# VEGWATCH MONITORING PROGRAM: PRACTICE AND FINDINGS 2011 TO 2018

# OVERVIEW

SARAH SHARP

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REPORT TO THE MOLONGLO CONSERVATION GROUP

CAPITAL REGION LANDKEEPERS

Molonglo CONSERVATION GROUP

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For more information on the Vegwatch program or to obtain copies of this report go to: Molonglo Conservation Group, https://molonglo.org.au or contact communications@molonglo.org.au

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***About the author***

Sarah Sharp is one of the developers of the Vegwatch program, and has taken the lead role in training, field and other assistance to volunteers, collation of data, testing of the database during development and data entry since its inception. She is a plant ecologist, and she has undertaken survey and assessment of condition of grassland ecosystems through work with ACT Government and as a consultant and volunteer for the past 30 years. Her particular area of interest and expertise is in ecological management of grassy ecosystems.

# 1. BACKGROUND

This document is an overview of the report, *Vegwatch Monitoring Program: practice and findings 2011 to 2018* (Sharp 2020), which is available at http://www.molonglo.org.au. The overview provides a summary of the findings and recommendations for changes to the monitoring program.

## Structure of the report, *Vegwatch Monitoring Program: practice and findings 2011 to 2018*

Chapter 1: An overview of the outcomes of the program so far, in relation to the six aims listed above (this publication).
Chapter 2: The background to monitoring and the application of the Vegwatch program.
Chapter 3: Detailed statistical analysis to identify which factors most influenced changes measured and the identification of the most effective indicators of change.
Chapter 4: Feedback provided by participants and other stakeholders on their experiences using the program.
Chapter 5. Description of condition and change in condition in each plot, based on the factors influencing condition and described as changes to particular indicators.

## Purpose of the study

This first review of data from the Vegwatch program has provided the opportunity not only to report and summarise the findings of the monitoring undertaken to date in 33 Vegwatch monitoring plots between 2011 and 2018, but to also investigate the methodology and commonly applied inferences behind change in condition. Future reviews will utilise recommended changes to the metrics and data analysed. This review also identifies the value of the citizen science program to support conservation-based management.

It is important to take into account that between two and seven years of monitoring in sites is a very short period to gain useful results (Charlie Krebs in Lindenmayer and Gibbons (2012) reported that interesting results didn't appear in a monitoring program he ran until after about 10 years). Thus, the result findings reported are preliminary.

The aims of this report are to identify if the Vegwatch program is effective and whether it is achievable. More specifically the aims were to:

1. Identify and acknowledge the contribution of citizen scientists in collecting vegetation data to assist in conservation of native ecosystems;
2. Review the methods used and the effectiveness of the indicators used to measure vegetation condition;
3. Make recommendations that will improve on-ground management applied by volunteers and others to enhance the condition of the conservation areas;
4. Describe the changes in condition in the locations being monitored;
5. Identify the data that can be incorporated into other studies, including the ACT Conservation Effectiveness Monitoring Program and the State of the Environment Report; and
6. Recommend changes to improve and expand the Vegwatch program.

The Capital Region Landkeepers Trust and the ACT Environment Grants Program are thanked for supporting and partially funding the preparation of this report. I acknowledge with gratitude the valuable contributions of the Vegwatch participants and input by many others into this report.

## The role of monitoring in conservation management

Monitoring plays a key role in the application of adaptive management. As management actions are implemented, monitoring is a strategic tool used to measure changes in defined attributes, to identify whether the specified desired outcomes are being met. Effective monitoring not only identifies that actions have occurred (e.g. revegetation has been undertaken), but what changes to ecological attributes have occurred (e.g. the percentage survival of each species). Monitoring identifies and measures change and can help identify which variables (drivers) may be related to those changes (short-term and long-term weather patterns, landscape features, historical land use and disturbance). Additional studies, importantly research or trials, are required to identify the reasons why the changes have occurred. Together with research, quantitative monitoring is a tool that justifies remedial actions (National Environmental Science Programme, undated).

The Vegwatch program was developed between 2011 and 2013 by the Molonglo Conservation Group (formerly Molonglo Catchment Group, MCG) to support an adaptive management approach to conservation of ecological systems. The Vegwatch program was intended to guide and help people to quantitatively measure changes to vegetation attributes over time, to help identify whether on-ground management activities were achieving the desired outcomes. In addition, the program was developed to provide data that could contribute to a larger

dataset in order to guide adaptive management of conservation areas.

Vegetation attributes measured and methods used are consistent with other existing monitoring and vegetation assessment programs, and include identification of plant species abundance, quantitative measures of vegetation cover and collation of data on structural and habitat features.

The plots were established in locations of specific interest to the participants in the program, where the participants were undertaking on-ground work, usually in ParkCare, Landcare or Friends groups. The majority of the plots were established within reserves, either government reserves or in some cases, leased (ACT) or privately owned (NSW) sites managed primarily for conservation (Table 1).

