive alien plants in the natural area of the wetland are anticipated to increase in extent within this area, particularly given that the wetland is subject to other impacts likely to favour these species.</td></tr>
<tr><td>Slight improvement</td><td>☐</td></tr>
<tr><td>Remain the same</td><td>☐</td></tr>
<tr><td>Slight decline</td><td>☒</td></tr>
<tr><td>Large decline</td><td>☐</td></tr>
</table>

The method can be used for comparing the relative impacts of different land-cover scenarios. For example, let is compare the wetland above with the same wetland rehabilitated by halting the discharge of untreated wastewater (currently impacting upon 13% of the wetland) and withdrawing annual crops from the wetland and plugging artificial drains in these areas (45% of the wetland) and controlling invasive alien plants. From the total magnitude of impact in Table A6 it can be seen that this rehabilitation more than halves the total impacts on the wetland.

Table A6: Impact magnitude scores for the land-cover types occurring within the example wetland under the current scenario shown in Figure 2 and under a rehabilitated scenario.

Land-cover/disturbance types[1]		**Overall intensity of impact**	**Current scenario**		**Rehabilitated scenario**	
			Extent	**Magnitude**	**Extent**	**Magnitude**
Annual crops, commercial, not irrigated	Conventional tillage, with moderate artificial drainage[3]	5.6	45%	2.5	0%	0.0
Semi-natural vegetation, including old lands	With negligible artificial drainage	1.8	0%	0.0	45%	0.8
Infilling without infrastructure	Foreign material/ solid waste (e.g. concrete rubble, plastic) used as infill	8.3	2%	0.2	2%	0.2
Natural, with wastewater flows[13]	Natural area of wetland into which the point-source release of untreated or poorly treated wastewater flows.	5.1	13%	0.7	0%	0.0
Natural	Natural vegetation with minor impacts such as scattered invasive alien plants	1.2	40%	0.5	53%	0.6
		TOTAL MAGNITUDE OF IMPACT:		**3.9**		**1.6**