**Table 1. Characteristics of the Vegwatch plots included in the statistical analysis and summary of condition and trend**. Plots that meet the criteria as endangered ecological communities are in bold. See the list of abbreviations for names for vegetation associations and vegetation structure. **Key**: Condition: dark green: very good condition; green: good condition (with some concerns); orange: moderate condition; red: poor condition. Trend: ←→: stable; ↑: improving; ↓: declining; ↑↓: variable; ?: trend uncertain due to lack of repetitions. * indicate completed monitoring projects.

| Site | Participants | Land use | Plot | No surveys | Management | Vegetation association | Veg struc-ture | Overall condition and trend |
|---|---|---|---|---|---|---|---|---|
| **Aranda Bushland** | Friends of AB | N. reserve | ASG_1 | 4 | SJW control | SGW | GW | ←→ |
| **Black Mountain NR** | Friends of BM | N. reserve | BLM_S | 5 | Control burn 2014 | RSF | FOR | ↑ |
| | | | BLM_C | 5 | None (control) | RSF | FOR | ←→ |
| | | | BLM_A | 5 | Control burn 2012 | RSF | FOR | ↑ |
| **Bullan Mura Yarralumla** | Sharp (MCG) | Open space | BMY_1 | 5 | Woody weeds 2014 | **YBRG** | GW | ↑↓ |
| | | | BMY_3 | 2 | Cool burn 2018 | **YBRG** | GW | ↑? |
| **Captains Flat cemetery** | Capt. Flat Landcare | Cemetery | CFC_1* | 2 | No mgmt | SGCBW | FOR | ←→? |
| **Captains Flat property** | CF Landcare | Farm | CFH_1* | 3 | Woody weeds '15, livestock | NG | GL | ←→ |
| **Cooleman Ridge NR** | CR ParkCare | Nature reserve | CRA_2 | 5 | Control burn 2017 | **YBRG** | GW | ↑ |
| | | | CRD_1 | 5 | SJW control | YBRG | DerGL | ↑ |
| **Icon Water Williamsdale** | Sharp (MCG) | Cons'n (offset) | IWW_1B | 2 | Cool burn 2018 | **YBRG** | GW | ←→? |
| | | | IWW_2C | 2 | Control plot | **YBRG** | GW | ←→? |
| **Isaacs Ridge NR** | IR ParkCare | N. reserve | ISR_1 | 5 | SJW control | NG | DerGL | ↑ |
| **'Millpost' Bungendore** | Sharp (MCG) | Farm | MLP_1B | 2 | Cool burn 2018 | BGSOF | SW | ←→? |
| | | | MLP_2C | 1 | Control plot | BGSOF | SW | |
| **Mt Ainslie NR** | MA ParkCare | N. reserve | MAI_1* | 3 | Reveg: shrubs, trees 1980s | EPN | SW | ←→ |
| | | | MAI_2* | 2 | | EPN | SW | ←→ |
| **Mt Majura NR** | Friends of MM | N. reserve | MMA_1 | 3 | Reveg: forbs 2013 | **YBRG** | GW | ←→ |
| **Mt Painter NR** | Friends of MP | N. reserve | MPA_1 | 7 | Weed control | **YBRG** | GW | ←→ |
| | | | MPA_2R | 6 | Reveg: forbs 2011 | NG | DerGL | ←→ |
| | | | MPA_2C | 6 | Control plot | NG | DerGL | ←→ |
| | | | MPA_3 | 6 | Control burn 2014 | **YBRG** | DerGL | ↑↓ |
| **Mt Taylor NR** | MT ParkCare | N. reserve | MTA_1* | 3 | Wildfire 2003 | MBSF | SW | |
| **Royalla Swainsona Res.** | Royalla Landcare | Reserve (offset) | RSR_1 | 1 | Revegetation, date unknown | MBSF | SW | |
| **St Marks Grassland** | Sharp | Uni campus | STM_1 | 2 | Ecological burn 2018 | **NTG** | GL | ←→? |
| **Tennant St Fyshwick** | Sharp, MCG | Unleased | TSF_1 | 2 | No mgmt | **NTG** | GL | ←→? |
| **The Pinnacle NR** | FOTPIN | N. reserve | TPI_1 | 7 | Reveg: woody 1980S, forbs 2011 | **YBRG** | SW | ←→ |
| **Tuggeranong Hills NR** | TH ParkCare | N. reserve | TUH_1 | 2 | No mgmt | **YBRG** | GW | ←→? |
| **Umbagong G'l Latham** | FOG | Open space | UMG_1 | 2 | Ecological burn 2018 | **NTG** | GL | ←→? |
| **'Wandiyali' Googong** | Sharp (MCG) | Cons'n reserve | WAN 1B | 2 | Cool burn 2018 | **YBRG** | DerGL | ↑? |
| | | | WAN_2C | 2 | Control plot | YBRG | Der GL | ←→? |
| **Yarramundi Grassland** | FOG | Cons'n reserve | YAG_1 | 2 | Control burns '11 '17 | **NTG** | GL | ←→? |
| | | | YAG_2 | 2 | Control burns '11 '17 | **NTG** | GL | ←→? |

## 2. SUMMARY OF FINDINGS

The report reviews the effectiveness of a large-scale (in both duration and area) citizen science program for monitoring vegetation condition. The Capital Region Landkeepers Trust and the ACT Environment Grants Program partially funded the preparation of this report, the first of its kind in the ACT and region.

Volunteers from community groups (mostly ParkCare, Landcare and Friends groups) have been involved in the program to monitor sites in the Molonglo River catchment area and beyond since 2011. They used the Vegwatch methodology published in the *Vegwatch Manual* (Sharp and Gould 2014), which was developed in conjunction with scientists and community.

This report assesses the characteristics of the program during 2011–2018, including the robustness of the program, the drivers that are affecting vegetation condition and the effectiveness of vegetation attributes in identifying ecological change in condition. Statistical analyses were used to test the ecological validity by comparing these data with data collected by ACT government ecologists. It summarises participants' feedback on their own experiences and what they gained from participating, and what problems or issues they faced.

The report describes changes in condition in 33 Vegwatch plots in 22 sites in ACT and the surrounding region, using monitoring data between 2011 and 2018. Table 1 summarises the major characteristics of the Vegwatch plots, including their overall condition and trend. A report on each plot is presented in Chapter 5 of the report.

Changes to the program are identified to make it more effective: more robust and simpler metrics, simpler collation of condition indicators and a more refined method of communication of results. As a result, the program's data will be able to be easily shared with other scientists and practitioners to improve management outcomes.

The Vegwatch program has been successful in a number of ways:

1. Its methods are consistent, robust, and compatible with methods common in other programs.
2. Citizen scientists have shown they are capable of monitoring vegetation and habitat change.
3. Participants have gained knowledge and understanding of ecological processes occurring in the sites that they are involved in managing.
4. The data are comparable with data collected by professional ecologists.
5. Changes in condition due to natural ecological drivers or historical processes have been quantified and identified for all plots and distinguished from changes as a result of other factors, particularly management.
6. There are possibilities for wider application of the updated Vegwatch. It could be incorporated into other programs, including to provide quantitative monitoring of outcomes of on-ground activities undertaken as a part of grant reporting.
7. Vegwatch monitoring data may be used as a component of other monitoring programs for identifying changes in condition as a result of particular management interventions.

Weaknesses in the program implementation have been identified:

1. Some data proved difficult for participants to record accurately; for example, some people found species identification and estimating abundance and cover challenging.
2. The lack of on-going support to participants has decreased motivation and compromised the quality of some data.
3. Lack of resources has limited opportunities to communicate the results to volunteers, community, government and other groups, to share the data with other organisations or otherwise promote the program.
4. While the program was effective in identifying changes to condition indicators in the individual monitored locations, there was limited scope to generalise about the impacts of management interventions on those changes. Possible trends are suggested but need further testing and potentially more replication built into the program or data combined with larger datasets.

## 3. OUTCOMES AGAINST THE AIMS OF THE VEGWATCH PROGRAM REPORT

Plots were measured in seven vegetation associations and two modified associations (Table 1). The majority of monitoring plots were located in Yellow Box – Blakely's Red Gum grassy woodland (YBRG, nine plots in seven locations in grassy woodland, four plots in three locations in derived grassland (DerG) and natural temperate grassland (NTG, five plots in four locations). Plots were also measured in Snow Gum Woodland (SGW, one plot), Mealy Bundy – Broad-leaved Peppermint shrubby mid-high open forest (MBSF, two plots in two locations), Brittle Gum – Scribbly Gum tall dry open forest (BGSOF, two plots in two locations), Scribbly Gum – Candlebark Woodland (SGCBW, one plot in one location), in disturbed native grassland (NG, four plots in three locations) and in environmental native plantings (EPN, two plots in one location). Vegetation structure in these plots were grassland (13 plots of which seven contained derived grassland), grassy woodland (nine plots), shrubby woodland (seven plots) and forest (four plots). Five plots in three sites met the criteria as Natural Temperate Grassland of the South-Eastern Highlands critically endangered ecological community (Australian Government 2016). Eleven plots met the criteria for the White Box – Yellow Box – Blakely's Red Gum Grassy Woodlands and Derived Native Grasslands (YBRG) critically endangered ecological community (Australian Government 2005).

Management included interventions resulting in biomass reduction (burning and woody weed control) or revegetation and more incremental management such as reduction of particular weeds, general management, and on-going livestock grazing as well as varying levels of intensity of grazing by kangaroos.

Data from 31 Vegetation plots, and also data from seven plots sourced from ACT Government monitoring programs were combined in analyses to compare quality of data and to identify the indicators of change in condition. Sub-sets of the data based on vegetation structure were analysed to identify the impacts on condition of natural drivers such as climate and landscape features and imposed drivers including historical management and disturbance, stressors including invasive weeds and changes resulting from imposed management. The most effective measures of condition were identified.

### 3.1 The contribution of citizen scientists in collecting vegetation data to assist with conservation of native ecosystems[1]

Vegwatch is the only citizen science-based vegetation monitoring program that has been undertaken within this region. The program was established to provide community volunteers who work on-ground the opportunity to quantitatively monitor vegetation attributes to see whether their on-ground actions are making a difference to the condition of the vegetation. Such monitoring is made more powerful by applying the same measurements across multiple locations, thus allowing for inter-plot and inter-site comparisons.

Like other citizen science programs in the ACT and region, such as Waterwatch and Frogwatch, Vegwatch provides opportunities for non-scientists to be involved in scientific studies that produce critical information to assist in conserving biodiversity. More than 80 participants have been involved in undertaking the surveys in the Vegwatch Program. Scientists or other trained practitioners have been a key part of ensuring accuracy and consistency of the data collected and giving confidence to the participants, providing training or assistance with surveys and with species identification. Data included in this report were collated from 114 surveys of 33 plots, measured between one and eight times between 2011 and 2018. The volunteers have provided valuable data that can now be incorporated into the implementation of an adaptive management program.

**Training at Umbagong Grassland**

Feedback was obtained from participants and other stakeholders involved in the program (Chapter 4). Many participants stated that as a result of implementing the monitoring in their sites they have learnt a great deal about the species and processes occurring over time and have enjoyed contributing to the program. However, many participants, often those with less experience in scientific process, found the program challenging, citing difficulty in remembering what to do from year to year, and their problems in plant identification, as well as in understanding the methodology.

[1] Chapters 3, 4, 5, Sharp 2020

The challenge of plant species identification and scientific process was anticipated, but there have been fewer resources than expected for providing consistent on-ground assistance to undertake training, calibration of field measurements and assistance with species identification to ensure data integrity. An effective citizen science program requires consistent facilitation, to ensure participants retain their skills, are given feedback and maintain motivation, in order to provide useful data that are well managed, reported and integrated into land management.

Even with the difficulties some participants identified, the data collected in the Vegwatch program compared well with data collected by professional ecologists. The data are of similar integrity, and therefore have provided valid and useful results. Vegwatch plots are frequently within locations that would otherwise not be monitored and that are in a wider range of conditions than would be prioritised in government-led studies. Such data are important for conveying greater understanding of the dynamics of different vegetation communities. The wider range of locations can add value to monitoring and research programs implemented by government and research institutions.

## 3.2 Identification of the most effective indicators to measure change in vegetation condition[2]

Methods used to survey the data were consistent with methods used in other surveys undertaken within this region. Data were collected within permanently marked plots of 0.1 ha (or of 0.04 ha if not containing vegetation over 2 m tall), and also along transects within that plot. The plot locations were selected by the participants, to ensure they provided information that was relevant to those participants' on-ground work. Monitoring was undertaken in plots in seven vegetation associations and two modified vegetation types (native plantation and degraded native grassland). The vegetation structure present in the plots were native grassland (natural grassland or derived grassland) grassy woodland, shrubby woodland and forest. The plots were located in nature reserves, rural land, private conservation reserves and urban locations.

Data collected from 108 surveys at 31 plot locations were used to analyse the effectiveness of the proposed indicators to measure change (data from two plots were not included in the analyses due to concerns about misidentification). Additional data were included from a further 36 surveys from 7 plots from monitoring programs undertaken by ACT Government, to test whether the quality of the data in the Vegwatch program were equivalent to data from other studies.

Multivariate and univariate statistical analyses were applied to assess whether the methods used to collect the data were robust, the data accurate and the results useful in identifying change in condition. Other data were investigated using descriptive statistics such as scatter diagrams and column graphs.

Potential variables – 'drivers' – causing change in vegetation condition were tested and the ones most influencing current condition and condition change were identified. Primary drivers are those that cannot be modified and that characterise each location. They include natural ecological factors (e.g. slope, aspect, geology, soils, climate conditions and climatic variation) and historical processes (historical land use and management). Secondary drivers include conservation management that aims to enhance the natural values by modifying stressors (e.g. control of invasive weeds).

A critical initial factor was to assess the robustness of the program and accuracy of the data collected to determine whether data measured by citizen scientists could be usefully used to interpret change in the data over time. This was assessed by several means and it was concluded that the Vegwatch data were of equivalent quality as ACT Government data, and can be used in interpretation.

The drivers that were deemed to have the most influence on changes in condition, in order of their degree of influence were:

1. Unique plot characteristics (proposed in particular to relate to each plot's historical management and disturbance);
2. Structural formation (that reflect landscape characteristics);
3. Seasonal weather variability (measured as root zone soil moisture levels); and
4. Interventionist management (management that resulted in significant measured alterations to biomass and/or composition, in this program being burning, woody weed removal and revegetation).

Sixteen attributes or scores were developed from species abundance data and cover, and cluster analysis, correlation analysis and Principal Components Analysis were used to determine which were the best indicators

[2] Chapter 3, Sharp 2020

of ecological condition. Further consideration was given to selecting those indicators that were most likely to result in the most accurate and consistent data across all surveyors, that is, those that are simplest to collect, are based on the least amount of qualitative assessment, and are the easiest to calculate. The most useful indicators of condition were identified as native species richness (species composition in plots), introduced species richness (species composition in plots), and groundcover attributes (native and introduced growth forms, bare ground and litter), measured at multiple points along a transect (Table 2).

Other attributes can be derived from these indicators: for instance, indicator species, and non-grass species richness (for calculating scores against listings for threatened ecological communities), and invasive species richness and composition, the frequency and composition of other species of interest and structural diversity. Several attributes currently included in the program are deemed suitable for measurement only by skilled practitioners, and may be measured less frequently or omitted from the Vegwatch program (Table 1). They are species abundance scores used to calculate floristic value scores, upper and mid-storey cover, benchmark condition score and habitat condition. Other indicators such as revegetation success should be measured using consistent methodology such as that described in the Vegwatch Manual (Sharp and Gould 2014).

**Table 2. Metrics and condition indicators proposed for future application in Vegwatch**

| **Basic method: annual measurements** | **Condition indicators** |
|---|---|
| Species richness: (presence data only) in a 0.1 ha plot | 1. Native species richness<br>2. Invasive species richness<br>3. Structural diversity<br>+. YBRG plots: Indicator species richness<br>+. NTG plots: Non-grass species richness |
| Transect: at 80 – 100 points within or bordering the plots, presence of groundcover attributes:<br>Native grass cover,<br>Native forb cover,<br>Native sub-shrub cover,<br>Introduced annual cover,<br>Introduced perennial groundcover,<br>Bare ground and/or algae,<br>Cryptogams (excluding algae), and<br>Litter cover<br>Rocks (permanent non-vegetative cover) | 4. Native groundcover<br>5. Introduced annual groundcover<br>6. Introduced perennial groundcover<br>7. Bare groundcover<br>+ other cover attributes to answer specific questions |
| **Advanced method: initial, mid and final measurements** | |
| Native species abundance (Braun-Blanquet)<br>Benchmark/BAM attributes:<br>Native overstorey cover<br>Native mid-cover<br>Introduced mid-cover<br>Introduced overstorey cover<br>No. trees with hollows<br>Fallen timber (m)<br>Habitat attributes | 8. Floristic value score<br>9. Benchmark score<br>10. Habitat condition score |
| **Revegetation (annual)** | 11. Revegetation success |

## 3.3 Management applied to enhance the condition of the conservation areas[3]

The indicators of change in condition, identified from the analyses, were used to interpret changes occurring as a result of the three management interventions applied in 26 plots in the program – burning, woody weed control and revegetation. While changes in the condition of the indicators are apparent, results were difficult to interpret conclusively because of the lack of replication of plots subject to different management, and the different timing of application of the treatments. Data from trials and research and/or more specific monitoring programs are required to provide more definitive recommendations.

The seasonal climatic conditions were highly variable during the monitoring period 2012 to 2018. The weather conditions were quantified by calculating the root zone soil moisture levels using methodology accessed from the Bureau of Meteorology (http://www.bom.gov.au/water/landscape). Soil moisture levels in the ACT and region were average between 2012 to 2015, well above average in 2016, below average in 2017 and well below

[3] Chapters 3, 5, Sharp 2020

average in 2018. The effects of the varying soil moisture levels were identified in the analyses, and were found to impact the changes in condition in sites subject to management interventions.

### *Burning*

Burning was the most frequently applied treatment in the Vegwatch program between 2012 and 2018, with 11 plots being monitored to assess the change after burns. Only three of these plots were monitored for three years or more after the burns were applied, the others were only monitored for one or two years after the burns were undertaken. Control (unburnt plots) were established at five of the locations. The burns were applied in different years, but the majority, including all the cool – cultural – burns, were applied in mid-2018, so although more comparable across locations, only one season's post-burn data were available for these eight locations for this review. As a result of the variability in time and place, only descriptive interpretation was possible. Continuation of monitoring of these sites will provide more information on the effects of the burns over longer periods of time.

Regeneration of shrubs was very high in forested plots after the burns, and native species richness increased significantly; introduced species cover and richness in these plots was low initially, and did not change. In grassy ecosystems there were much more varied responses at the plot level. Generally, across all the plots an initial decline in both native and introduced species cover post burn was followed by an increase in subsequent years.

In the plots for which data are available for more than three years native species richness decreased in 2017 and 2018, however, which may have reflected response to the burning or may have reflected low soil moisture availability. In the sites subject to cool burns, applied and measured during seasons of very low soil moisture, (with only one season's post burn data available), the response to the burns were mixed – in two of the four plots there was little difference in richness in the burnt or unburnt plots, but in two there was an increase in native richness in the burnt plot. Continuation of monitoring in these plots is recommended to determine whether the variability from year to year is strongly influenced by seasonal condition and intensity of the burns.

**Before and after a burn was undertaken, St Marks Grassland**

### *Woody weed control*

The two sites subject to woody weed control were very different from each other. The site at Bullan Mura in Yarralumla in which woody weeds (mainly tall shrubs and small trees) were removed was a native species dominated grassy woodland. Monitoring indicated that both native and introduced species richness and cover increased slightly after two years, but annual introduced species cover increased to high levels in 2016, when soil moisture levels were very high. The reduction of mid-storey vegetation may have exacerbated the impacts of high and low available soil moisture. After four years the woody weeds were re-appearing in low numbers, presumably from root stock. This underlines the need to undertake follow-up control within a few years of initial control. After woody weed control the Button Wrinklewort population in Bullan Mura was re-surveyed, and the numbers had increased from 61 plants counted in 2014 to 140 plants in 2016, although at least some of these plants may have been more visible after woody weed control.

The Captains Flat property had a very low native species diversity and cover. There was no increase in native or introduced species richness in the two years following the woody weed control.

### *Revegetation*

Five plots were established to monitor change in species richness following revegetation of herbaceous and sub-shrub species. A general trend was apparent, with an increase in species richness followed by a reduction in richness after several years. Given the dry seasonal conditions, survival may have been reduced by a lack of

moisture, but these trends follow patterns identified in other studies, in which there is a drop in survival of herbaceous species in particular, unless there is thorough preparation of the revegetation site and on-going weed control. In one plot (The Pinnacle Plot 1) the survival rate of 213 herbaceous and shrub seedlings was monitored: after eight years 66% of the original plantings were alive, with individual species' survival rates varying from 0% to 91%. Of the 11 species planted, four species had regenerated, varying from one to 17 plants established. In Mt Painter there was a 44% survival rate measured in 2016, prior to the severe dry conditions.

**Revegetation at The Pinnacle; the effect of seasonal conditions is very apparent in the groundlayer**

This latter study demonstrates the need to monitor plant survival in revegetation programs, to identify the rate of survival as well as identifying which species survive better than others and whether some species regenerate more regularly than others. This monitoring should be in conjunction with monitoring of the general condition of a site.

### *Conclusions*

One of the key characteristics of the Vegwatch program was that the participants self-selected areas in which to establish monitoring plots, according to their own interests and in relation to what they wanted to find out. As a result, the plots differed in terms of vegetation composition, condition, past management and the management applied during the program. In many sites, only one plot was established. Thus, unlike more structured monitoring programs or research, in which key factors are replicated and timing of management intervention is controlled, this study has not been compatible with analyses from which to suggest causes of change that occurred. However, some general findings can be summarised.

1. Biomass manipulation resulted in a dramatic change in the amount of vegetation and litter and consequent exposure of bare ground. The impacts of biomass reduction are likely to be higher in years of very low soil moisture conditions, so implementing biomass reduction during poor seasons or just prior to poor seasons may result in moderate to long-term reduction in condition until groundcover increases. Cool burns in which a larger amount of ground cover is maintained may have reduced impacts from low soil moisture conditions on regrowth of vegetative matter, compared to low-intensity control burns which tend to burn larger areas and remove more biomass.
2. Five of the twelve plots that were burnt increased in overall condition over the eight years; no other plots subjected to management interventions increased in condition, although all remained stable.
3. Revegetation of herbaceous species should be monitored to record the success of establishment (survival and regeneration), with particular observations over multiple sites to identify the species most successfully establishing. Revegetation programs required considerable preparation and on-going management, including weed control in the site prior to planting, and commitment to on-going weeding and/or watering if required.
4. Replication of plots and more specific identification of management objectives are required to improve the capacity of monitoring to measure changes in condition as a result of management. However, this will be more effective if better coordinated with management research.
5. Three to five years of monitoring data are inadequate to monitor the effects of biomass manipulation; variability remained high for many years in plots subjected to burns and woody weed control, and the plots were particularly susceptible to variations caused by very low available soil moisture.

## 3.4 Changes in condition in the plots being monitored[4]

The change in condition of indicators in each plot were calculated. To represent background variability in the data caused by primary drivers, 95% confidence intervals were calculated for the main condition indicators identified in the analyses. For each structural formation, data from plots in good condition, that had not been subject to management interventions and from the years of average soil moisture conditions were used to calculate the confidence intervals for the plots for eight indicators of condition. That outcome was then graphed with the data from each plot, together with the calculated soil moisture level for each plot. The timing of interventionist management was identified. Any variation beyond this range is deemed to reflect significant change, either reflecting management intervention or variability in seasonal conditions.

Condition levels were identified as poor (well below the confidence interval), moderate (below the confidence interval), good with some concerns (within the confidence interval), and good (above the confidence interval) (based on the classifications defined by ACT Government, Brawata et al. 2017 ) against the confidence intervals and against existing values. The trend in change in condition over time was identified as stable, improving, declining, variable, questionable for plots measured only twice and no trend identified for those measured only once or where data were deemed inaccurate. The overall condition and trend of each plot is presented in Table 1 and reports for each plot are in Sharp 2020, Chapter 5. An example of a plot report is presented below.

Vegetation attributes and condition indicators varied most in the plots within the grassy ecosystems. The monitored plots in derived grasslands tended to contain the highest component of introduced species, particularly introduced annual species, but many also had a very high native species richness and diversity. The four forested plots contained very low introduced species richness and cover, and very little bare ground.

Of the eight plots in good condition, four were forested plots in Black Mountain (BLM_A, BLM_C, BLM_S) and Captains Flat Cemetery (CFC_1), two were shrubby woodlands at Mt Taylor Nature Reserve (MTA_1) and Royalla Swainsona Reserve (RSR_1) and two were natural grassland plots at Umbagong (UMG-1) and Yarramundi Grassland (YAG_2).

The plots that demonstrated an increase in condition were five of the burnt plots in Black Mountain (BLM_S, BLM_A), Cooleman Ridge (CRA_2), Mt Painter (MP_3) and Wandyali Conservation Reserve (WAN_1B) and two other plots at Isaacs Ridge (IR_1) and Cooleman Ridge (CRD_1), in which control of St John's Wort was undertaken. Condition was stable in 23 sites, seven of which were burnt sites, three of which were revegetated, two subjected to woody weed control and ten subjected to no management interventions. No plots were declining in condition overall, although native species richness declined in two burnt sites over the period of monitoring.

## 3.5 Value of the citizen science for incorporation into other studies[5]

The value of the data lies in its application to improve conservation outcomes. The results of the Vegwatch monitoring can be applied by the community groups to modify their management on site or the results could be used in combination with other data to identify broader inferences.

For example, the citizen science data could be included in metadata analyses that contain other monitoring data collected using the same methods, to allow more robust statistical analysis that is not possible for smaller data sets. The data from this study have been provided on request to ACT Government for consideration for incorporation into a metadata analysis.

Other uses include incorporation into reports such as the State of the Environment reports, or for reports on the condition of particular sites or groups of sites (e.g. reserves) and to identify outcomes of implementing action plans for threatened species and ecological communities.

Information on the outcomes of on-ground management can be used to inform invasive species control programs, biomass control programs and single species management. Examination of the data could also assist in developing research programs.

The data or any sub-set of the data can simply be retrieved from the database. Any changes to the way data are collected would need to take compatibility issues into account.

[4] Chapter 5, Sharp 2020

[5] Chapters 3, 5, Sharp 2020

## Bullan Mura Yarralumla 2014–2018 BMY_1

**Monitoring** undertaken by Sarah Sharp
**Location:** Block 2, Section 128 in Yarralumla, between Alexandrina Drive and Forster Crescent and adjoining Stirling Ridge. The plot is more or less parallel and north of the powerlines.
**Land use**: open space (City Services)
**Vegetation Type** Yellow Box – Blakely's Red Gum Grassy Woodland (CEEC) **Vegetation structure** Grassy Woodland
**Management** Woody weed control autumn 2014.

**Aim:** to monitor change in vegetation and habitat condition following woody weed control.

| Condition indicators | Condition, trend | Interpretation |
|---|---|---|
| **Overall condition** | ↑↓ | Changes reflect soil moisture availability post woody weed control. Button Wrinklewort *Rutidosis leptorhynchoides* count of 62 in 2014, 140 plants in 2016; increase may be because plants were not as visible in 2014 or because of reduced competition for resources. |
| Native species richness | ↑↓ | Increase following control corresponds to available soil moisture |
| Native floristic value | ↑↓ | Increase following control corresponds to available soil moisture |
| Native groundcover | ↑↓ | Decreased in the first year following woody weed control, then increased |
| Proportion native groundcover | ↑↓ | Decrease n 2016 corresponds to increase in Intr. perennial groundcover |
| Introduced species richness | ↔ | Fluctuation corresponds to soil moisture availability |
| Introduced floristic value | ↔ | Fluctuation corresponds to soil moisture availability |
| Introduced annual groundcover | ↔ | Very strong increase in 2016 corresponds to soil moisture availability |
| Intr. perennial groundcover | ↔ | Fluctuation corresponds to soil moisture availability |
| Benchmark condition score | 63% | High woody weed content reduced condition. |
| Habitat diversity score | 73% | Some loss of habitat due to clearance of woody weed habitat; more open post weed control. |

**16/2/15**

**31/10/18**

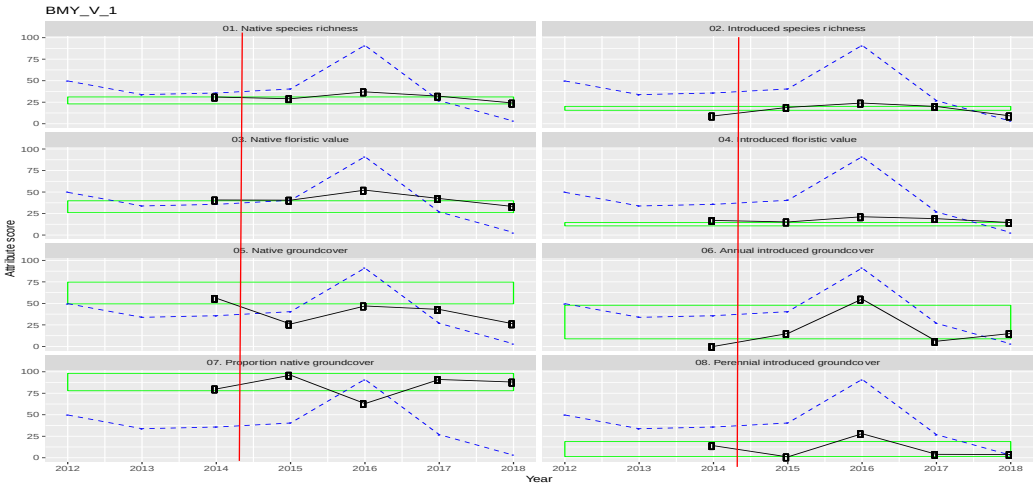


**Figure 1. An example of a report on changes in condition (see Chapter 5 of Sharp 2020).**

## 3.6 Recommended changes to improve and expand the Vegwatch program[6]

The results of the detailed analysis of the data have demonstrated the most effective way to continue, improve and expand the Vegwatch program. The review has identified what has been achieved and some weaknesses and, importantly, what is required if the Vegwatch program is to continue most effectively.

For the Vegwatch program (or any citizen science program to be successful) the people involved must gain personally from the surveys, for example, in enjoyment, education, better understanding of the results of their management applied on ground, sharing experiences, as well as in knowing that they are providing valuable information that will ultimately result in better conservation outcome.

The Vegwatch program aimed to use methods that require no in-depth botanical knowledge (Sharp and Gould 2014), however the difficulty of some participants identified this as a key problem to maintain motivation. It was concluded that the monitoring requires at least a moderate level of botanical knowledge and the skills (and interest) to follow identification of unknown specimens; it also requires help from others to ensure consistency and accuracy with plant identification and or measurement techniques. In addition, simpler methods, that retain consistency at least with a sub-set of data collected by more experienced ecologists, ensure greater accuracy (for example, not collecting abundance data for species).

Vegwatch should now move to a new phase, to be further expanded. If strengthened by increasing the number of groups involved, the extent of sites being monitored and the data being shared, then it can be more widely utilised in Government, scientific and community research and planning.

For Vegwatch to continue successfully, it is recommended that the following processes are implemented or strengthened:

***Collaborate with managers and other stakeholders to support the Vegwatch monitoring program***

1. Provide the data regularly to government for incorporation into larger data sets.
2. Ensure the Vegwatch program is undertaken in collaboration with other natural resource monitoring programs, including monitoring of single species, habitat or other function.
3. Promote opportunities for Vegwatch monitoring to be incorporated into other studies; for example, as part of NRM and other grant reporting.
4. Work towards establishing a coordinated approach between ACT Government and Vegwatch participants to undertake monitoring in select locations to fill gaps in broader programs.
5. Coordinate Vegwatch with other programs, for example:
    - Enter monitoring plot details onto the Collector app (used in ACT to identify on-ground work such as weed control) to link the monitoring with other actions including other surveys, management being applied, type of vegetation, protected plant locations;
    - Encourage use of Canberra Nature Map to record species locations; and
    - Enter data into the Atlas of Living Australia.
6. Encourage utilisation of the data by research scientists to help formulate research programs designed to support adaptive management.
7. Ensure the results are used to improve management.

***Ensure there is a facilitator to coordinate the program implementation***

8. Encourage and support existing volunteers to continue monitoring at existing locations.
9. Ensure there is on-going support to participants to:
    - Promote consistency of data collection and data management,
    - Provide assistance on the ground,
    - Provide or facilitate initial and refresher training,
    - Ensure timely data entry, and
    - Support a group of skilled volunteers to help with plant identification or other matters;
10. Hold regular refresher training sessions.
11. Ensure there is long-term maintenance of the Vegwatch database and facilitation of data migration so that data are not lost.
12. Encourage other groups to instigate monitoring where interventionist management is occurring.

[6] Chapters 3, 4, 5, Sharp 2020

***Improve frequency of feedback to participants and other stakeholders***

13. Provide regular feedback to participants and to managers to improve effectiveness of management.
14. Use the Internet and websites more effectively to provide updates and enable groups to stay in touch: Ensure regular reports are available on the website so all groups can see the results in a timely way. Include key documents on websites, including this report, plot reports, talk presentations, articles, guidelines and contact details.
15. Hold workshops, give presentations to participants, community and government to encourage collaboration.
16. Ensure participants are acknowledged for their involvement and how this benefits management outcomes.
17. Ensure no-one feels 'obliged' to undertake monitoring; ensure careful preparation and planning so that the monitoring is relevant and useful to the participants.

***Modify the metrics used in the program to ensure data are robust, provide consistent results, and are useful to answer pertinent questions***

18. Ensure data to be collected are as simple as possible, and require the least amount of decision making so that the data are easier to collect and are more consistent.
19. Coordinate a group of skilled practitioners to assist with more complex data measurements across a range of plots, enabling the simpler data to be collected by volunteers at each plot.
20. Simplify plant identification. Several options are:
    - Identify those species that only need to be identified to genus level
    - Have designated persons to help with post-survey species identification
    - Encourage better use of existing species identification resources (training, Canberra Nature Map, field guides and other websites)
    - Provide identification guides relevant to each plot species list, at least for those species that are hard to tell apart or where they need to be identified as native or introduced.
21. It may be relevant to apply Vegwatch at several different levels based on the levels of skills required or particular outcomes of the monitoring, from photomonitoring to more complex data measurements.
22. Ensure plots are optimally situated based on the group's aims and so that results can feed into a broader data set. Encourage the establishment of replicate plots within sites and between similar sites to enable more complex statistical analyses.
23. Ensure methodology and data entry guidelines are clear and consistently presented and well understood.
24. Prior to development of modified guidelines and incorporation of changes, involve relevant stakeholders that include ACT Government, catchment groups and participants to evaluate the findings of the analyses and recommendations provided in this review.

## 4. REFERENCES


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